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## Management strategies for used cooking oils. Case study Barrio Obrero, Puyo, Ecuador

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### Graphical Abstract

Waste cooking oil (WCO) Collection

Economic Evaluation NPV, IRR, Payback

B-Soap

C-Candle

### Abstract.

Waste cooking oil from the food industry, restaurants/food service establishments and households is a major environmental and ecological problem. The present work analyzed the technical and economic viability of three strategies for the use of waste cooking oil (WCO) in the gastronomic establishments of the “Obrero-Puyo” neighborhood, Province of Pastaza. The strategies analyzed were collection and sale to authorized managers, soaps and candles manufacture as possible alternatives for the WCO use. According to the economic evaluation results, candle making is the most economically

profitable option with a current value of \$447530.01, a return rate of 106% and a recovery period of 0.7 years. Finally, it is recommended that this analysis be extended to other neighborhoods and sectors of the Puyo city, in order to know the generation of the city, and integrate the other economic units in a project of greater scope.

Keywords: Waste oil, economic analysis, resource utilization, waste recycling

## Introduction

Waste cooking oil from the food industry, restaurants/food service establishments and households has become a major environmental and ecological problem, especially because it is generally discarded indiscriminately after use, in municipal landfills or discharged into drains without any treatment [1-3].

Recycling used oil is becoming a viable alternative for mitigating the environmental and ecological problems associated with its disposal [4]. However, developing countries have many limitations, little awareness of waste material recycling, the certainty of procedural standards, and effective infrastructure for their recovery [5,6].

Researchers have studied the potential use of the recycled WCO through integration into animal feed chains, soap production or conversion to biodiesel [7,8]. However, there are limited studies on evaluating alternatives that can be implemented in developing countries.

In the Puyo city there is not adequate management of WCO, no system for collection, storage and final disposal. Based on this, the objective of this work is to analyze the technical and economic viability of three alternatives for the WCO use in the different gastronomic establishments of the "Obrero-Puyo" neighborhood.

## Materials and Methods

The generation of used cooking oil from the establishments under study were quantified for 4 weeks.

### *Waste cooking oil strategies management*

1- Sale to authorized managers: Collection of WCO at the City's Clean Collection and Recycling Points, WCO filtration, storage and sale.

2- Soap making: The collected WCO were filtered and used to make soaps, saponification with 95% pure caustic soda, colorants and essences were added, later was placed in 200g molds, for 3 to 4 days.

3- Candle Making: The process was done with filtered WCO, steric acid, colorants and essences were added, finally, the mixture were placed in a mold of 75g.

### *Characterization of raw materials and products*

pH: Potentiometric method, in a pH-meter, Hanna Instruments.

Free alkalinity: Titration with 0.1 N hydrochloric acid solution (HCl).

Free acidity: Titration with a 0.1N solution of potassium hydroxide (KOH).

Determination of moisture and volatile matter: It was analyzed by the method of surfactants.

### *Economic and financial indicators*

The feasibility of the three proposals was evaluated through the main dynamic indicators: Net Present Value (NPV), Internal Rate of Return (IRR) and Payback (PB).

## Results and Discussion

*Quantification of used cooking oil consumption by establishment.*

Table 1 shows the results of the non-parametric Wilcoxon Rank-sum test (Mann-Whitney). The comparison between the two types of gastronomic units shows significant differences (Value of  $P < 0.05$ , 95% confidence). Fast food establishments have the highest WCO generation values (average of 13.7 L) compared to group 1 (restaurants), an average of 4 L. The analysis of the total quantity shows that fast-food establishments discard 273 L per week, and restaurants discard a total of 103 L per week. This is evidence of increased WCO disposal by the fast-food local population.

Table 1. Results of waste generation statistics by type of economic unit group (1) Restaurants, (2) Fast food

Group	Obs	Mean	SD	Rank Sum	Expected
1	27	4	4.04	528	648
2	20	13.7	15.11	600	480
Combined	47	8.06	11,30	1128	

SD-Standard deviation, z-Value = -2.593, P-Value= 0.0095

Table 2 shows the results of the WCO characterization (Acidity, Alkalinity, Density, pH).

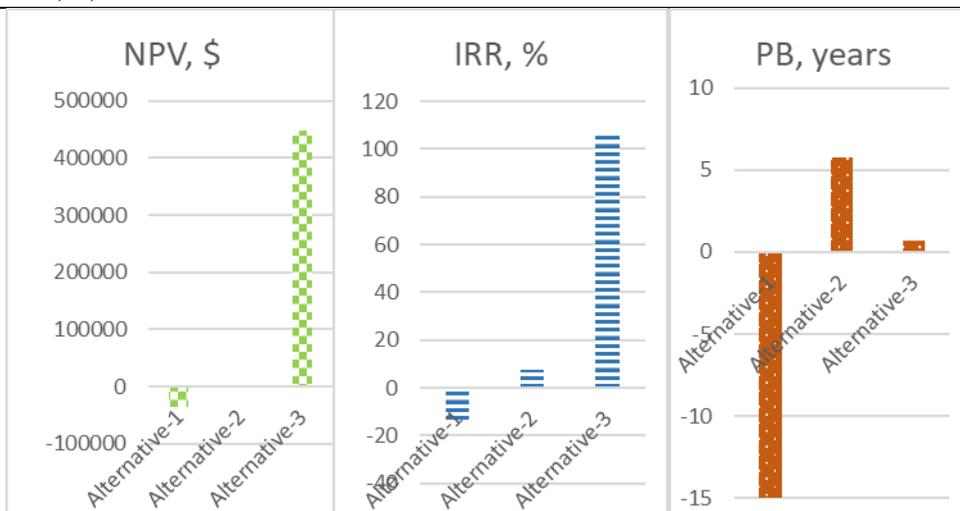
Table 2. Chemical characterization of used cooking oil.

Parameters	Mean	Medium	Variance	$\sigma$	C.V
Free Acidity ( $\text{mg g}^{-1}$ )	0.03	0.03	$1.596\text{E}^{-05}$	0.004	0.129
Free Alkalinity ( $\text{mg g}^{-1}$ )	0.12	0.12	0	0	0
Impurity (%)	2	2	0	0	0
Density ( $\text{g cm}^{-3}$ )	0.91	0.91	0	0	0
pH	7.85	7.85	0	0	0

$\sigma$  -Standard deviation, CV-Coefficient of variation

Figure 1 shows the results of the financial and economic indicator for the three alternatives under study. The values show that Alternative 1 and 2 (Sale of WCO to an authorized manager and manufacture of soaps) have a negative NPV (-34845.82 and -1412.06 USD respectively), which reflects that the proposals are not economically profitable in the projected time of 10 years. While proposal 3 (candle-making process) has a value of USD 447 530.01, this value shows the substantial net benefits that the project could generate during its useful life (10 years). In addition, Internal Rate of Return (IRR) present good value (106%), and the investment recovers in 0.70 years, making this alternative viable and profitable.

Figure 1. Financial and economic indicator for three alternative proposed.



## Conclusions

The results of the technical-economic analysis showed that candle making is the most economically profitable option. It is recommended that studies be carried out in other Puyo city neighborhood, in order to know the WCO city generation and to integrate the other gastronomical units in a project of greater scope.

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