Original Research

Sustainability and Economic Feasibility through the Production of Oyster Mushroom (Pleurotus Ostreatus (Jacq.) P. Kumm.) Derived from the Waste of Coffee-Industry: A Case Study in the Western Area of San Salvador, El Salvador

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Abstract

This research aims to assess the sustainability and feasibility of the production of *Pleurotus ostreatus* using ground coffee seed and pulp waste as substrate, and then demonstrating its economic profitability. Different raw materials were characterized as substratum and technical aspect production in the greenhouse for *P. ostreatus* were analyzed with the economic analysis for financing the project. With this technique, we found an option of sustainable model production, which concedes added value to the agricultural wastes from coffee processing once is used as a source of substrates for the production of *Pleurotus ostreatus*. The results obtained from the production of mushrooms through the waste from ground coffee and pulp are feasible and profitable in San Salvador. The use of coffee waste in the production of mushrooms will reduce the waste or biomass resulting from the coffee industry, therefore, it is a sustainable alternative in environmental terms. Moreover, economic analyses from PI's were 3.047052287, given that it was >1, consequently, the project was accepted, while the IRR was 51.47% per year, that is $ 0.52 which is recovered for every dollar invested. Hence, in terms of financial

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analyses, it is believed that mushroom production is economically profitable and environmentally sustainable.

Keywords: economic viability, coffee grounds waste, coffee pulp, pollution reduction, sustainable agriculture

Introduction

The agriculture technology of edible mushroom production has been increasing in El Salvador due to the feasibility of planting in recent years, in different types of substrates, mainly those are obtained from agricultural waste such as the use of "corncob" for being a great source of cellulose, which helps to improve the growth and development of mushroom. This type of substrate is obtained from the cultivation of corn. In addition, sustainable agriculture proposes long-term alternatives in viable economic aspects that improve the quality of life of the producer and society in general, without altering the environmental quality. Funding and inversion of the project are determined through the techno-economic analysis. Furthermore, El Salvador since the last decades has promoted programs aimed at genetic, planting, and sustainable improvement in coffee production, this includes associated crops production of mushrooms [1]. By using this technique, the production of *Pleurotus Ostreatus* benefits the environment because it encourages the implementation of mitigation and compensation strategies [2]. Moreover, in this research, the use of waste from pulp and ground coffee from the coffee industry is proposed. El Salvador has been characterized as a country that produces high quality coffee. According to B. Kilian, the sustainable certification processes on coffee have brought several benefits to the Latin America producers, as well as Central America, where Costa Rica and El Salvador are recognized for their high/strict altitude coffee plantation and cup of excellence. It can be assumed that a big part of the higher price premiums, achieved in these countries are due to their well-known high-quality coffee [3]. Furthermore, taking into consideration that the consumption of mushrooms improves health and quality of life due to its nutritional contributions [4, 5].

Furthermore, coffee products are exported, including other sub-products thereof, with added value for subsequent sale abroad at a much higher price. One of these sub-products is the waste that is obtained through the agro-industry process of the coffee plantation. The reuse of these wastes is allowed to be valued, therefore, the coffee farms can take advantage of these resources [6]. The solid waste from the coffee agro-industry can be used for other purposes, for instance source of compost, substrate, biodiesel products and its by-products [7-10]. All these wastes obtained during the agro-industry process activity cause an adverse environmental impact if they are thrown into natural sources of water. Therefore, the cultivation of edible mushrooms as *Pleurotus ostreatus*, could be an alternative to mitigate and compensate the pollutants from the agro-industry of coffee and it can help to increase economic profitability. There are different environmental impacts arising at different stages of the life cycle of the coffee agroindustry. It was found that coffee cultivation is a significant contributor for ecosystem damage in all brewing scenarios, particularly on land-use related midpoint indicators [11, 12]. The technology applied to the cultivation of edible mushrooms allows earning large productions in relatively little space. Moreover, the production of *P. ostreatus* is presented as an alternative from an economic, social and environmental point of view for the management and use of agroindustry waste, environmental protection and employment generation, which fits well in the sustainable model contexts. In addition, giving added value to solid waste, which is obtained from the coffee agro-industry, can generate extra income for producers. Further to this, international markets are interested in by-products from Oyster mushroom because it possesses excellent nutritional and medicinal qualities. Sustainable mushroom farming does not have to be complicated or expensive. Oyster mushrooms can be grown indoors on pasteurized corn stalks, wheat and a wide range of other materials including paper and pulp by-products, can also be grown on hardwood stumps and logs. The waste substrate from Oyster production is useful as fodder for cows, chickens, and pigs. Therefore, this is a sustainable production alternative which increases the economy and protects the environment impact especially from the coffee waste industry [13-15]. The fruiting bodies of the *Pleurotus ostreatus*, which are the edible parts, are an excellent source of good quality protein, this is because, in their content, all essential amino acids are presented where the predominant are alanine, glutamic acid, and glutamine [16].

In addition to this, the National Center for Agricultural and Forestry Technology, (CENTA), and Tottori University, Japan conducted an investigation in 2009 to 2013 where they mapped the production of mushrooms in El Salvador highlighting 12 places primarily in mountain range, volcano area, and mountains of El Salvador, where 1240 specimens were collected and 101 species were identified, however, the investigation confirmed that the agricultural production of *P. Ostreatus* has not intensified [17]. The production and market of mushrooms is still growing and there is a niche market segment. Also, The Regional Network Program for the support of associations of small coffee

producers in Central America and the Caribbean involves six countries: Guatemala, Dominican Republic, El Salvador, Honduras, Costa Rica, and Nicaragua. Therefore, this case study aims to improve the quality of life of small coffee producers in rural areas, as well as, communities in mountainous regions, in order to produce quality coffee in terms of sustainability and implement the diversification of crops or polycultures in association with the coffee.

Methodology

Study Area

A reconnaissance of the mountainous regions was carried out, it was taken into consideration the mapping carried through by the University of Tottori, Japan, and The National Center for Agricultural and Forestry Technology [18] where they describe that the altitudes range from 800 to 2418 meters above sea level is basically favorable for the reproduction of mushroom in El Salvador, as well as other important climatic factors which affect the natural growth, below we present the mushroom biodiversity map in El Salvador (Fig. 1).

Evidently, there is a great diversity of mushroom. Moreover, is clear is that fungi kingdom play a really important role in the functioning of ecosystems. [19, 20] In addition to recycling nutrients and helping plants and crops grow efficiently, fungi provide us with compounds that produce antibiotics, statins to treat cholesterol, and immunosuppressant. [21] Moreover, some fungi (endophytes and mycorrhizae) can help plants respond to stresses such as increased temperatures and drought. Advances in its agricultural applications could translate into improved food security, environmental sustainability and increased production income, as is the case in this case study. [22, 23]

Further, in accordance with the mapping by the University of Tottori, Japan, and CENTA the biodiversity found through actualization and identification of varieties such as: *Auricularia auricula-judea, Cookeina speciosa, Amanita jacksonii, Pseudohydnum gelatinosum, Cookeina tricholoma, Geastrum* sp. *Pleurotus Ostreatus, Ganoderma* sp*., and Agaricus* sp*.,* which are growing naturally in salvadoran flora (Fig. 2).

Therefore, the municipality of San Martin was chosen as a case of study, which is situated in the department of San Salvador approximately 800 meters above sea level and it is located in the western area of San Salvador and bordered on the north by San José Guayabal. As anteriorly reported, this research examined two main components of the project, i.e., its sustainability and its financial-economic feasibility. The production of oyster mushroom *(pleurotus ostreatus (jacq.) p. kumm.)* from the organic waste derived from the coffee processing, involved the construction of two greenhouses. The project size was established on the construction of two greenhouse galleries with the specific requirements and cost, furthermore, for the first phase, it is designated to produce an arroba per

Altitude (m)

0 - 200
200 - 600
600 - 1100
1100 - 1600
1600 - 2700

① National Park Montecristo, ② National Park El imposible, ③ National Park Cerro Verde
④ A.A. La Magdalena ⑤ Green Lagoon ⑥ P.R. La Cecebadilla ⑦ R.F. Cinquera ⑧ Island Los Cedros
⑨ M.A. Conchagua ⑩ Valley Zapotitán ⑪ P.A. Santa Rita ⑫ San Salvador

Abbreviation:
(A.A.) Agricultural Area
(P.R.) Peak Range
(R.F.) Rain-Forest
(M.A.) Mountain Area
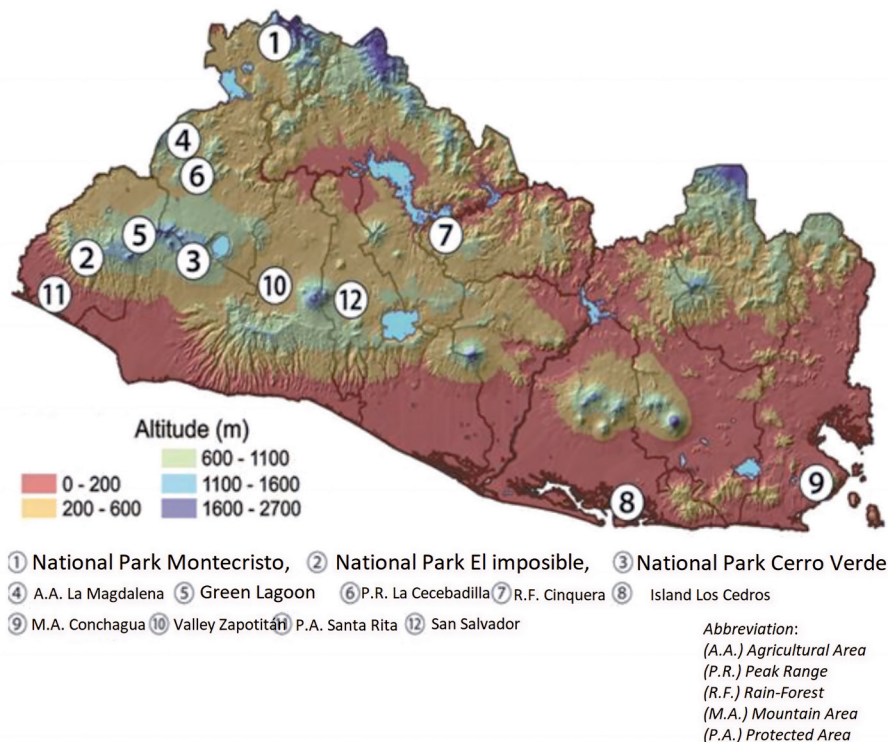*(P.A.) Protected Area*

Fig. 1. The Mushroom biodiversity map in El Salvador. This map describes the production of Mushrooms depending on the favorable altitude and area of El Salvador.
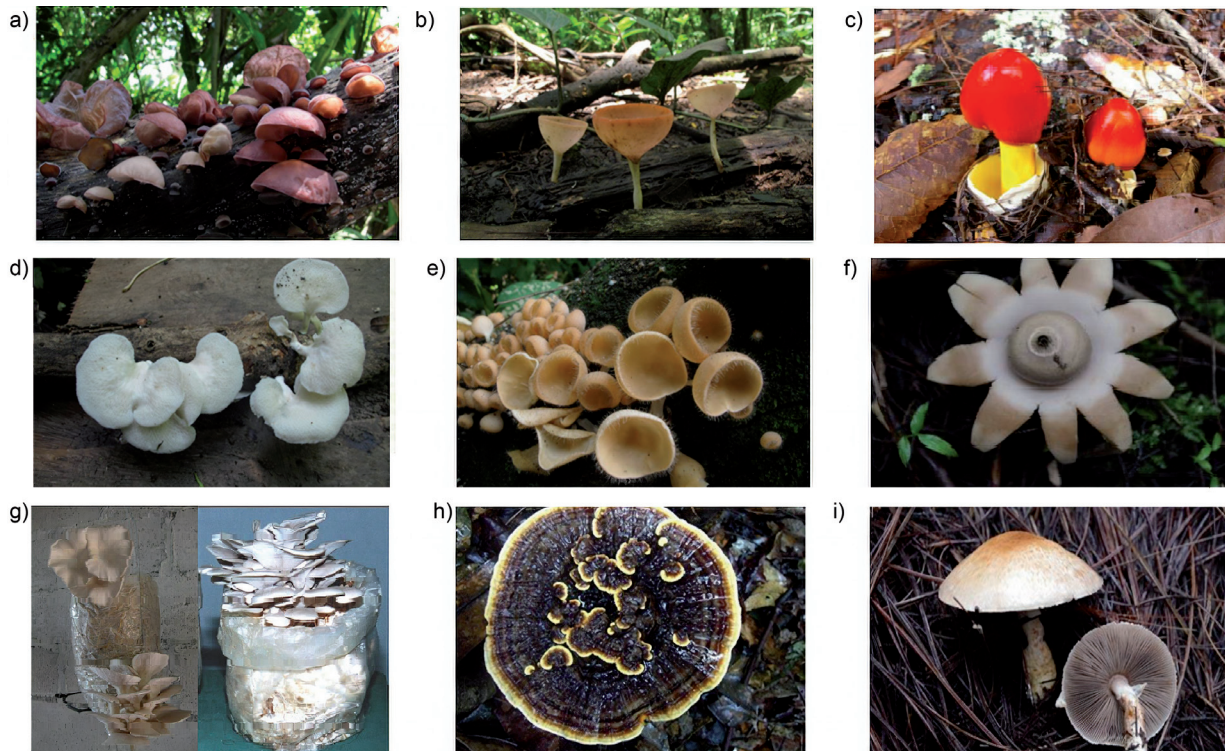
Fig. 2. Examples of Mushrooms varieties in the Salvadoran flora.

day. Moreover, the dimensions for both greenhouses we describe below: five meters long and three and a half wides. The useful life of the greenhouses with good maintenance is approximately a six-year lifespan [24, 25]. Moreover, the cost of the greenhouses were US dollar ($) 962.00 which covers the installment and construction. The altitude, humid, warm climate and subtropical forest are favorable conditions for the natural development of these mushrooms. According to the lag-period method on the operation cost, the working capital was quantified.

Costs Calculations: TC = FC + VC

...where Total Cost (TC), is equal to Fixed Cost (FC) plus Variable Cost (VC), furthermore, the total variable cost (TVC) and breakeven point (BEP) were used. Moreover, the NPV and IRR were taken into consideration from Boateng and Baker [26-28]. The Total variable cost was divided by the number of units produced, which remainder will be the unit variable cost, as following:

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = O$$

...where:
C_n = Net Cash Flow, successively every year.
N = Years of the Project.
r = The discount rate.
O = Net Expenses.

In order to obtain "C_n" the mathematical operation is subtracting from the incomes the expenses, this means that the total income for years, will be subtracted by: (operating expenses, administration, sales, financial, taxes of law). From this operation, Net Income will be left as a result [29, 30]

As a consequence, C_n = Net Cash Flow subsequently every year. Further, N = years of the Project; the number of cash flows (in this case, the project period, is seven years; consequently, is considering annual cash flows, then the number would be 7). r = the discount rate (as this case, 7%). Net Expenses is equal to O = Investment activities minus Working Capital plus Financial Activities.

To calculate *IRR,* it is necessary to obtain certain values first such. Therefore, the following formula below is:

$$IRR = \sum_{t-1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

...were:
C_t = Net Cash Inflow During the Period t.
r = "Discount Rate."
t = "Number of Time Periods."
C_0 = "Total Initial Investment Cost."

In order to take some decisions in the project, the use of the "Profitability Index" it is necessary, therefore, to calculate it the follow formula is: [31, 32]

$$PI = \frac{\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}}{I}$$

...where if:

Profitability Index is higher than 1, the project is accepted - (*PI*>1) is Accepted

Profitability Index is equal 1, it is indifferent - (*PI* = 1) is Indifferent

Profitability Index is less than 1, the project is rejected - (*PI*<1) is Rejected

Finally, if the product is accepted it is important to take into consideration the commercial demand, assuming that the product can favor the national economy where it is produced. [33]

Results and Discussion

This section describes and gives details an explanation of the results obtained from the sustainable alternative, technical and financial evaluation of the implications of carrying out this project. Distinct processes were involved, such as those used for the production and characterization of raw materials, the equipment, and machinery used, it is very important to emphasize that the substrate used for the production of mushrooms is merely organic sources of unused biomass that practically end up in garbage without giving it an added value or alternatives of agro-industrialization. It also explains how the distribution of the plant was defined and the specifications of the civil works, among other aspects of interest in order to prevent possible failures in the effective implementation of the project.

Moreover, this project is focused on the sustainable production of oyster mushrooms using ground coffee seed and pulp as a substrate, resulting from the industrialized waste of coffee production as an innovative solution for the use of the biomass waste from the agro-industry which avoids environmental pollution. In addition, it generates social, economic and environmental gains besides being an alternative to mitigation and compensation impact. Further, oyster mushrooms do not need a particular type of soil to be cultivated, basically, it need an optimal space to grow properly; the spaces must be clean, dry, very well ventilated, and small enough to be controlled, such as greenhouses or other small structures with roofs, as long as there is a good distribution of the place, where the areas must be separated from each other to avoid contamination or mishandling of the raw material.

Technical Evaluation

The process started using an organic substrate, which was made from coffee pulp and ground coffee seed (residues). Subsequently, the substrate was deposited in water with hydrated lime (calcium oxide) for approximately 12 hours, later on, the substrate

was removed to the container with water, in order to drain and cool. Afterward, the inoculum distribution process was carried out, as result, the mycelium grew up in the substrate from ground coffee and pulp, this process is called "sowing". Subsequently, the inoculated substrate was settled for sowing in 5 mm plastic bags of approximately 25 pounds. Afterward, the bags were transported to the "growing room" or "incubation rooms". In this stage the temperature must be maintained at 24ºC, during 15 days approximately, eventually, the bags were transferred to the place of production. It is emphasized that before starting the process, the spores must be inoculated from the pure *Pleurotus ostreatus* mycelium, this contributes with success in all stages of *P. Ostreatus* production, and reduce the financial loss. The production process is conformed by eight stages which are described below:

1. To combine and weigh, the pulp and ground coffee seed were weighed in a ratio of three parts.
2. To repose, the compost were stirred daily or by lapses of three days (fermentation).
3. To sterilize, the compost was deposited in a room with isolated walls, which was controlled by temperatures for a period of 24 hours. Subsequently, it was subjected to a pasteurization process for six to eight hours and then cooled at 20 to 26ºC.
4. To distribute, the seeds were spread with a dispenser or manually on the compost (sowing).
5. To fill, the compost was moved in plastic bags with an average size of 1 kg.
6. To transfer, the bags were transported to the incubation area.
7. To control, during two weeks, the humidity and temperature were monitored through the hygrometer at 22ºC.
8. To propagate, the bags were transported to the production hall for the proliferating stage (fruiting).

The pasteurization process lasted six to eight hours and then it was cooled to 20 to 26ºC; the spores of *Pleurotus ostreatus* were sown and the fertilizer produced was applied. Subsequently, were transported from the bags which contained the sown spores. Afterwards, the bags were moved to the incubation area where the temperature and humidity were monitored until achieved 100% colonization. Finally, the bags were transported to the production room for the fructification scenario under controlled temperature conditions between 20 to 24ºC.

For the execution and implementation of this project in the municipalities of Santa Tecla and Antiguo Cuscatlán belonging to the Republic of El Salvador, it was necessary first, to identify the market segment, which were interested in the production of mushrooms with the technique using the waste from coffee industry as substrate. Thus, by obtaining 100% of the sprouted mushroom, it could lead to support the research and break paradigms regarding the viability of coffee residues which were used as a substrate for mushroom production. With the implementation of

this agro-industrial project; the agricultural sustainability for the Moreover, the cultivation of oyster mushroom implies mitigation and compensation impacts measurables besides its contribution to the world food security that is more and more insufficient, as it is the case of third world countries like El Salvador; at the same time it promotes the sustainability of other resources for the production of the products like the land and the water, products of high agricultural demand that when using this methodology of obtaining the mushrooms it favors the sustainable management of the natural resources; It can satisfy the needs of present and future generations of the products that are being obtained, given the case of the mushrooms.

It has been demonstrated that the production of mushrooms from the pulp and ground coffee waste is possible and very profitable in the long term, not only economically, but it is also very sustainable for the environment since it mitigates the contamination of the waste through the recycling of the same. This alternative is very reliable for those markets interested in acquiring this type of food, as was seen in the research, in addition, it is known that there is very little supply of this product.

Financial Evaluation

The market for mushroom production is profitable according to the niche studies that were carried out in the research for the project. According to data from the Foundation for Technological Innovation (FIAGRO), by 2013 there will be wholesale sales of fresh mushrooms in supermarkets (75% of mushroom consumption nationally) and processed mushrooms in supermarkets and pizzerias (56% and 38% respectively). This market for mushroom production can improve in the coming years if it is given the appropriate monitoring and investment for the acceptance of this product. In El Salvador, mushroom seed imports in 2019 amounted to US$17,860.00 (BCR, 2019), a figure that, according to the high demand from restaurants, supermarkets and canteens in the well-known gourmet markets,

has tended to increase in recent years, which favors mushroom growers in the country.

Determination of Financial Needs

First, it is necessary to analyze the initial investment, the availability of equity, liquidity or short-term availability, which could be converted into equity to finance the initial investment. Moreover, the short-term returns of the project will allow covering the monthly payment of the loan.

The establishment of project resources will come from the company itself and from the income and expenditure budgets, where surpluses of operations are achieved. The discrepancy or missing between the total of the investment and the total of the own resources will be the financial needs of the project.

Initial investment: $ 36,421.70
Bank loan: $ 7,500.00
Own funds: $ 28,921.70
Rate: 9.25%
NPER   7
Year Payment $ 1,502.70

The NPER is a function which returns the number of periods for an investment based on an interest rate and a constant payment schedule as showing in the following table (Table 1).

Financial Evaluation by Net Present Value (NPV) and Internal Rate of Return (IRR)

For the realization and calculation of the Net Present Value, it is necessary to make the sales budget for the first year of operations. (Table 2, Table 3 and Table 4).

From the chart Annual Sales Budget, which serves to project an increase in the future, annual sales of 3% every year. Moreover, taking into consideration the credit time of the loan from the bank it's planned for 7 years, therefore the minimum duration for this project will be seven years.

Therefore, for the realization of this exercise, the MARR, IRR, and NPV was obtained through Microsoft

Table 1. Payment, interest and remaining balance per year of the loan from the bank.

PERIOD	Payment	Interest	Capital	Remaining balance
0				$7,500.00
1	$ 1,502.70	$ 693.75	$ 808.95	$6,691.05
2	$ 1,502.70	$ 618.92	$ 883.78	$5,807.27
3	$ 1,502.70	$ 537.17	$ 965.53	$4,841.74
4	$ 1,502.70	$ 447.86	$ 1,054.84	$3,786.90
5	$ 1,502.70	$ 350.29	$ 1,152.41	$2,634.48
6	$ 1,502.70	$ 243.69	$ 1,259.01	$ 1,375.47
7	$ 1,502.70	$ 127.23	$ 1,375.47	$ 0.00

Table 2. Annual Sales Budget.

	Annual Sales Budget											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sales projections	3937	3937	3937	3937	3937	3937	4725	4725	4725	4725	4725	4725
Cash sales (40%)	1574.8	1574.8	1574.8	1574.8	1574.8	1574.8	1890	1890	1890	1890	1890	1890
Sales to credit (60%)	2362.2	2362.2	2362.2	2362.2	2362.2	2362.2	2835	2835	2835	2835	2835	2835
Total sales	**3937**	**3937**	**3937**	**3937**	**3937**	**3937**	**4725**	**4725**	**4725**	**4725**	**4725**	**4725**

Table 3. Annual cash flow (Financial Net Flow).

	Cash flow											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cash sales	1574.8	1574.8	1574.8	1574.8	1574.8	1574.8	1890	1890	1890	1890	1890	1890
Accounts receivable	2362.2	2362.2	2362.2	2362.2	2362.2	2362.2	2362.2	2835	2835	2835	2835	2835
(+) Loans	7500	0	0	0	0	0	0	0	0	0	0	0
Total cash income	11437	3937	3937	3937	3937	3937	4252.2	4725	4725	4725	4725	4725
Production costs	727.5	727.5	727.5	727.5	727.5	727.5	836.63	836.63	836.63	836.63	836.63	836.63
Administrative expenses	1844	1844	1844	1844	1844	1844	1844	1844	1844	1844	1844	1844
Tax payment	308.1	308.1	308.1	308.1	308.1	308.1	359.62	477.82	477.82	477.82	477.82	477.82
Total cash outflows	2879.6	2879.6	2879.6	2879.6	2879.6	2879.6	3040.3	3158.5	3158.5	3158.5	3158.5	3158.5
Net economic flow	8557.4	1057.4	1057.4	1057.4	1057.4	1057.4	1212	1566.6	1566.6	1566.6	1566.6	1566.6
Debt service	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1
Financial Net Flow	**8424.3**	**924.3**	**924.3**	**924.3**	**924.3**	**924.3**	1078.9	1433.5	1433.5	1433.5	1433.5	1433.5

Table 4. Annual cash flow (Flow Net Profit).

	Cash flow											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total sales	3937	3937	3937	3937	3937	3937	4252	4252	4725	4725	4725	4725
(-) production costs	727.5	727.5	727.5	727.5	727.5	727.5	836.63	836.63	836.63	836.63	836.63	836.63
Gross profit	**3209.50**	**3209.50**	**3209.50**	**3209.50**	**3209.50**	**3209.50**	**3415.37**	**3415.37**	**3888.37**	**3888.37**	**3888.37**	**3888.37**
Selling and administrative expenses	1844	1844	1844	1844	1844	1844	1844	1844	1844	1844	1844	1844
Financial services	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1	133.1
Operational utility	**1232.40**	**1232.40**	**1232.40**	**1232.40**	**1232.40**	**1232.40**	**1438.27**	**1438.27**	**1911.27**	**1911.27**	**1911.27**	**1911.27**
Interests	0	0	0	0	0	0	0	0	0	0	0	0
Utility before tax	1232.4	1232.4	1232.4	1232.4	1232.4	1232.4	1438.5	1438.5	1438.5	1438.5	1438.5	1438.5
Income tax	308.1	308.1	308.1	308.1	308.1	308.1	359.62	359.62	359.62	359.62	359.62	359.62
Flow Net profit	979.93	924.30	924.30	924.30	924.30	924.30	1078.85	1433.45	1433.45	1433.45	1433.45	1433.45

Excel using the "Formula"; followed by the icon "Financial", category IRR and NPV as shown in the following tables (Table 5, Table 6 and Table 7).

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 0$$

Net Present Value (NPV).

To calculate NPV it is necessary to obtain first certain values. Therefore, the following formula below is:

Through the following formula we will obtain the *NPV*. To verify the veracity of the data, we performed the calculation of the *NPV* in the following formula:

Table 5. MARR, IRR and NPV.

MARR (Minimum Acceptable Rate of Return)	7.00%
IRR (Internal Rate of Return)	52%
NPV (Net Present Value)	$ 57,247.11

Table 6. Net Income of the Project.

Period of Time (years)	0	1	2	3	4	5	6	7
Income		$51,972.00	$53,531.16	$55,137.09	$56,791.21	$58,494.94	$60,249.79	$62,057.29
Expenses								
Operations		$ 8,736	$ 8,998	$ 9,268	$ 9,546	$ 9,832	$ 10,127	$ 10,431
Administrative		$ 14,208	$ 14,634	$ 15,073	$ 15,525	$ 15,991	$ 16,471	$ 16,965
Sales		$ 7,920	$ 8,158	$ 8,402	$ 8,654	$ 8,914	$ 9,181	$ 9,457
Financial		$ 694	$ 619	$ 537	$ 448	$ 350	$ 244	$ 127
Taxable income		$ 20,414	$ 21,122	$ 21,856	$ 22,617	$ 23,407	$ 24,226	$ 25,077
Income Tax (25%)		$ 5,104	$ 5,281	$ 5,464	$ 5,654	$ 5,852	$ 6,057	$ 6,269
Net Income		$ 15,311	$ 15,842	$ 16,392	$ 16,963	$ 17,555	$ 18,170	$ 18,808

Table 7. Net Cash Flow of the Project

Cash flow statement		1	2	3	4	5	6	7
Operational Activities								
Net Income		$ 15,311	$ 15,842	$ 16,392	$ 16,963	$ 17,555	$ 18,170	$ 18,808
Investment activities	$(28,922)							
Equipment / Machinery								
Redemption value								
Rate of tax on profits								
Working Capital	$ (-6,497)							
Financial Activities	$ 7,500							
Credit Funds								
Payment to Capital		$ 809	$ 884	$ 966	$ 1,055	$ 1,152	$ 1,259	$ 1,375
Net Cash Flow	$(27,919)	$ 14,502	$ 14,958	$ 15,427	$ 15,908	$ 16,403	$ 16,911	$ 17,432

$$NPV = \left[\frac{C_n1}{(1+r)^{\wedge11}} + \frac{C_n2}{(1+r)^{\wedge12}} + \frac{C_n3}{(1+r)^{\wedge13}} + \frac{C_n4}{(1+r)^{\wedge14}} + \frac{C_n5}{(1+r)^{\wedge15}} + \frac{C_n6}{(1+r)^{\wedge16}} + \frac{C_n7}{(1+r)^{\wedge17}}\right] - 0$$

$$NPV = \left[\frac{\$14,502}{(1+0.07)^{\wedge11}} + \frac{\$14,958}{(1+0.07)^{\wedge12}} + \frac{\$15,427}{(1+0.07)^{\wedge13}} + \frac{\$15,908}{(1+0.07)^{\wedge14}} + \frac{\$16,403}{(1+0.07)^{\wedge15}} + \frac{\$16,911}{(1+0.07)^{\wedge16}} + \frac{\$17,432}{(1+0.07)^{\wedge17}}\right] - 27,919$$

$$NPV = [13,553.2710 + 13,064.8965 + 12,593.0273 + 11,268.5134 + 10,855.7735] - 27,919$$

$$NPV = [85,166.73103 - 27,919] = \$57,247.73103$$

$$NPV = \$ 57,247.73$$

Therefore, in this operation we can say that the *NPV* equation matches the data obtained through Excel Financial Functions.

Internal Rate of Return (IRR)

To calculate *IRR* it is necessary to obtain certain values. Therefore, the following formula below is:

$$IRR = \sum_{t-1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

Accordingly:

$$IRR\ Approximation = \sum \left(\frac{\sum Income}{\sum Expenses} - 1\right) \div 1$$

From the chart Net Cash Flow: year 1 = ($ -27,919), year 2 = ($ 14,502), year 3 = ($ 14,958), year 4 = (15,427), year 5 = ($ 15,908), year 6 = ($16,403) and year 7 = ($ 17,432)

$$IRR\ Approximation = \frac{(\frac{111,541}{27,919} - 1) \div 7}{}$$
$$IRR\ Approximation = (3.995165 - 1) \div 7$$
$$IRR\ Approximation = (2.995165) \div 7$$

$$IRR\ Approximation = \frac{0.4278880654}{}$$
$$IRR\ Approximation = 0.43$$

Up to this part of financial operation, it has obtained only the starting percentage of the IRR because it's not the real one, according to the information obtained through the financial program the IRR is 52%, nevertheless, we should remember that the IRR forces the NPV to become ZERO. Through the following chart, we can observe the following results for every percentage as 43 which is the initial, the 51, and 52 that have been calculated (Table 8).

In the table we can see the periods in seven years that the project has been programmed and at the same time the different values of r for example:
a) Using r = 43% the remaining IRR value is 4,709.5055 is an extremely high value and we have to take into consideration that as the percentage increases, the value decreases or approaches to zero.
b) Using r = 51% the value of IRR is considerably reduced to 227.6081 nevertheless we still remember that IRR leads to NPV = 0 (zero).
c) Using r = 52% the IRR value gives us negative - 255.7709 means that the percentage equal to zero is passed

Therefore, to obtain the exact value of IRR, an Interpolation is carried out, is can observed in the following (Fig. 3).

The values that come closest to zero are 0. 51 and 0.52. Moreover, the sum of 227.6081 and 255.7709 gives us 483. 379. Where the exact value of IRR is found and the difference between both values which is 0.01, therefore a rule of three is made to find the value of "x".

$$r = 0.01 \longrightarrow 483.379$$

$$X = \quad \longleftarrow 227.6081$$

$$x = \frac{227.6081 * 0.01}{483.379}$$

Table 8. Results for IRR percentage. Summary table of the operations IRR

| Year	Net Cash Flow	Formula	r = 43%	r = 51%	r = 52%
1	14502	$14502/(1+r)^{\wedge1}$	10141.2587	9603.97351	9540.78947
2	14848	$14848/(1+r)^{\wedge2}$	7260.99076	6511.995088	6426.5928
3	15427	$15427/(1+r)^{\wedge3}$	5275.61831	4480.749218	4392.89392
4	15908	$15908/(1+r)^{\wedge4}$	3804.27088	3059.903942	2980.17132
5	16403	$16403/(1+r)^{\wedge5}$	2743.10921	2089.481587	2021.64709
6	16911	$16911/(1+r)^{\wedge6}$	1977.66654	1426.617693	1371.22197
7	17432	$17432/(1+r)^{\wedge7}$	1425.59103	973.8870393	929.912534
			32628.5055	28146.6081	27663.2291
	27,919	IRR	4709.5055	227.6081	-255.7709
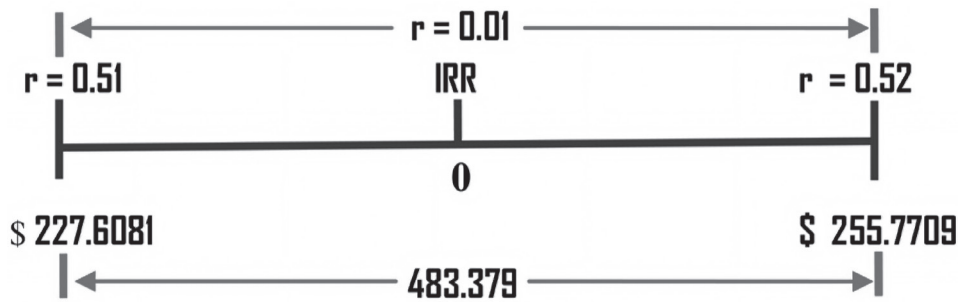
Fig. 3. Value of Internal Rate of Return (IRR).

$X = 4.7086882 \times 10^{-03}$; $X = 0.004708688214$

$IRR = 0.51 + 0.004708688214$;
$IRR = 0.514708688214$

$IRR = 51.47\%$

To verify the veracity of the data, we performed the calculation of the IRR in the following formula.

$$IRR = \left[\frac{C_t 1}{(1+r)^{\wedge 1}} + \frac{C_t 2}{(1+r)^{\wedge 2}} + \frac{C_t 3}{(1+r)^{\wedge 3}} + \frac{C_t 4}{(1+r)^{\wedge 4}} + \frac{C_t 5}{(1+r)^{\wedge 5}} + \frac{C_t 6}{(1+r)^{\wedge 6}} + \frac{C_t 7}{(1+r)^{\wedge 7}} \right] - 0$$

$$IRR = \left[\frac{\$14,502}{(1+0.5147)^{\wedge 1}} + \frac{\$14,958}{(1+0.5147)^{\wedge 2}} + \frac{\$15,427}{(1+0.5147)^{\wedge 3}} + \frac{\$15,908}{(1+0.5147)^{\wedge 4}} + \frac{\$16,403}{(1+0.5147)^{\wedge 5}} + \frac{\$16,911}{(1+0.5147)^{\wedge 6}} + \frac{\$17,432}{(1+0.5147)^{\wedge 7}} \right] - 2,7919$$

$$IRR = [9574.1731 + 6472.49992 + 4439.16823 + 3022.89994 + 2057.26462 + 1400.26275 + 952.929648] - 27,919$$

$$IRR = 27,919 - 27,919$$

$$IRR = 0 \ (Zero) \ when \ the \ rate \ is \ 51.47\%$$

We can conclude that the IRR of 51.47% per annum; it tells us that: for the money invested it will recover on average 51.47% each year and for every dollar invested, it will get back approximately $ 0.52 cents (Table 9).

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Profitability Index

The Profitability Index is a useful tool for making decisions in a project, for example:
– If the Profitability Index is higher than 1, it is accepted - (PI = > 1 Accepted)
– If the Profitability Index is equal 1, it is indifferent (PI = 1 Indifferent)
– If the Profitability Index is less than 1, the project is rejected (PI = < 1 Rejected)

The data was tabulated and calculated through the financial formula, as can be observed in the following table, the result was 3.047052287 it means the Profitability Index is higher than "1", Therefore, the project is accepted (Table 10).

To obtain the Profitability Index it is necessary to calculate with the following formula.

$$PI = \frac{\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}}{I}$$

Table 9. Summary table of the operations IRR

Year	Net Cash Flow	Formula	r = 43%	r = 51%	r = 52%	r = 51.47%
1	14502	14502/(1+ r)^1	10141.2587	9603.97351	9540.78947	9574.1731
2	14848	14848/(1+ r)^2	7260.99076	6511.995088	6426.5928	6472.49992
3	15427	15427/(1+ r)^3	5275.61831	4480.749218	4392.89392	4439.16823
4	15908	15908/(1+ r)^4	3804.27088	3059.903942	2980.17132	3022.89994
5	16403	16403/(1+ r)^5	2743.10921	2089.481587	2021.64709	2057.26462
6	16911	16911/(1+ r)^6	1977.66654	1426.617693	1371.22197	1400.26275
7	17432	17432/(1+ r)^7	1425.59103	973.8870393	929.912534	952.929648
			32628.5055	28146.6081	27663.2291	27919.1982
	27,919	**IRR**	4709.5055	227.6081	-255.7709	0

Table 10. The data tabulated and calculated through the financial results.

Year	Net Cash Flow	Formula	PI
1	14502	14502/(1+ 0.07)^1	13553.27103
2	14848	14848/(1+ 0.07)^2	12968.81824
3	15427	15427/(1+ 0.07)^3	12593.02735
4	15908	15908/(1+ 0.07)^4	12136.13703
5	16403	16403/(1+ 0.07)^5	11695.1123
6	16911	16911/(1+ 0.07)^6	11268.51335
7	17432	17432/(1+ 0.07)^7	10855.7735
			85070.6528
	27,919	85,070.6528/ 27,919	3.047052287

Moreover, to verify the veracity of the data, we performed the calculation using this formula:

The PI (Profitability Index) =

$$PI = \frac{\dfrac{C_F 1}{(1+r)^{\wedge 1}} + \dfrac{C_F 2}{(1+r)^{\wedge 2}} + \dfrac{C_F 3}{(1+r)^{\wedge 3}} + \dfrac{C_F 4}{(1+r)^{\wedge 4}} + \dfrac{C_F 5}{(1+r)^{\wedge 5}} + \dfrac{C_F 6}{(1+r)^{\wedge 6}} + \dfrac{C_F 7}{(1+r)^{\wedge 7}}}{I}$$

$$PI = \left[\frac{\$14,502}{(1+0.07)^{\wedge 1}} + \frac{\$14,958}{(1+0.07)^{\wedge 2}} + \frac{\$15,427}{(1+0.07)^{\wedge 3}} + \frac{\$15,908}{(1+0.07)^{\wedge 4}} + \frac{\$16,403}{(1+0.07)^{\wedge 5}} + \frac{\$16,911}{(1+0.07)^{\wedge 6}} + \frac{\$17,432}{(1+0.07)^{\wedge 7}} \right] \div 27,919$$

$$PI = [13,553 \times 2710 + 13,064 \times 8965 + 12,593 \times 0273 + 12,136. \times 3703 + 11,695 \times 1123 + 11,268 \times 5134 + 10,855 \times 7735] \div 27,919$$

$$PI = 85,070.6528 \div 27,919$$

$$PI = 3.047052287$$

Therefore, we can conclude that the PI equation matches with the data obtained through Excel Financial Functions. Accordingly, the result was 3.047052287.

To obtain the expected benefits, according to this case of study, 10% of the total population of El Salvador consumes mushrooms, this represents only the locations were taken for the research which are Santa Tecla and Antiguo Cuscatlán, this percentage can generate $182,820.99 US per month, that's if the mushrooms are sold in the first crops at a price of $5.25 per pound, the price can increase gradually according to the demand, the season and the competition in the market. Based on this, the expected internal rate of return (IRR) of 51.47% per year, it can be concluded that the money invested will be recovered at a rate, on average, of 51.47% each year. Therefore, for every $ 1.00 US dollar invested approximately $0.52 will be returned.

Conclusions

This case of study sought to analyze the financial feasibility and sustainability of the project, with a mitigation approach, using the solid waste from the coffee agro-industry in order to produce Oyster Mushroom (*Pleurotus Ostreatus*). In addition, implementing this project, we become the first to venture into this market segment through production (substrate) because there is few knowledge of this alternative technology, which deals with of breaking agricultural paradigms rooted in the culture of the Salvadoran coffee producers, which mitigates and compensates at the same time the environmental impact generated by the coffee agribusiness, by reusing these biomass and renew it as substrate source (by-product) for *P. Ostreatus* productions. Further, with the start-up of this agro-industrial project, we improved the national economy due to the generation of new sources of work, decreasing the imports of this product. Moreover, one of the main components of this project is the physical construction of two greenhouses for daily production. According to the results, this project is feasible, as there will be sufficient supplies to carry out as raw material, infrastructure, land, and human resources available to carry out the cultivation of oyster mushrooms at the agro-industrial level. Finally, the financial analyses obtained through: *NPV* = $ 57,247.73, *IRR* = 0 (zero) when the rate is 51.47% and *PI*>1 = 3.04705228, shown basically the acceptability and feasibility of this case of study, evidencing that the project is economically profitable.

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Conflict of Interest

The authors declare no conflict of interest.

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