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Presentation of the content

In the first article we present, *Study of the termal and mechanical properties of the magnetite/polypropylene composite*, by BOCARANDO-CHACÓN, Jacqueline Guadalupe, VARGAS-VÁZQUEZ, Damián, LARIOS-OSORIO, Martín and MENDOZA-DUARTE, Mónica Elvira, with adscription in the Universidad Tecnológica de Querétaro, Centro de Materiales Avanzados S.C., Universidad Autónoma de Querétaro, in the next article we present, *Early reaction of bean varieties to root rot under laboratory conditions*, by CID-RÍOS, José Ángel, VELÁSQUEZ-VALLE, Rodolfo, CHEW-MADINAVEITIA, Yasmin Ileana and SERVIN-PALESTINA, Miguel, with adscription in the Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, in the next article we present, *Physicochemical and biological tests to determine water quality in the San Luis Ayucan River, Municipality of Jilotzingo, Estado de Mexico State*, by GRANADOS-OLVERA, Jorge Alberto, RANGEL-RUIZ, Karelia Liliana, VARGAS-SOLANO, Zaira and GARCIA-CERON, Victor Hugo, with adscription in the Universidad Politécnica de Cuautitlán Izcalli, Universidad Tecnológica Fidel Velázquez, Colegio de Estudios Científicos y Tecnológicos del Estado de México plantel Cuautitlán Izcalli, in the next article we present, *Dehydration of strawberry (Fragaria vesca) using a direct solar dryer*, by CABRERA-REQUENES, Joshua Salvador, GONZÁLEZ-CABRERA, Adriana Elizabeth, VILLEGAS-MARTÍNEZ, Rodrigo Cervando and GARCÍA-GONZÁLEZ, Juan Manuel, with adscription in the Universidad Autónoma de Zacatecas, Universidad Nacional Autónoma de México.

Content

Article	Page

Article
Journal Simulation and Laboratory
December 2023 Vol.10 No.29 1-5

Study of the termal and mechanical properties of the magnetite/polypropylene composite

Estudio de las propiedades térmicas y mecánicas del composito magnetita/polipropileno

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Abstract

Currently, innovation in materials is a highly explored area, due to the requirements to satisfy the industrial needs for intelligent materials that arise mainly with an improvement in physical and mechanical properties. Within the classification of intelligent materials are composites and in this work it is proposed to combine a very versatile and low-cost polymer such as polypropylene and the important mineral called magnetite. By manual injection, three compounds are obtained and evaluated the effect on the thermal and mechanical properties of the polypropylene (PP) composite reinforced with different concentrations of mineral magnetite (5%, 10% and 20%) is evaluated. The three composites obtained (MP5, MP10 and MP20), were characterized by thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC) and Dynamic Mechanical Analysis (DMA). A favorable effect with MP20 composite is achieved on the thermal properties of polypropylene, managing to extend the thermal stability up to 420°C and improve the storage modulus up to almost 2 GPa.

Composite, Magnetite, Reinforcing agent

Resumen

En la actualidad la innovación en materiales es un área muy explorada, debido a los requerimientos para satisfacer las necesidades industriales por materiales inteligentes que surgen con un mejoramiento en las propiedades físicas y mecánicas. Dentro de la clasificación de los materiales inteligentes se encuentran los compositos y en este trabajo se propone combinar un polímero muy versátil y económico como lo es el polipropileno y un mineral importante como lo es la magnetita. Mediante inyección manual se obtienen tres compositos y se evalúa el efecto en las propiedades térmicas y mecánicas del composito de polipropileno (PP) reforzado con diferentes concentraciones de magnetita mineral (5%, 10% y 20%). A los tres compositos obtenidos (MP5, MP10 y MP20), se les caracterizó mediante Análisis de Termogravimetría (TGA), Calorimetría Diferencial de Barrido (DSC) y Análisis Dinámico Mecánico (DMA). Se observa un efecto favorable con el composito MP20, logrando aumentar la estabilidad térmica hasta 420°C y aumentando el módulo de almacenamiento hasta 2 GPa.

Composito, Magnetita, Refuerzo

Citation: BOCARANDO-CHACÓN, Jacqueline Guadalupe, VARGAS-VÁZQUEZ, Damián, LARIOS-OSORIO, Martín and MENDOZA-DUARTE, Mónica Elvira. Study of the termal and mechanical properties of the magnetite/polypropylene composite. Journal Simulation and Laboratory. 2023. 9-29:1-5.

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Introduction

Thanks to the excellent properties of polypropylene such as high thermal stability, high chemical durability, easy processability and low cost, it is a very versatile material for different applications, not to mention its reusability [1, 2, 3 and 4]. Polypropylene composites are attracting attention among other aspects for their versatility in different applications ranging from medical [5 and 6], industrial [7] and aerospace [8, 9 and 10] as well as in the production of composites with interesting properties such as light weight, low cost, high resistance to elastic deformation, etc. It is known that polypropylene among thermoplastics is one of the most attractive thermoplastics to reinforce and improve its properties making it compatible with most processing techniques [11].

Magnetite is a very abundant mineral in the earth's crust and in addition to possessing important physical properties such as high density, thermal and electrical conductivity, it is also known to be opaque to x-rays and can block radiation, including microwaves and radar [12]. Glass is currently used for this purpose and has also been used for its modification to obtain composites [13].

In this work we propose to obtain three composites with polypropylene matrix with different concentrations of magnetite as a reinforcing agent.

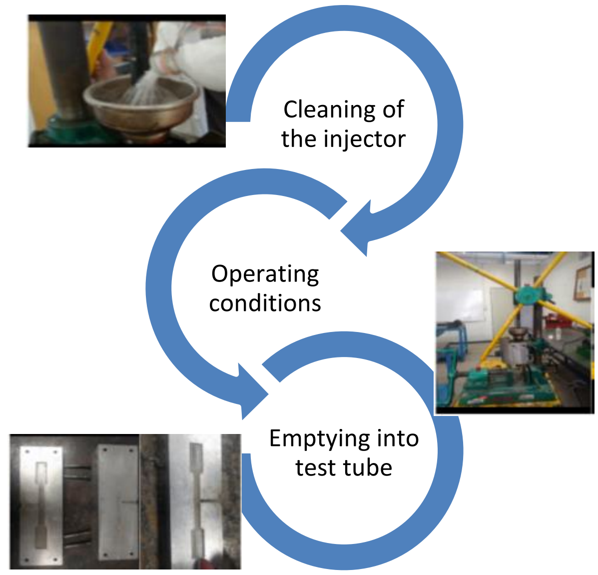
Experimental development

Obtaining the composite

To obtain the composite, magnetite mineral from a mine in Oaxaca was used as a reinforcing agent and the versatile thermoplastic polypropylene (PP) pellets with a density of 900 kgm-3 and a melting temperature of 170°C were used as a polymeric matrix.

In the process of obtaining the composite, the injection method was used using a manual injector Vulcano brand/model, the injection of the composite with the reinforcement of the clays was deposited in a mould for tensile specimens with measures of 2.5X8 in.

Based on the literature review, 3 concentrations of magnetite were established: 5% (MP5), 10% (MP10) and 20% (MP20) of the total PP, and then the mixture was mixed with the polypropylene, where the injector hopper was used for the mixing process, which was preheated to 130°C.



Graphic 1 Process of obtaining the Magnetite-PP composite
Source: Own elaboration

Once the specimens with the corresponding magnetite concentration were obtained, dynamic mechanical analysis (DMA) tests were carried out with a deformation sweep from room temperature of 25°C to 200°C with a heating ramp of 10°C/min. These tests were carried out on a TA Instruments RSA III.

Thermal analysis (TGA-DSC)

In order to know the thermal behaviour of the composites, a standard DSC-TGA-SDT Q600V20 was used.

Stress Test

An INSTRON INS-001 tensile testing machine was used to determine the maximum stress of the composites obtained. The tests were carried out at room temperature and with a humidity of 20% under the procedure of the ASTM D638 standard (stress properties of plastics) with a speed of 100 mm/min.

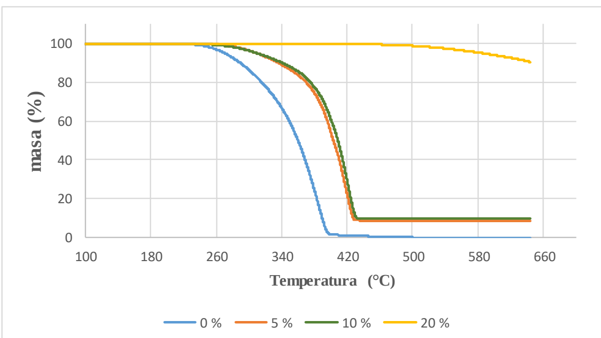
Rotational rheology (viscosity)

A Physica MCR 501 rotational rheometer was used to obtain the flow curve. A gap=1mm was used, from a temperature of 200°C, with a geometry of 25 mm parallel plates and a shear rate range of 0.0001-100 (1/s), recording the stress values (Pa).

Results

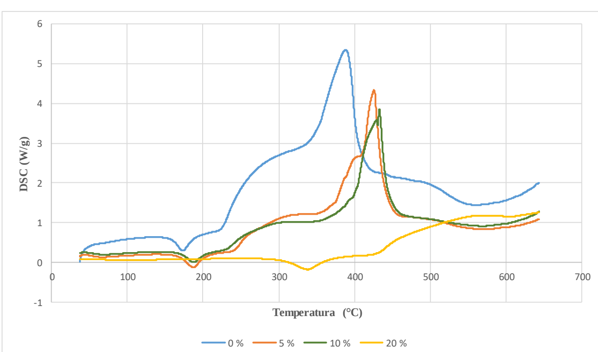
Thermal analysis (TGA-DSC)

Graph 2 shows the behaviour of pure polypropylene, as well as the composites with different concentrations of magnetite.



Graphic 2 Thermogravimetric analysis of the obtained composites and pure PP
Source: own elaboration

In the thermograms (graphic 2), a significant decomposition of PP and the composites MP5 and MP10 can be observed in the temperature range from 240 to 420 °C, achieving a positive thermal reinforcement by the magnetite from the lowest concentrations (5 and 10%) resisting up to a temperature of 280°C in comparison with the pure PP. It can be seen that with the highest concentration of magnetite (MP20) the thermal stability of the composite has been increased by approx. 50%, remaining stable up to 500°C.



Graphic 3 Differential scanning analysis of the obtained composites and pure PP
Source: Own elaboration

Graphic 3 shows that the melting temperature of the MP5 and MP10 composites achieves a delay of 30°C compared to pure PP. In a favourable way, the MP20 composite achieves a delay of the crystallisation phase up to a temperature of 430°C compared to pure PP.

Tensile test

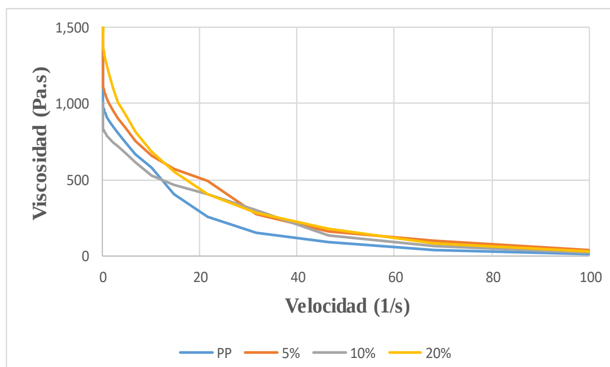
Table 1 shows the storage modulus achieved by each composite compared to neat PP.

Sample	Module E (kPa)
PP	464503.336
MP5	264269.543
MP10	572806.501
MP20	1991694.450

Table 1 Tensile test on PP and the composites obtaine
Source: Own elaboration

It is observed that the incorporation of magnetite in the MP5 composite has a negative effect by lowering the storage modulus of pure PP. However, with the highest concentration of the reinforcing agent (MP20), a significant increase in the storage modulus of~ 2 GPa is achieved.

Rotational rheology (viscosity)



Graphic 4 Viscosity of the PP and composites obtained
Source: Own elaboration

Graphic 4 shows that regardless of the concentration of the reinforcing agent (magnetite), the four samples show a decrease in the loss modulus or viscosity of the material; however, as the speed increases, the composites show a damping in the decrease of viscosity, which is a direct contribution of the reinforcing agent.

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Conclusions

The characterisation of the composites obtained with different concentrations of the reinforcing agent (magnetite) shows a favourable effect by improving the thermal and dynamic-mechanical properties of the polypropylene. With the MP20 composite it was possible to increase the thermal stability up to 420°C and to increase the storage modulus up to 2 GPa.

In this way, we contribute with information for the processing of this versatile and economical material.

Acknowledgements

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Article

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Early reaction of bean varieties to root rot under laboratory conditions

Reacción temprana de variedades de frijol a la pudrición de la raíz en condiciones de laboratorio

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Abstract

Root production (RP) is a disease caused by various pathogens and causes a reduction in bean (Phaseolus vulgaris L.) yield. The PR occurs before and after the emergence of the seedlings between the first and 5 to 9 days after sowing (dds). However, few works have been reported on the effect of this disease in early stages. The objective of the work was to determine the early reaction of bean varieties to root rot in different soils under laboratory conditions. 26 composite soil samples were taken in commercial bean plots in the state of Aguascalientes. Bean seeds of the Bravo, Centenario, Coloso, Raramuri, San Rafael and Negro Zacatecas pinto varieties were sown in plastic counters in duplicate of each of the soil samples. On average, 7 days after sowing, the roots of each seedling in all containers were collected to identify and classify the incidence and severity of the disease. Also, the pathogens present in the seedlings. The results indicate that only in eight plots was an incidence of the disease of 25% recorded and the varieties with the highest percentage of incidence values between 75.1 and 100% were Pinto Centenario, Pinto Coloso. Also, a higher incidence was observed in pinto bean varieties compared to black bean varieties. PR caused lesions ranging from trace to root death in seedlings of the six bean varieties evaluated from pre-emergence to six or eight days after emergence. Rhizoctonia spp., Fusarium spp. and Sclerotium rolfsii in lesions or on the root and hypocotyl of the plants of the six bean varieties.

Pathogens, Incidence, Soil health

Resumen

La producción de la raíz (PR) es una enfermedad causada por diverso patógenos y provoca una reducción de rendimiento de frijol (Phaseolus vulgaris L.). La PR se presenta previo y posterior a la emergencia de las plántulas entre los primeros y 5 a 9 días después de siembra (dds). Sin embargo, se han reportados pocos trabajos sobre el efecto de esta enfermedad en etapas tempranas. El objetivo del trabajo consistió en determinar la reacción temprana de variedades de frijol a la pudrición de la raíz en diferentes suelos bajo condiciones de laboratorio. Se tomaron 26 muestras compuestas de suelo en parcelas comerciales de frijol en el estado de Aguascalientes. Las semillas de frijol de las variedades pinto Bravo, Centenario, Coloso, Raramuri, San Rafael y Negro Zacatecas, fueron sembradas en contadores de plástico por duplicado de cada una de las muestras de suelo. En promedio a los 7 días después de siembra se recolectaron las raíces de cada plántula en todos los contenedores para identificar y clasificar la incidencia y severidad de la enfermedad. También, se los patógenos presentes en las plántulas. Los resultados indican que solo en ocho parcelas se registro una incidencia de la enfermedad del 25% y las variedades con mayor porcentaje de valores de incidencia entre 75.1 y 100% fueron Pinto Centenario, Pinto Coloso. También, se observó una incidencia superior en las variedades de frijol pinto con respecto a las variedades de frijol negro. La PR causó lesiones que variaban desde trazas hasta la muerte de raíces en plántulas de las seis variedades de frijol evaluadas desde pre emergencia hasta seis u ocho días después de la emergencia. Se identificó a Rhizoctonia spp., Fusarium spp. y Sclerotium rolfsii en lesiones o sobre la raíz e hipocotilo de las plantas de las seis variedades de frijol.

Patogenos, Indicencia, Salud del suelo

Citation: CID-RÍOS, José Ángel, VELÁSQUEZ-VALLE, Rodolfo, CHEW-MADINAVEITIA, Yasmin Ileana and SERVIN-PALESTINA, Miguel. Early reaction of bean varieties to root rot under laboratory conditions. Journal Simulation and Laboratory. 2023. 10-29:6-12.

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Introduction

During the production process, common bean (*Phaseolus vulgaris* L.) plants are affected by various pathogens that reduce their yield and quality. With some regularity a wide number of pathogens destroy or disable the aerial part of the plants, however, diseases caused by soil-dwelling organisms are a constant yield drain; root rot (RP) has been reported as a severe threat in some American countries such as Brazil, Mexico, Peru, Nicaragua and the United States (Naseri, 2014). Yield losses of up to 100% have been reported in Uganda and up to 70% in Rwanda and Kenya; elsewhere bean planting has been halted due to severe outbreaks of the disease (Diaz et al., 2021). Globally, RP is recognised to be caused by several pathogens including Pythium spp., Fusarium spp., Rhizoctonia solani, and Sclerotium rolfsii (Paparu et al., 2017; Mayo-Prieto et al., 2020); in north-central Mexico the pathogens most commonly associated with this disease are Fusarium spp., Rhizoctonia spp, Colletotrichum spp, Thielaviopsis spp, Pythium spp, as well as the nematodes Meloidogyne spp. and Nacobbus aberrans (Groenewold-Labrada et al., 2003; Velásquez-Valle et al., 2022). RP can occur pre- or post-emergence causing lesions in the root or hypocotyl during the first weeks of growth (Araya and Hernández, 2006; Conner et al., 2014). Usually the severity of PR and its impact on plant development are assessed at stages close to flowering or harvest (Naseri 2014; Jacobs et al., 2019), although it is known that some pathogens such as Fusarium spp. can cause temporary symptoms between five and nine days after artificial inoculation of bean plants (Abawi and Pastor, 1990) but, in general, little is known about the reaction of bean plants to the disease in the first days after emergence, consequently, the aim of the work was to determine the early reaction of bean varieties to root rot in different soils under laboratory conditions.

Materials and method

During April 2023, soil was collected from 26 commercial plots in the state of Aguascalientes; in each plot, three subsamples of approximately 500 g each were taken from the first 20 cm of the soil profile. The soil subsamples were homogenised and two samples of approximately 400 g were taken from the resulting mixture and placed in a plastic pot; the soil was moistened to allow bean sowing.

Seed of the pinto bean varieties Bravo, Centenario, Coloso, Raramuri and San Rafael released by INIFAP and Negro Zacatecas (public domain) provided by MC José Ángel Cid Ríos (Campo Experimental Zacatecas, INIFAP) was used. Prior to sowing, the seed was surface disinfested with a commercial chlorine solution (0.2%) allowing it to dry before sowing. The fungal colonies were counted in each soil using the dilution technique where an aliquot of the 10-6 dilution was sown in a box of PDA culture medium; after five days of incubation, the number of fungal colonies was counted.

For each variety, two containers with each soil type were used; 10-12 seeds of each bean variety were placed in each container. After sowing, the containers were kept at room temperature (16 to 26°C) in the laboratory.

At 6 - 8 days after emergence the plants were removed from the soil, excess soil was removed from the root and the incidence (presence of one or more lesions) of disease in the hypocotyl was assessed and classified as low (0 - 25%), medium (25.1 - 50.0%), high (50.1 - 75.0%) and extreme (75.1 - 100.0%). In addition, the severity or degree of PR damage to the hypocotyl was determined according to the following damage categories: 0 (healthy): hypocotyl with no visible external damage; 3 (slight damage): hypocotyl with traces of longitudinal lesions; 5 (moderate damage): hypocotyl with circular or oval lesions, but without necrosis; 7: (severe damage): hypocotyl with necrotic lesions and/or longitudinal or circular lesions advancing into the neighbouring portion of the stem. The severity of PR for each variety was calculated by multiplying the number of plants with damaged hypocotyl by the value of each category and dividing the result by the number of damage categories present; the result was classified as mild (0 - 25%), medium (25.1 - 50.0%), severe (50.1 - 75.0%) and extreme (≥ 75.1%). At the time of assessment, the foliar symptoms present on each plant were recorded. Pathogens present in randomly selected seedling lesions were identified morphologically to genus level using the taxonomic keys provided by Barnett and Hunter (1972) and Watanabe (1994).

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Results and discussion

In only three of the bean varieties (Pinto Bravo, Pinto Raramuri and Negro Zacatecas) planted in soil from eight plots (1, 7, 14, 15, 18, 20, 23 and 25) was disease incidence less than 25%. In 71.1% of the soils, PR incidence ranged from 25.1 to 70%, regardless of bean variety or type. The highest disease incidences (75.1 - 100%) were reached in 21.8% of the soils irrespective of bean variety or type (Figure 1).

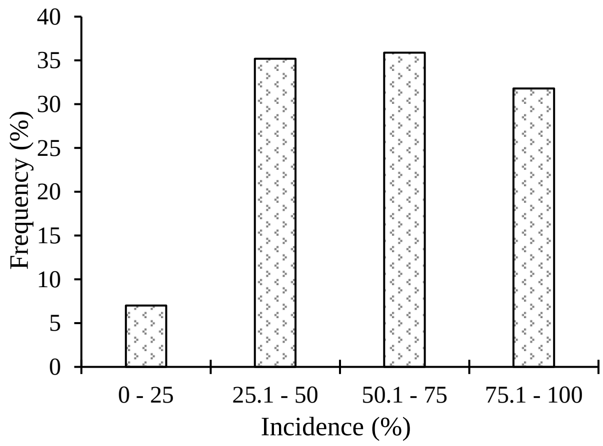

Figure 1. Distribution of bean root rot incidence (%) in soil from 26 plots.

The distribution of RP incidence in four categories (0-25, 25.1-50, 50.1-75 and 75.1-100%) revealed that in the first category (0-25%) only three varieties (Pinto Bravo, Pinto Raramuri and Negro Zacatecas) recorded disease incidence in that range and that the percentage of soils where those values were obtained was not higher than 20%. On the contrary, the varieties Pinto Centenario, Pinto Coloso and Pinto San Rafael, did not obtain RP incidence values in this category (Table 1).

Variety	Advocacy (%)			
	0 - 25	25.1 - 50	50.1 – 75	75.1 – 100
Pinto Bravo	20.0	40.0	20.0	20.0
Pinto Centenario	0.0	30.7	42.3	28.9
Pinto Coloso	0.0	44.0	32.0	24.0
Pinto San Rafael	0.0	20.8	50.0	29.1
Pinto Rarámuri	9.1	31.8	40.9	18.1
Negro Zacatecas	17.4	52.2	17.4	13.0

Table 1 Distribution of root rot incidence of six bean varieties in soil from 26 plots

Most of the disease incidence values were recorded in the intermediate categories (25.1-50 and 50.1-75%) in all varieties; the combined values of both categories ranged between 60 (Pinto Bravo) and 73% (Pinto Centenario). At the other extreme, the varieties with the highest percentage of incidence values between 75.1 and 100% were Pinto Centenario, Pinto Coloso and Pinto San Rafael which, coincidentally, did not obtain incidence values between 0 and 25%.

The number of soils where the incidence was extreme (75.1 - 100%) varied between five and seven for the pinto varieties while in the black bean variety it was three. The Pinto Centenario and San Rafael varieties stand out for the high incidence in seven soils (Table 2). It should be noted that the soil of some plots, such as plot 3, was consistently associated with extreme incidence of RP in four of the five pinto bean varieties and in the black bean variety.

Variety	Soil/Incidence (%)						
P. Bravo	3 (76.9)	5 (100)	16 (90)	19 (90)	26 (85.7)	-	-
P. Centenario	1 (80)	3 (100)	5 (100)	11 (83.3)	12 (92.3)	19 (90.5)	23 (86.7)
P. Coloso	1 (78.6)	3 (86.7)	17 (90)	18 (81.8)	20 (78.6)	25 (100)	-
P. San Rafael	6 (93.7)	8 (88)	12 (100)	20 (100)	22 (83.3)	23 (100)	24 (94.1)
Pinto Rarámuri	3 (77.8)	5 (76.9)	8 (88)	23 (93.9)	26 (80)	-	-
Negro Zacateas	3 (92.3)	9 (92.3)	23 (100)	-	-	-	-

Table 2 Soils with higher incidence of RP in six bean varieties under laboratory conditions

The average extreme incidence values of PR ranged between 83.3 and 94.9% in Pinto Raramuri and Negro Zacatecas, respectively; Pinto Raramuri and Pinto Coloso stood out with mean extreme incidence values of 83.3 and 85.9% in five and six soils, respectively (Figure 2). It is interesting to note that Negro Zacatecas and Pinto San Rafael with similar mean extreme incidence values (94.9 and 94.1%, respectively) had extreme incidence values in three and seven soils, respectively, but the values obtained in these soils exceeded 90% in most cases (Table 2).

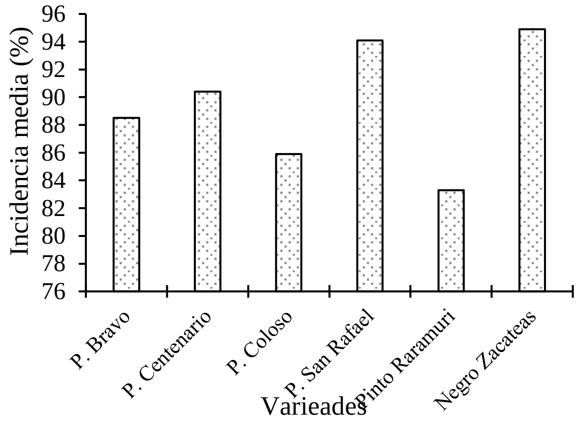

Figure 2 Average incidence of RP in soils with extreme incidence in six bean varieties under laboratory conditions

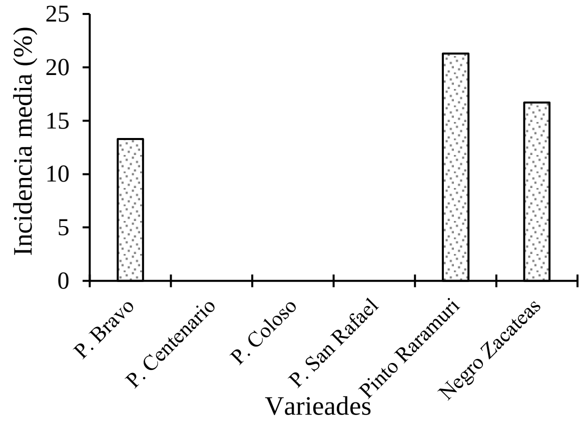

Figure 3 Average incidence of RP in soils with mild incidence in six bean varieties under laboratory conditions

In only three of the six bean varieties were recorded PR incidences lower than 25%; such incidence was recorded in five soils planted with the Pinto Bravo variety with values ranging between 0.0 and 21.4%; in the Negro Zacatecas variety the minimum incidence values were obtained in four soils where the incidence values were between 0.0 and 21.7%. The Pinto Rarámuri variety obtained minimum incidence values of the disease in two soils with values of 17.6 and 25%. It is important to note that no incidence values less than or equal to 25% were recorded in any of the soils planted with the varieties Pinto Centenario, Pinto Coloso and Pinto San Rafael (Table 3).

Variety	Soil/Incidence (%)						
P. Bravo	14 (7.6)	18 (11.7)	20 (12.5)	23 (21.4)	25 (0.0)	14 (7.6)	18 (11.7)
P. Centenario	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0
P. Coloso	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0
P. San Rafael	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0
Pinto Rarámuri	15 (25)	18 (17.6)	0/0.0	0/0.0	0/0.0	15 (25)	18 (17.6)
Negro Zacateas	1 (11.7)	7 (0.0)	10 (16.7)	14 (21.7)	0/0.0	1 (11.7)	7 (0.0)

Table 3 Soils with RP incidence less than 25% in six bean varieties under laboratory conditions

The average of mild PR incidence values ranged between 0.0 in the soil from plots 25 and 7 for Pinto Bravo and Negro Zacatecas, respectively, and 25% in the soil from plot 15 planted with Pinto Raramuri. The Pinto Bravo variety obtained the lowest average of slight incidence of the disease, 13.3%, followed by the varieties Negro Zacatecas, 16.7% and Pinto Raramuri 21.3%; it is opportune to remember that in the varieties Pinto Centenario, Pinto Coloso and Pinto San Rafael no incidences of RP lower than 25% were registered (Figure 3).

When considering separately the average incidence of RP in pinto and black bean varieties, it was observed that in 16.7% of the soils the average incidence of the disease was in the range of 0 to 25.0%, in contrast to the pinto varieties, whose average incidence was higher than 25.0%. Furthermore, in 66.7% of the soils, the average incidence of PR in the black variety reached values between 0 and 50.0%, while in the pinto varieties this incidence was obtained in only 26.9% of the soils.

When combining the values of PR incidence in both bean types, it was observed that the higher incidence of the disease in pinto bean varieties in soils where the black bean variety obtained values lower than 25.0% eliminates the influence of the latter, so that no incidence values are reported for that range of incidence when the combined values of pinto and black bean varieties are used (Table 4).

Varieties	Incidence (%) 0 – 25.0	25.1 - 50	50.1 – 75.0	75.1 – 100.0
Black Type	16.7	50	20.8	12.5
Pinto Type	0.0	26.9	57.7	15.4
Black + Pinto	0.0	34.6	50	15.4

Table 4 Distribution of the average incidence (%) of RP in six varieties of pinto and black bean in 26 soils under laboratory conditions

In general, the average incidence of PR exceeded 40%, regardless of variety and soil origin, however, in Pinto Bravo and Negro Zacatecas plants the incidence of the disease was 44 and 49%, respectively, while in the rest of the varieties it exceeded 50%, highlighting the high incidence of PR in Pinto San Rafael with 69% (Figure 4).

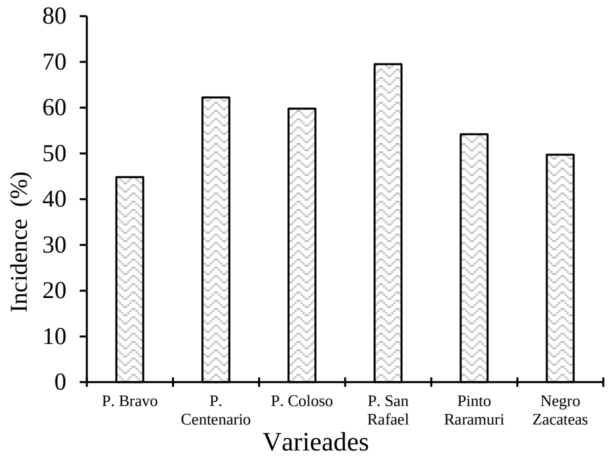

Figure 6 Average incidence of RP under laboratory conditions on six bean varieties in 26 soils collected in Aguascalientes

One of the main factors by which the incidence and severity of RP is variable is the soil; the specific physicochemical and biological conditions of each soil will determine, at least partially, the phytopathological behaviour of the host, common bean in this case. In the soil collected in 16 plots, the highest incidence values were recorded, that is, without considering the bean variety; however, the soils from plots 3, 5 and 23 stand out as having high incidence values for the disease in the six varieties evaluated. These three soils represent 30% of the cases where there were high incidences of RP. In 90% of the soils with high disease incidence, the previous crop was maize (Table 5).

Variety					
Pinto Bravo	Pinto Centenario	Pinto Coloso	Pinto San Rafael	Pinto Raramuri	Negro Zacatecas
5[x] (100.0)[y]	3 (100.0)	5 (100.0)	12 (100.0)	25 (93.9)	23 (100.0)
16 (90.0)	5 (100.0)	17 (90.0)	20 (100.0)	8 (88.0)	3 (92.3)
19 (90.0)	12 (92.3)	3 (86.7)	23 (100.0)	26 (80.0)	9 (92.3)
26 (85.7)	19 (90.5)	18 (81.8)	24 (94.1)	4 (77.8)	6 (73.7)
3 (76.9)	23 (86.7)	20 (78.6)	6 (93.7)	5 (76.9)	25 (58.8)
x Plot number; and Incidence (%) of RP.					

Table 5 Soils with maximum incidence of PR with six bean varieties under laboratory conditions

Among the soils with lower incidence of RP, those collected in plots 7, 9, 10, 14, 18 and 20 stand out, which together represent 63.3% of the 30 soils with lower incidence of the disease, however, the range of minimum incidence separates the varieties in two groups; in the first one, Pinto Bravo and Negro Zacatecas could be located, which presented similar ranges of minimum incidence; 0 - 21. 4 and 0 - 28%, respectively, while in the second group would be Pinto Raramuri (17.6 - 36.7%), Pinto Coloso (30 - 42.8%), Pinto Centenario (33.3 - 41.2%) and Pinto San Rafael (40 - 51.7%) (Table 6).

Variety					
Pinto Bravo	Pinto Centenario	Pinto Coloso	Pinto San Rafael	Pinto Raramuri	Negro Zacatecas
5x (0.0)y	14 (33.3)	7 (30.0)	13 (40.0)	18 (17.6)	7 (0.0)
14 (7.6)	20 (41.2)	4 (30.7)	2 (43.7)	15 (25.0)	1 (11.7)
18 (11.7)	22 (41.2)	9 (33.3)	18 (43.7)	20 (27.3)	10 (16.7)
20 (12.5)	7 (41.7)	10 (42.8)	7 (47.6)	9 (31.8)	14 (21.7)
23 (21.4)	10 (42.1)	11 (42.8)	9 (51.7)	19 (36.7)	2 (28.0)
x Plot number; and Incidence (%) of RP.					

Table 6 Soils with minimum incidence of RP with six bean varieties under laboratory conditions

Symptoms and associated pathogens

No foliar symptoms were observed on most of the plants assessed, irrespective of variety; wilting or yellowing was occasionally observed. In contrast, longitudinal or circular reddish-brown lesions on the hypocotyl or a dry rot of the main root, often associated with *S. rolfsii* infection, were observed on most of the damaged roots (Figures 7 and 8).

Figure 7 Oval, reddish-brown lesions on the hypocotyl of bean seedlings

Figure 8 Dry rot of the main root of bean seedlings associated with *Sclerotium rolfsii* infection

Fusarium spp. and *Rhizoctonia* spp. were identified in most of the oval to circular reddish-brown lesions on the hypocotyl of asymptomatic seedlings; *Sclerotium rolfsii* was also identified forming a thick, white to greyish mycelium on the root and hypocotyl between which sclerotia formed initially white and eventually turned brown.

Most of the seedlings infected with this fungus germinated but did not emerge; when the attack occurred after emergence, the affected seedlings wilted and died. Occasionally the fungus continued its mycelial development on the soil surface where it also formed sclerotia (Figure 9).

Figure 9 Sclerotia and mycelium of *S. rolfsii* developing on the soil surface.

These fungi (*Fusarium* spp., *Rhizoctoni*a spp. and *Sclerotium rolfsii*) have been globally mentioned (Abawi, 1989) as a cause of bean root rot. It has been mentioned (Saremi et al., 2011) that severe infections of pathogens such as *Fusarium* can lead to plant death because damage to the root tip causes numerous rootlets to be emitted providing inadequate water supply; however, in the current study, the greatest amount of damage was observed in the hypocotyl and was associated with Rhizoctonia spp. lesions mainly, with most of the roots being healthy. When S. rolfsii occurred, destruction of the entire root system, including the hypocotyl, was present.

Conclusions

Root rot caused lesions ranging from trace to dead roots on seedlings of the six bean varieties evaluated from pre-emergence to six to eight days after emergence. The average natural incidence of the disease ranged from 44.8 (Pinto Bravo) to 69.5% (Pinto San Rafael).

Rhizoctonia spp., *Fusarium* spp. and *Sclerotium rolfsii* were identified in lesions or on the root and hypocotyl of the plants of the six bean varieties.

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Physicochemical and biological tests to determine water quality in the San Luis Ayucan River, Municipality of Jilotzingo, Estado de Mexico State

Pruebas fisicoquímicas y biológicas para determinar la calidad del agua en el Rio San Luis Ayucan, Municipio de Jilotzingo, Estado de México

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Abstract

Jilotzingo is one of the 125 municipalities that make up the Estado de Mexico State, which has a wealth of flora and fauna thanks to its rivers and springs. Unfortunately, the bad practices of society damage the hydrography of the area, as part of the 2030 agenda, the priorities of Today's Society are established on various current issues such as Sustainable Development, within this agenda, Goal 6 talks about the importance of clean water and its sanitation, this work focuses on the analysis of water quality as it is essential for public health and the sustainability of aquatic ecosystems. Physicochemical and biological tests were carried out to determine critical parameters such as hardness, acidity, alkalinity, flocculation, total chlorides and microorganisms, all tests are based on Mexican Standards such as NMX-AA-072-SCFI-2001, NMX-AA - 036-SCFI-2001, NMX-AA-073-SCFI-2001 and the obtained results are compared with NOM-127-SSA1-2021 to verify the permissible limits of water quality for human use and consumption since the inhabitants they use for their daily activities.

Water quality, Pollution, Mexican standards

Resumen

Jilotzingo es uno de los 125 municipios que conforman el Estado de México, el cual cuenta con una riqueza en flora y fauna gracias a sus ríos y manantiales, lamentablemente las malas prácticas de la sociedad dañan la hidrografía de la zona, como parte de la agenda 2030 se establecen las prioridades de la Sociedad Actual sobre diversos temas de actualidad como lo es el Desarrollo Sostenible, dentro de dicha agenda el Objetivo 6 habla sobre la importancia del agua limpia y su saneamiento, el presente trabajo se centra en el análisis de la calidad del agua ya que es esencial para la salud pública y la sostenibilidad de los ecosistemas acuáticos. Se realizaron pruebas fisicoquímicas y biológicas para determinar parámetros críticos como dureza, acidez, alcalinidad, floculación, cloruros totales y microorganismos, todas las pruebas estas basadas en las Normas Mexicanas como lo son la NMX-AA-072-SCFI-2001, NMX-AA-036-SCFI-2001, NMX-AA-073-SCFI-2001 y comparando los resultados obtenidos con la NOM-127-SSA1-2021 para verificar los limites permisibles de calidad del agua para su uso y consumo humano ya que los habitantes la utilizan para sus actividades cotidianas.

Calidad del agua, Contaminación, Normas mexicanas

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Introduction

Natural waters obtained from different media such as rain, the sea, rivers, and lakes, even drinking water, contain dissolved chemical compounds from the environment (air and soil). Chemical compounds in natural waters are essential in determining important properties of water. Some of these compounds are vital for aquatic plants and animals. However, several of these chemical compounds can interfere with the intended use of water, and are therefore considered contaminants (Paucar Cruz, J. 2019). A pollutant is defined as any substance or energy that is introduced into the environment and that has unwanted effects or that negatively affects the usefulness of a resource (Prada, D., López, G, 2020). Pollutants can cause long- or short-term harm by changing the growth rate of plant or animal species, or by interfering with human services, comfort, health, or property values (Prada, D., López, G, 2020).

Wastewater, which is liquid bodies of water with a varied composition, coming from municipal, industrial, commercial, agricultural, or other public or private use, can suffer a degradation in its original quality (Akpor, O. B., & Muchie, B., 2011). This wastewater can contain a variety of contaminants that can alter or modify the natural composition of the water and degrade its quality. This can hinder the use of water and prevent it from fulfilling its ecological function (Akpor, O. B., & Muchie, B., 2011).

The hardness of the water, which refers to the concentration of calcium and magnesium ions. Hardness is responsible for the formation of scale in containers and pipes, which can cause failures and losses of efficiency in different industrial processes such as heat transfer units (Guzmán Rivera, H. J. 2020).

Acidity and alkalinity are critical factors that affect the pH balance in water. Acidity refers to the presence of dissociable substances in water that generate the hydronium ion, such as strong acids, weak acids, and medium strength; also, the presence of certain metal cations that contribute to the acidity of the medium.

On the other hand, alkalinity refers to the presence of hydrolysable substances in water that generate the hydroxyl ion, such as strong bases and hydroxides of alkaline earth metals; Carbonates and phosphates also contribute significantly to alkalinity (Rogel Bueno, A. E., & Toala Pin, A. A., 2020).

The presence of total chlorides in water can arise from various sources, including saline pollution and the use of disinfectant chemicals. A high chloride content can damage metal structures and prevent plant growth. High concentrations of chloride in wastewater, when used for irrigation in agricultural fields, significantly deteriorate soil quality.

Microbiological analysis is an essential tool to evaluate the health safety of water and detect the presence of contaminants early. In this case, culture techniques were used in a specific medium (CompactDry EC) for the detection of coliforms and E. coli. The procedure ensured adequate growth of the microorganisms, facilitating their subsequent identification.

Jilotzingo is a municipality belonging to the State of Mexico that is in the central area of the state, it is a forested area that has a temperate subhumid climate, with several hills and multiple rivers and streams which make it a site with abundant flora among which the pines, oaks and firs stand out (Jilotzingo, 2023)

Methodology

To determine the quality of the water in the San Luis Ayucan River, sampling was carried out at strategic points of the tributary, which were, Paraje de La Cuesta, Montaña de San Luis Ayucan and Tributary of the San Luis River and with the help of the students from the Polytechnic University of Cuautitlán Izcalli who are currently studying Biotechnology Engineering, the Physicochemical and Biological tests were carried out.

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Figure 1 Sampling in the San Luis Ayucan River

Materials and methods

Analytical grade chemicals without the need for additional purification and distilled water were used in all tests. For the magnesium and calcium tests, EDTA, NH_3, NH_4Cl and Eriochrome black T were used as shown in the diagram in Figure 2.

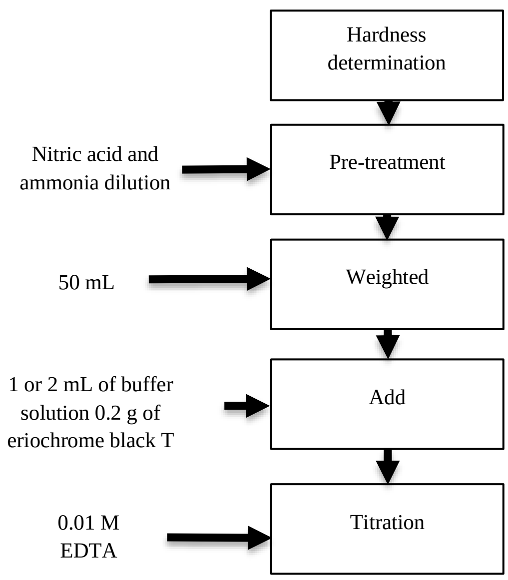

Figure 2 Block diagram for hardness determination

The determination of alkalinity and acidity involved the use of solutions of NaOH, HCl, phenolphthalein and methyl orange as seen in Figure 3.1 and 3.2.

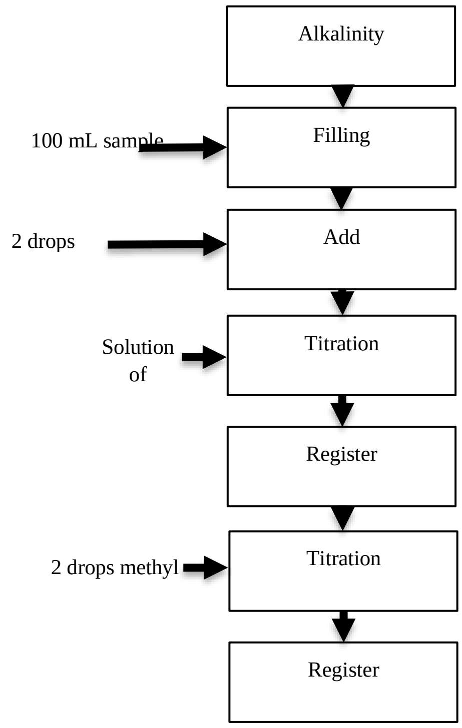

Figure 3.1 Block diagram for alkalinity determination

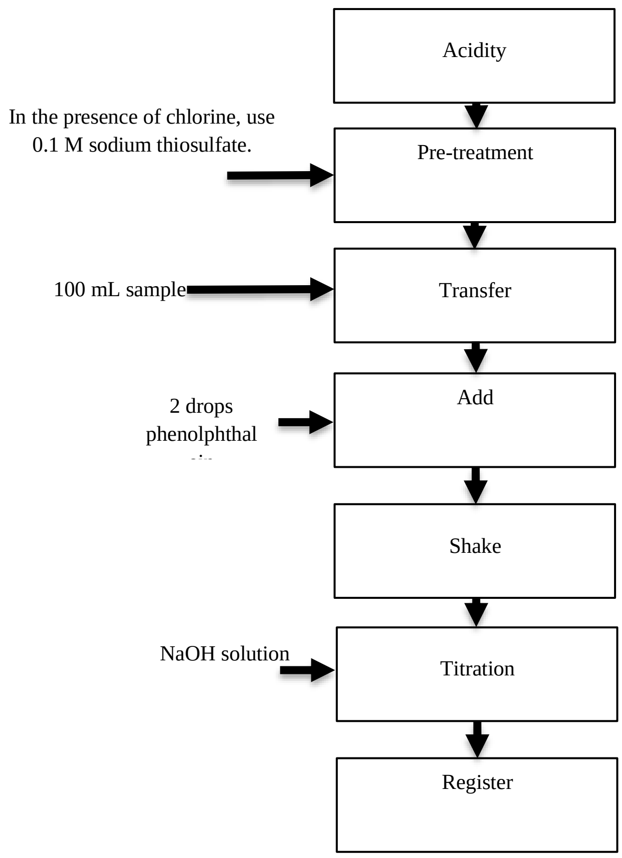

Figure 3.2 Block diagram for acidity determination

For the jar test, a 6-unit PHIPPS AND BIRD shaker was used, and aluminum sulfate was used as a flocculating agent (Figure 4). For the determination of chlorides, K_2CrO_4, $AgNO_3$, $CaCO_3$ and CH_3COOH were used (Figure 5).

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Journal Simulation and Laboratory
December 2023, Vol.10 No.29 13-18

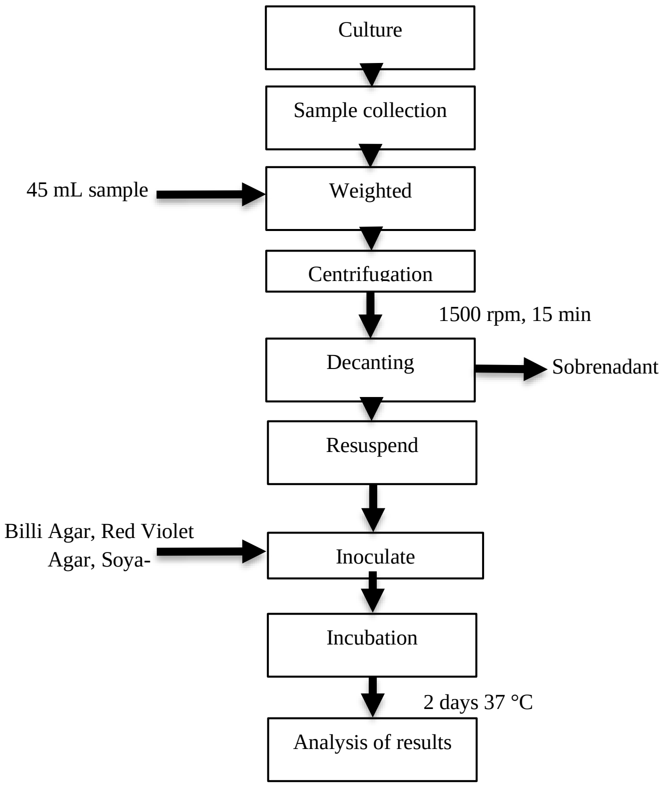


Figure 4 Block diagram for the Jars test

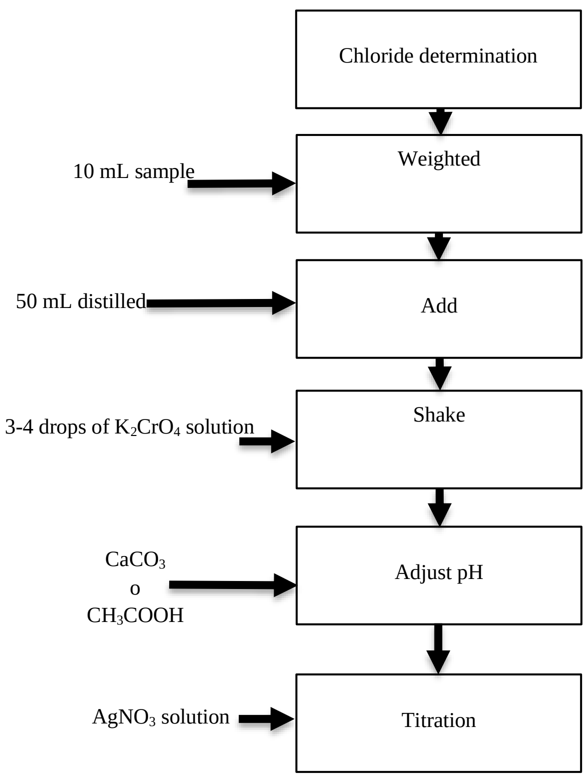


Figure 5 Block diagram for the determination of chlorides

Finally, for the determination of coliforms, the CompactDry EC, lighter and bacteriological loop tests were used (Figure 6).

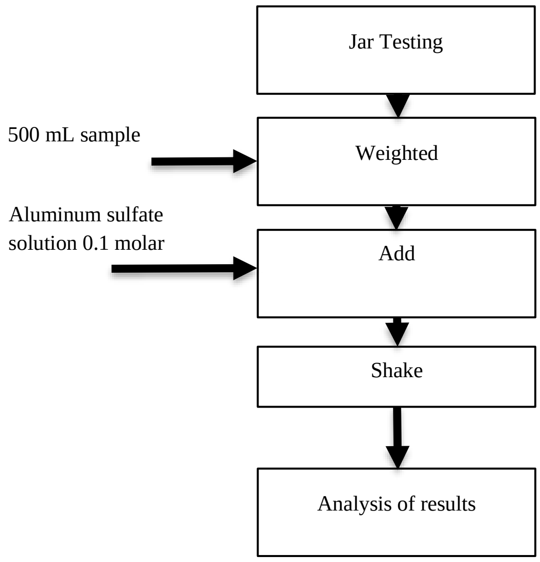


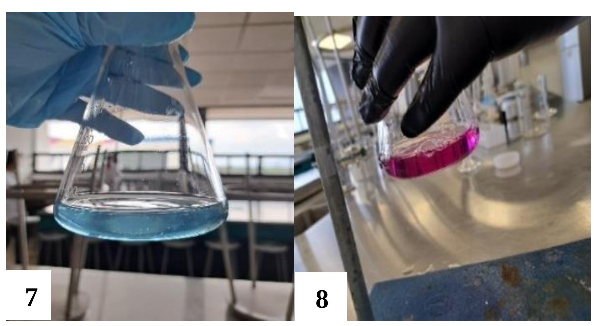
Figure 6 Block diagram for the determination of biological tests

Results

Magnesium and Calcium Tests

The determination of the total hardness in a water sample was carried out, following the analysis method established by the Mexican standard NMX-AA-072-SCFI-2011. This method involves titration with a visual endpoint indicator, using Eriochrome black T.

During the analysis, a color change of the indicator was observed to red in the presence of calcium ions and then blue by magnesium ions. The results obtained were 650.0 mg/L, which are shown in Figure 7 and 8 where the change in the color of the samples can be seen and comparing with NOM-127-SSA1-2021 we can examine that the value obtained exceeds the limits. permissible maximums by 30%.

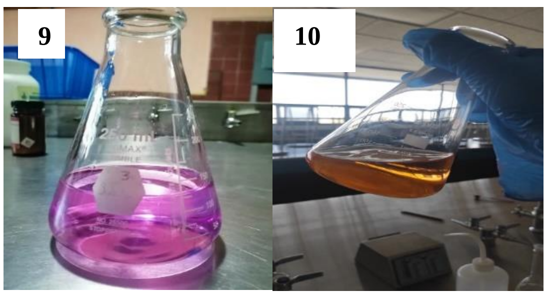


Figures 7, 8 Magnesium and Calcium Tests

Determination of Acidity and Alkalinity

Tests were carried out to determine the acidity and alkalinity in the water samples, following the analysis method established by the Mexican standard NMX-AA-036-SCFI-20011. This method involves titration with a visual endpoint indicator, using phenolphthalein and methyl orange as indicators.

During the analysis, a color change of the indicator was observed from colorless to pink in the acidity titration with sodium hydroxide with a pH of 6.5, and from tan to orange or yellow in the alkalinity titration with hydrochloric acid with a value of 8.5 pH, as seen in Figure 9 and 10.



Figures 9, 10 Alkalinity and acidity tests

Flocculation Test

In the laboratory, the Flocculation Test, also known as the Jar Test, was carried out with the purpose of determining the Total Dissolved Solids (TDS) in a water sample, using the reagent Aluminum Sulfate as a flocculating agent, in accordance with the standard. Mexican NMX-AA-051-SCFI-2001.

However, when analyzing the results obtained, a behavior according to its pH was observed (Figure 11).

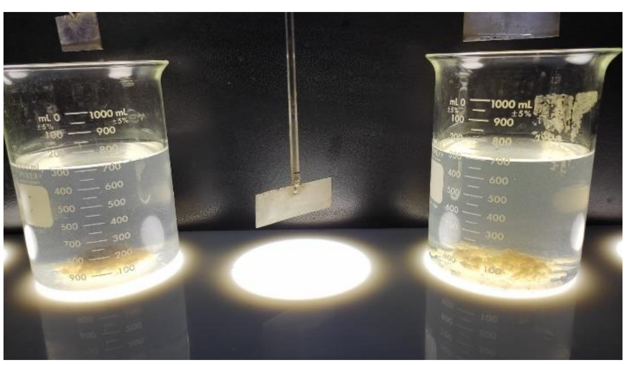


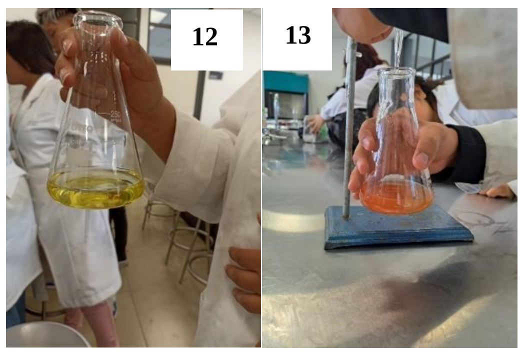
Figure 11 Jar Test

Determination of Total Chlorides (Mohr Method)

Within the framework of the research on water quality, the quantification of Total Chlorides was carried out using the Mohr Method.

To carry out this measurement, the following reagents and materials were used: K2CrO4 (Indicator), AgNO3 (Titration solution), CaCO3 and CH_3COOH (Buffer Solution Components). During the titration process, a color change was observed in the solution, going from a yellow tone to a red/orange color, which indicated the formation of silver chromate.

The results obtained were in accordance with expectations and adjusted to the values in accordance with the NOM-127-SSA1-2021 standard. Images 12 and 13 clearly show the color change in the solution, which validates the reliability of the data obtained.



Figures 12, 13 Determination of total chlorides

Biological Determination

Microbiological analysis is an essential tool to evaluate the health safety of water and detect the presence of contaminants early. In this case, a specific test that identifies the presence of coliform bacteria and *E. coli* was used (CompactDry EC). The procedure ensured adequate growth of the microorganisms, facilitating their subsequent identification.

The results showed the growth of *E. coli* colonies in the corresponding test. In addition, other colonies of coliform, pink-stained bacteria were observed. Among the bacteria that we can find in this group of coliforms we can mention: *Klebsiella pneumonia, Citrobacter spp, Enterobacter spp.*, all of them causing various infections in humans.

Therefore, the detection of its presence is an important indicator of water quality, especially if this water is used for human consumption.

In figure 14 you can see the tests applied to the water samples, the points in pink-red tones represent colonies of coliform bacteria and the points in blue represent the presence of *E. coli* colonies.

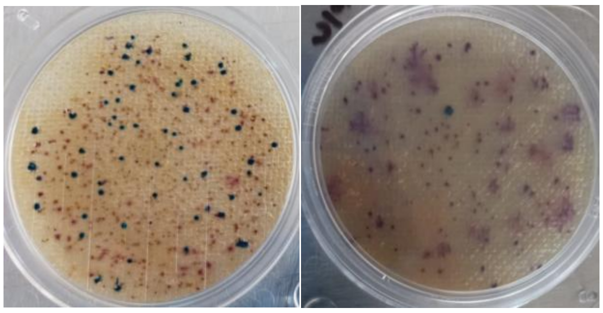


Figure 14 Biological Determination

Acknowledgment

Sincere thanks are offered to the municipality of Jilotzingo in the Estado de Mexico State for their support in carrying out sampling in their water bodies, as well as to the municipal president Ms. Ana Teresa Casas González and the director of ecology, Dr. Rubén Mayen González, for their interest and support in carrying out these studies to promote the care of the municipality's natural resources.

Conclusions

For the correct interpretation of the information obtained, repetition of tests and increasing the number of sampled areas is required to obtain a more definitive conclusion given that the current results show an irregularity between the pH values, dissolved organic matter and chlorides with the hardness values. and microbial growth.
According to the above, it can be complemented with tests to determine metals, oils and greases, and determination of emerging contaminants using analytical and physicochemical methods.
The studies and analyzes of this type of tests are essential to understand and ensure water quality, which contributes to the protection of public health and the environment.

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Article

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Dehydration of strawberry (*Fragaria vesca*) using a direct solar dryer

Deshidratación solar de fresa (*Fragaria vesca*) usando un secador solar directo

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Abstract

Strawberries are a highly perishable fruit and their availability is limited to no more than a week under ambient conditions, so solar dehydration increases their shelf life. The experimentation was carried out at the Solarimetric Station installed in building 6 of the Chemical Engineering Program of the UAZ. Strawberries of similar appearance and size were chosen, washed, disinfected and cut into slices (thickness 0.2 cm). The initial moisture content was determined using an OHAUS thermobalance, the samples were placed in polymer mesh trays (34.2 cm long and 24 cm wide) in two transparent acrylic cabinet dryers (74 x 80 cm base, front height 13 cm and at the bottom 40 cm). Both dryers were instrumented and operated by natural and forced convection. The samples were weighed at 30-minute intervals during the process and their initial and final color was measured. The experimentation was carried out at the Solarimetric Station installed in building 6 of the Chemical Engineering Program of the UAZ. It was possible to reduce the water content in the strawberries to increase their shelf life and be able to preserve them for longer.

Strawberry, Food dehydration, Solar energy

Resumen

Las fresas son una fruta altamente perecedera y su disponibilidad se limita a no más de una semana en condiciones ambientales, por lo que la deshidratación solar aumenta su vida útil. La experimentación se realizó en la Estación Solarimétrica instalada en el edificio 6 del Programa de Ingeniería Química de la UAZ. Se eligieron fresas de apariencia y tamaño similar, se lavaron, desinfectaron y se cortaron en rodajas (espesor 0,2 cm). El contenido de humedad inicial se determinó mediante una termobalanza OHAUS, las muestras se colocaron en bandejas de malla polimérica (34,2 cm de largo y 24 cm de ancho) en dos gabinetes secadores de acrílico transparente (74 x 80 cm de base, altura frontal 13 cm y en el fondo 40 cm). Ambos secadores fueron instrumentados y operados por convección natural y forzada. Las muestras se pesaron a intervalos de 30 minutos durante el proceso y se midió su color inicial y final. La experimentación se realizó en la Estación Solarimétrica instalada en el edificio 6 del Programa de Ingeniería Química de la UAZ. Se logró disminuir el contenido de agua en las fresas para aumentar su vida de anaquel y poder conservarlas durante más tiempo.

Fresa, Deshidratación de alimentos, Energía solar

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Introduction

The dehydration of food for its preservation is an issue that has been growing over the years, the use of environmentally friendly sources to reduce the carbon footprint produced by fossil fuels has led to the use of solar radiation as alternative to carry out food dehydration, significantly reducing production costs.

It is estimated that the energy used during the dehydration process is approximately 12% to 40% of the total energy consumption in drying industries. The use of solar energy can play an important role in the dehydration of food or drying of materials and in such a way that it would be possible to reduce the consumption of conventional energy sources by between 27% to 80%. Therefore, the use of solar energy for dewatering applications should be encouraged to a greater extent, as it is a source of economical clean energy and reduces the carbon footprint produced by conventional energies (fossil fuels) (Lingayat et al., 2021).

The Sun is a source of energy that has existed since the creation of our universe, we have the Sun with us all the time, it has millions of years of life left, so it can be said that its energy is an inexhaustible resource, in addition, the Energy from the sun is considered a primary renewable energy, since energies such as solar, wind, hydraulic, oceanic, geothermal, biomass and other energy sources are derived from it (Agbo et al., 2021).

Depending on the area in which they are located, the amount of solar radiation received varies, with Africa being the part of the world that receives the most radiation, but Mexico is one of the countries on the American continent most favored by solar radiation, specifically the northern area, so solar dehydration is a viable activity to implement and exploit in Mexico. The state of Zacatecas, according to the National Institute of Electricity and Clean Energy, receives an annual average daily solar radiation between the values of 4.7 and 5.8 kWh/m^2 day (Valladares & Figueroa, 2017).

However, there is a wide variety of perishable foods that are not consumed due to lack of availability for long periods of time, their waste contributes to the pollution of the atmosphere and the soil, an example of these foods are strawberries, their durability does not It takes more than a week and the processes for its conservation are highly expensive. Therefore, solar dehydration can be an opportunity to add value to strawberries. If this fruit is dehydrated where it is produced, this can reduce food losses and help small farmers have higher incomes (Arroyo et al., 2018).

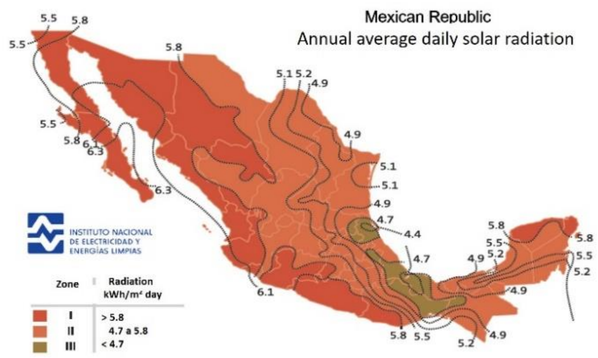

Figure 1 Annual average daily solar radiation in Mexico
Source: (Valladares & Figueroa, 2017)

Due to this problem, solar food dehydration is one of the oldest methods to preserve food, it reduces its moisture content, providing stability to the product, which is why solar dehydrators are an alternative energy source for dehydrating food. foods, but they must be improved to produce large quantities of good quality products in short times (Roratto et al., 2021).

Drying kinetics studies the moisture content removed by evaporation, time or energy consumption. The drying process is a unit operation that involves the transfer of heat from the surrounding hot air to the surface of the product to be dried and the transfer of matter from the water inside the product to its surface, followed by the transport of moisture to the surface of the product. the air found in the surroundings (Pérez-Lozano et al., 2019).

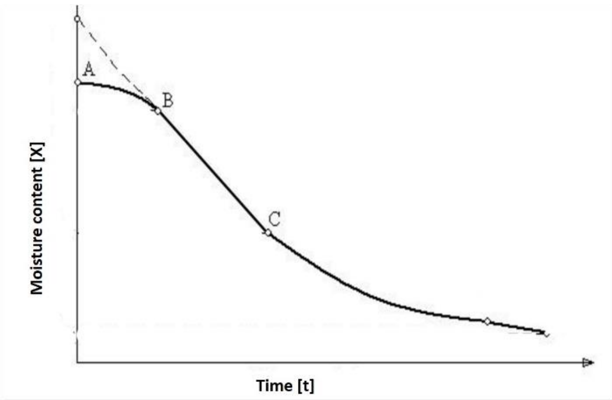

Figure 2 Typical drying curve
Source: (Ortiz, 2018)

Where there is an induction period (A), a period of constant speed (B) and a period of decreasing speed (C) (Ortiz, 2018).

Methodology

The steps followed during the experimentation are generally described:

1. Selection with a similar degree of maturation of the samples for washing and disinfection (cut slices with a thickness of 2 mm).

2. Placement of samples in polymer mesh trays

3. Initial characterization, measurement of weight, humidity and color

4. Drying Operation

5. Final characterization, measurement of weight, humidity and color.

The drying operation is detailed below:

1. The transparent acrylic dryers (Natural and Forced Convection) are placed in operation 30 min before to stabilize the drying chamber facing south.

2. The trays with the samples are introduced into the dryers.

3. Samples are selected to evaluate the change in color, the loss of humidity and are weighed every 30 minutes, until the equilibrium humidity is reached.

4. In each measurement, the temperature and relative humidity of the air are determined

5. Solar radiation, temperature, and wind speed corresponding to the test day are measured.

The conditions under which the drying operation was carried out were recorded using two Checktemp thermometers for measuring the internal temperature of the dryers, determining the global irradiance using a Kipp & Zonen CMP 22 pyranometer and measuring the wind speed. using an RM-Young vane anemometer (Bañuelos Mireles et al., 2019).

Results

The experimentation took place in the summer and winter periods with the different inclinations that the Sun presents throughout the year.

In the summer test, the average initial humidity of the strawberry samples was 85.22%.

The total dehydration time for natural convection was 7 hours with a final humidity percentage of 8.40% and for samples using forced convection it was 5.5 hours with a final humidity of 9.74%.

In Table 1 we can see that the strawberry samples have an initial average mass of 2.367 g and a final average mass of 0.233 g. It can be seen that, after 360 minutes of dehydration time, the masses of the samples remain constant. While in table 2, the masses of samples 1 and 2 began to remain constant after 270 minutes, samples that for sample 3 began to remain constant after 210 minutes.

Natural Convection			
Time (min)	**Sample mass 1 (g)**	**Sample mass 2 (g)**	**Sample mass 3 (g)**
0	2.9	2.1	2.1
30	1.9	1.7	1.9
60	1.5	1.4	1.4
90	1.2	1.0	1.1
120	0.8	0.8	1.0
150	0.6	0.7	0.9
180	0.8	0.7	0.9
300	0.3	0.3	0.5
360	0.2	0.2	0.3
420	0.2	0.2	0.3

Table 1 Sample masses due to natural convection in summer

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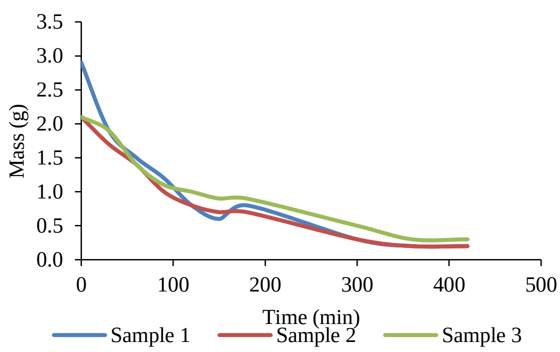
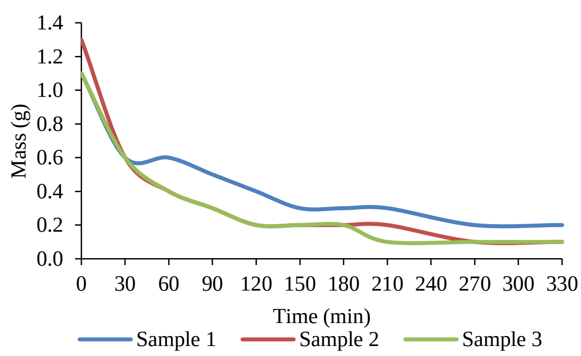
Forced Convectión			
Time (min)	**Sample mass 1 (g)**	**Sample mass 2 (g)**	**Sample mass 3 (g)**
0	1.1	1.3	1.1
30	0.6	0.6	0.6
60	0.6	0.4	0.4
90	0.5	0.3	0.3
120	0.4	0.2	0.2
150	0.3	0.2	0.2
180	0.3	0.2	0.2
210	0.3	0.2	0.1
270	0.2	0.1	0.1
330	0.2	0.1	0.1

Table 2 Sample masses by forced convection in summer

Graph 1 shows the drying curve through natural convection in which we can observe a decrease and subsequently an increase in mass after 150 minutes of the strawberry samples because they were stored to be able to continue the next day with the drying process. dehydrated, during this storage time they continued to lose moisture until reaching equilibrium. For the drying curve of the samples by forced convection that is observed in graph 2, the periods of induction, constant speed and decreasing speed are not as marked as in the operation using natural convection.



Graphic 1 Strawberry drying curve through natural convection in summer



Graphic 2 Strawberry drying curve through natural convection in summer

The winter samples presented an initial average humidity percentage of 95.6%.

Dehydration by natural and forced convection had a total time of 6.5 hours with final humidity percentages of 8.51% and 8.9% respectively.

In table 3, there was an initial average mass of 2.2 g and a final average of 0.19 g through natural convection. For samples 1 and 3, after 300 minutes their mass begins to be constant. However, from Table 4 it can be seen that the masses of the samples due to forced convection remained constant after 300.

Natural Convection			
Time (min)	**Sample mass 1 (g)**	**Sample mass 2 (g)**	**Sample mass 3 (g)**
0	2.1	2.0	2.3
30	1.8	1.7	1.9
60	1.5	1.4	1.6
90	1.2	1.2	1.3
120	1.0	0.9	1.0
150	0.8	0.7	0.8
180	0.5	0.5	0.5
240	0.3	0.3	0.3
300	0.2	0.2	0.2
360	0.2	0.17	0.2
390	0.2	0.17	0.2

Table 3 Sample masses due to natural convection in winter

Forced Convectión			
Time (min)	**Sample mass 1 (g)**	**Sample mass 2 (g)**	**Sample mass 3 (g)**
0	1.7	1.8	1.6
30	1.4	1.4	1.3
60	1.1	1.1	1.0
90	0.9	0.8	0.7
120	0.6	0.6	0.5
150	0.4	0.4	0.3
180	0.3	0.2	0.2
240	0.3	0.2	0.2
300	0.18	0.16	0.16
360	0.18	0.15	0.15
390	0.18	0.15	0.15

Table 4 Masses of the samples by forced convection in winter

In graphic 3 it can be seen that the samples using natural convection presented a similar behavior in the decrease in their mass and the periods of induction, constant speed and decreasing speed are not as noticeable as in the summer samples. However, for samples using forced convection (graph 4), these periods are not more noticeable.

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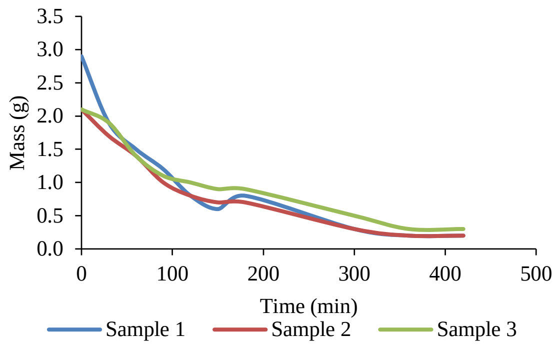
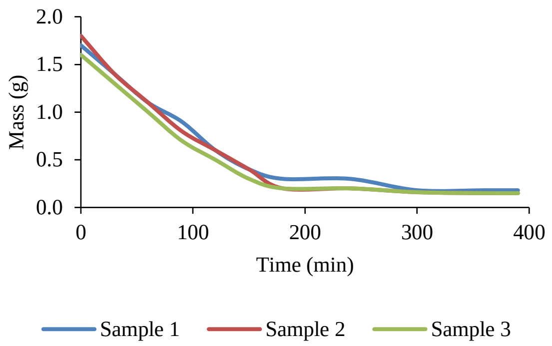


Graphic 3 Strawberry drying curve through natural convection in Winter



Graphic 4 Strawberry drying curve through forced convection in winter

For the annual irradiance and irradiation in the state of Zacatecas, the information was taken from the thesis work carried out by Rodríguez in 2018 as seen in Table 4.

Month	Global Mean Irradiance (W/m²)	Average Sun Hours	Average daily irradiation kWh/m²
January	389.02	10.77	4.19
February	430.33	11.26	4.85
March	573.95	11.86	6.81
April	611.85	12.53	7.67
May	593.06	13.09	7.77
June	484.64	13.37	6.48
July	527.70	13.25	6.99
August	507.10	12.77	6.47
September	401.38	12.12	4.87
October	409.35	11.46	4.69
November	371.73	10.90	4.05
December	352.19	46.96	4.45
Annual	471.02	15.03	5.73

Table 5 Annual information on solar radiation in Zacatecas for the year 2018
Source: (Rodríguez Ramos et al., 2021)

An annual daily irradiation of 5.73 kWh/m^2 was considered, with which a monthly irradiation of 172.8 kWh/m^2 was obtained in the state of Zacatecas.

In Table 6, the irradiances, masses and average times of the dehydration process for natural and forced convection of the summer and winter periods were determined.

	Mass (g)	Time (h)	I (kWh/m²)	Total I (kWh/m²)
Natural Convection	74	6.75	2.94	19.86
Forced Convection	70.6	6	2.55	15.32

Table 6 Average data of the total dehydration process

Considering a minimum installed capacity (1 tray) and maximum (3 trays) in the dryers, the results obtained for the quantity of strawberries that can be dehydrated monthly and annually are summarized in Tables 7 and 8.

Minimum (1 tray)			
Mass	Initial (kg)	Month (kg)	Year (kg)
Natural Convection	0.071	0.614	7.37
Forced Convection	0.0706	0.792	9.51

Table 7 Minimum capacity of the dehydration process

Maximum (3 trays)			
Mass	Initial (kg)	Month (kg)	Year (kg)
Natural Convection	0.213	1.843	22.12
Forced Convection	0.212	2.376	28.52

Table 8 Maximum capacity of the dehydration process

Conclusions

In the summer test, during the dehydration days there were moments of cloudy skies, however, it did not make it difficult to carry out the process. Forced convection showed better results in the quality of the product in terms of color, smell and final flavor, with a final humidity of 9.74%. Natural convection presented a lower final humidity with a value of 8.4%, but the final quality of the product was not as desired, it had a darker color compared to the forced convection samples, and a burnt smell and taste.

For the winter tests, despite having cold air compared to summer, appropriate temperatures were achieved inside the houses, 39.5°C for natural convection and 37.9°C for forced convection. The best color quality of the product was achieved through forced convection, showing a tone a little lighter than natural and with a final humidity of 8.9%. Regarding the smell and flavor, the best results were through natural convection with a final humidity of 8.514%, which was mentioned that the dehydrated strawberries had a sweeter flavor, close to jam.

For both dehydration periods, it is proposed to start as early as possible to avoid having to store the samples and continue the next day, and to be able to obtain better results and drying curve graphs.

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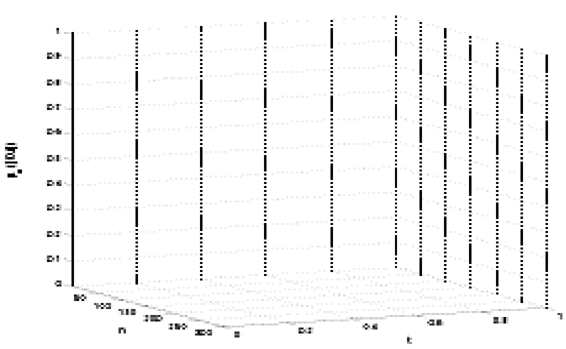

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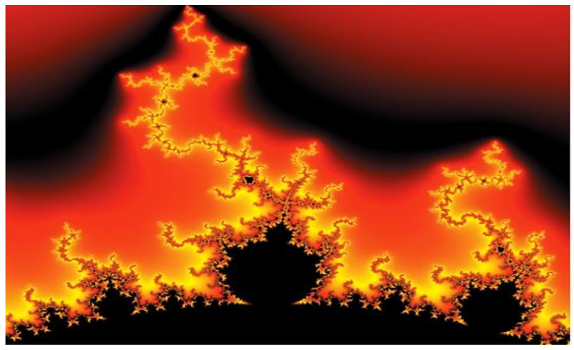

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