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Evaluation of the Vegetal Oil Used Domestic of the City of Riobamba

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Abstract

Riobamba located in the Republic of Ecuador, has 255 741 inhabitants, has no data on used vegetable oils, nor projects for its use, so the objective of this study was to establish: consumption of domestic vegetable oils, generation of domestic used vegetable oils, disposition habits of these residues and their characterization to evaluate potential uses. 60 families participated during five months with collection of residual oils, volume measurement and data reporting, 394 surveys were applied, after than to do the statistical analysis was established: consumption of edible oil of 5.16 L / year / inhabitant, generation of residual oil 1.52 L / year / inhabitant, and, with 70.97% that expressed their intention to deliver its waste oils to collector they would be collected 275.19 m3 / year / population. After of one pretreatment of the residual oil was characterized according to Mexican standards, it was obtained: humidity 0.068%, relative density 0.9641, acid number 1.13 mg KOH/g, free fatty acids 0.49%, soap content 0%, saponification number 192.48 mg KOH/g, ester number 191.35 mg KOH / g, and unsaponifiable matter 0.471%; these results identify a suitable raw material for some processes: theoretically, 255.9 m^3 of biodiesel would be obtained by alkaline trans esterification; or by saponification 213 356.4 Kg of soap, in addition to other alternatives.

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Keywords

Domestic used vegetable oil; Organic waste; Non-biodegradable; Alkaline trans esterification; Saponification

Introduction

Although the application of chemistry in industrial production is determinant, it is possibly more relevant in the solution of the problems generated by the different types of waste: urban, agricultural and industrial; the chemical composition of all waste is the basis of its potential to become raw material and input of other processes acquiring added value, reduce or eliminate pollution, generate productive activities, create jobs through the production of industrial organic products that more than its chemical meaning have a great value for its use; in a way that contributes to the balance between human needs and the sustainability of their quality of life without affecting resources.

In 2014, the world production of the main fats and oils was estimated at 200 million tons, only compared to palm oil Ecuador produced 227.8 thousand tons (González-Cárdenas), 1 liter of residual oil can contaminate 1 000 to 40 000 liters of water (Gonzales *et al.,* 2015), the final disposal that the cities give to this waste is to eliminate them by the sinks producing clogging of pipes due to its characteristic binding, bad odors, dirt, proliferation of microorganisms, sanitary vectors and costs by wastewater treatment (Reoil

Mexico, 2009), 63.35% of the municipalities in the country perform wastewater treatment which has a cost, but in the end these waters are discharged to the water sources (INEC, 2016).

These wastes are non-biodegradable organic waste pollutants that enter the water sources and the irrigated soils generating environmental costs in the short and medium term, health damages are added due to improper handling in the frying processes, reuse several times, or returns to the consumer through clandestine managers who after clarification sell it for different food businesses, the population density, bad habits of consumption and handling of the oils, generation of waste and final destination given to these waste are proportional to the extent of the pollution produced by used vegetable oils.

At a global and national level, these wastes are already being used, in the city of Riobamba there is no data on this subject, so the objective of this study was to establish the generation of used vegetable oils at the domestic level, and obtain information on the management of oils and their residues, making visible with figures the magnitude of the damage caused by citizens, whether due to ignorance, lack of environmental culture or absence of local programs. Policies are relevant to the successful collection of these residues, and the application of chemical synthesis for its treatment and / or use, added to a multidisciplinary approach to the management of these wastes, the development of valuable products such as biodiesel, fertilizers, soaps, polymers and other industrial products, is an action in favor of the environment.

Materials and Methods

Geographic location

The collection of the used oils and the application of the surveys were carried out in the career of Industrial Engineering of the Engineering Faculty of the UNACH.

The statistical treatment of the collection of used oils and of the surveys, and the characterization of the used oils collected was carried out in the Laboratories of the ESPOCH Faculty of Sciences.

Materials and equipment

The reagents and solvents used in this investigation were analytical grade. Sodium hydroxide and 96% ethyl alcohol were Merck Ensure brand, HCl brand Fer.Met, Phenolphthalein and Meyer Orange brand Meyer. We used: POL-EKO brand stove, AHAUS analytical balance, RADWA PM 50 moisture balance, METER TOLEDO digital density meter for direct measurement, and for indirect measurement pycnometer, VULCANO brand muffle, and materials: desiccator, crucibles, separating funnel, vessels of precipitation, stirring rod, spatula, burette, erlenmeyer flask, reflux distillation equipment, controllable heating blanket, bain-marie.

Methodology

Obtaining information on vegetable oil management habits and the final disposition of the waste began with the application of 30 pilot surveys, once the internal consistency was established, 394 surveys were conducted in the homes of the students and nearby people to ensure the veracity of the information and the adequate disposition to collaborate.

To determine the generation of used vegetable oil, these residues were collected in the families of 60 students of the Industrial Engineering career of the UNACH during the months of October, November, and December of 2016, and, January and February of 2017. The collection it was made in the oil containers and for the measurement of volumes, 500 mL test tubes, LMS Germany brand, were used with the reading of the lower meniscus.

Characterization of domestic used vegetable oil

The domestic used vegetable oil (AVUD) was mixed and left to decant, then the pretreatment was carried out: first filtrate with Mesh No. 25 mesh 1 mm, second filtrate with Mesh Mesh No. 3600 of 106 micrometers and a filtration vacuum with Whatman filter paper No.40 ashless. It was homogenized, and washed with deionized water or type B water at a temperature of 70 ° C to remove chemical impurities (rubber) (Lafont *et al.*, 2011), and dried at 110 ° C for 1 hour to remove moisture.

The following Mexican standards were applied by the character of animal oils and animal fats: NMX-F-211-SCFI-2006, NMX-F-075- SCFI-2012, NMX-F-101-2006, NMX-F-101 -2012, NMX-F-492-SCFI-2009, NMX-F-174- SCFI-2014, NMX-

K-395-1972, NMX-K-306-SCFI-2006; for the determination of humidity, relative density, acidity index, % free fatty acids, soap content, saponification index, ester index and unsaponifiable matter respectively. Nine trials were performed for each parameter.

Statistical analysis

For the statistical analysis, the Cronbach alpha was used to establish the internal consistency of the pilot survey, after which the 394 surveys were applied, coding, tabulating and determining descriptive, correlational, and Chi ^{2} statistics for frequency analysis, in the same way We proceeded to the statistical analysis of the information obtained from the 60 families participating in the collection of the AVUD, using the SPSS 24 program.

Results and Discussion

From the follow-up to 60 families, during five months on the consumption of vegetable oil (AV) and the generation of AVUD the results presented in table 1 were estimated:

In Riobamba the consumption of AV is 5.16 L / inhabitant / year, this value is lower than what is estimated in other cities: for the Metropolitan District of Quito (DMQ) per capita consumption was 6.87 L / year in 2014 (Secretary of the environment *et al.,* 2014), in Chile of 12.6 L / year (Madariaga, 2016), for Bizkaia, Spain 12.8 L / year. AVUD generation was established at 1.52 L / inhabitant / year, for Cuenca generation of 4 L / year / inhabitant is reported (Town hall of Cuenca, 2018), for the MDQ the oil waste per capita was 2.76 L / year (40 %), for the province of Bizkaia in Spain from 2 - 4 L / inhabitant / year. In this research the waste generation is 29.38%, that is to say, of every 1000 mL of purchased vegetable oil, 294 mL of used oil is discarded, it is less than 40% of Quito, and it is in the range 15.6 - 31% of Bizkaia According to the population of Riobamba (INEC, 2016), and considering that 70.97% (of the 394 respondents) have indicated their intention to deliver the waste to a collector, the annual generation of AVUD would be 275 191.18 L / population / year.

The participations in the surveys according to sex are shown in table 2, and the age, number of people in the households and the expenditure they make in buying vegetable oil is shown in table 3 and all the variables show great variability, ie CV % high The habits of oil handling are presented in Table 4, it is observed that 33.50% of the respondents discard used oils after each frying, in terms of health is beneficial since each type of oil has different tolerances to the temperature, in addition, these wastes have better conditions to be reused, 39.09% discarded every two fritters, and the remaining 27.42

% waste if it is dirty, burned or never discarded, this percentage is the waste with greater chemical transformation, the consumption of oils and fat subjected to successive thermal heating influences plasma lipid peroxidation and is higher the higher the number of applied heatings, for which reason it is recommended not to abuse the reheating of the oils used in the frying (Abiles *et al.,* 2009).

The frequency with which consumers burn the oils is detailed in Table 5, it was established that only 5.84% indicated that they never burn the oil, 94.16% report that sometimes, rarely or always they burn the oil, if we contrast with the frequency with which they dispose of these residues it should be approximately this same percentage, which leads to the conjecture that oils are consumed in bad conditions, the high temperatures also increase the thermolitic reactions and affect an excessive thermooxidative deterioration of the oil, accelerate the hydrolysis of triglycerides and increase the content of free fatty acids (FFA), giving the oil a darker color and an unpleasant odor (Felizardo Pedro *et al.,* 2006), together it implies poor quality of the prepared foods, after 4 uses the dioxins that releases vegetable oil affects health, if there is a repeated consumption of used vegetable oils, free radicals and arcylamides are developed which are carcinogenic substances, all gastrointestinal diseases are related to stomach and colon cancer, hepatotoxicity is included for the substances used for rinsing to return to To sell as edible oil, it should also be considered that the burnt residual oil will require greater pre-treatments so that they can be used. It should also be considered that the burnt residual oil will require greater pre-treatments so that they can be used. It should also be considered that the burnt residual oil will require greater pre-treatments so that they can be used. Reflective and self-analysis questions on the handling of the oils and the waste produced in the kitchen were included in table 6, it can be mentioned that they are recognized when the oil has been burned, it is eliminated through the sink, the contamination is avoided in frequencies of 352, 229, 268 respectively, causing it to differ significantly (P <0.01), 58.26% eliminated by the sink. From the national survey it is reported with respect to fats and / or oils (INEC, 2016) that in Ecuadorian households 54.35

Table.1 Residual oil index

Variables	Volume	Percentage
Per capita consumption of oils (L / hab.year)	5,16	
Waste per capita of oils (L / hab.year)	1,52	
Amount of Oil Acquired (L / hab.year)	1 319 828,89	100
Amount of residual oil (L / population.year)	387 757,06	29,38
Amount of oil used (L / population, year)	932 071,83	70,62
According to intention to deliver residual oil to a collector (L / poblano.year)	275 191,18	70,97

Source: Research Group

Table.2 Sex of the respondents

Alternatives	Frequency	Percentage
Male	132	33.50
Female	262	66.50
Total	394	

Source: Research Group

Table.3 Age, Number of people / household, and monthly expenditure on oil from 394 families

Variables	Minimum	Maximum	Rank	Average	Deviation	CV %
Age	18	84	66	35,39	12,82	35,94
# people	1	10	9	4,27	1,64	38,38
Expense in oil	1.25	28	26.75	9,53	6,07	63,75

Source: Research Group

Table.4 When do you discard cooking oil?

Alternatives	Frequency	Percentage
Sometimes	2	0.51
Every 2 frituras	154	39.09
After C / Frying	132	33.50
Never throw it away	3	0.76
If it's dirty	70	17.77
If it burns	33	8.38
Total	394	

Source: Research Group

Table.5 Frequency with which the cooking oil burns

Alternative	Frequency	Percentage
Sometimes	195	49,49
Never	23	5,84
Rarely	121	30,71
Always	55	13,96
Total	394	

Source: Research Group

Table.6 Self-analysis of the handling of oils and waste produced in the kitchen

Alternatives	And	No	Total	Chi ^{2}	Sign
Recognizes when the oil has burned	352	42	394	50,76	**
Be careful not to burn the oil	298	95	393	1,09	Ns
Remove by the sink	229	164	393	46,80	**
You take care of nature	298	95	393	1,09	Ns
Avoid pollution	268	125	393	5,68	*
Total	1445	521	1966	105.42	**

Chi 0,05,4: 9.49

Chi 0,01,4: 13.28

Table.7 Did you know the following information?

information	Yes	Do not	Something Known	Total	Chi ^{2}	Sign
The oils have different tolerance to temperature	174	160	59	393	2.55	Ns
1 L waste oil contaminates 1000 - 40000 L water	167	170	57	394	0.50	Ns
When the oil is burned, it becomes toxic and harmful	199	147	47	393	14.40	**
The oil used with chips waste propitiate microorganisms lethal	160	173	59	392	0.03	Ns
The higher the purity of the oil, the lower the temperature at which it burns	121	205	65	391	14.68	**
Non-sticks lose their property at a temperature higher than their tolerance	153	181	57	391	0.57	Ns
There are different anti-adherents with different heat tolerances	158	169	65	392	0.08	Ns
Non-sticks decompose at high temperatures releasing gases of polymers that cause fever	153	181	56	390	0.59	Ns
Oils begin to smoke at a lower temperature than deterioration of the non-stick	125	205	64	394	12.84	**
Used oil can be used to make other products	162	159	71	392	1.20	Ns
The processed products of waste oils can be considered as non-contaminants	167	152	75	394	3.12	Ns
Total	1739	1902	675	4316	50.57	**

Chi 0.05, 20: 31.41

Chi 0.01, 20: 37.57

Table.8 Now that you know more information about vegetable oils, what would you be willing to do?

Intention	Yes	Do not	Total	Chi ^{2}	Sign
Collect used oil if there are ordinances with fines	263	128	391	0.87	ns
Collect used oil if there are ordinances that do not include fines	292	99	391	16.05	**
Continue discarding by the sink	207	183	390	24.45	**
Total	762	410	11.72	41.37	**

Chi 0.05, 20: 27.59

Chi 0.01, 20: 33.41

Table.9 Percentages and characteristics of vegetable oils used by 60 families

Oil brand	% used	Source	Fatty acid content
			Saturated fatty acids:
The favourite	58.8	Soy oil	C16: 0 Palmitic
			C18: 0 Stearic
Palm of Gold	13.8	African palm	C20: 0 Arachidic
			C22: 0 Behenico
		Pure soybean and olein oil	**Monounsaturated fatty acids:**
The Cook	12.3	Palm	C18: 1 (n-9) Oleic
			C18: 1 (n-7) Vaccenico
Sunflower	11.6	Sunflower seeds	C20: 1 (n-9 / n-11) Gadoleico
			Polyunsaturated:
Alesol	2.3	Soybean and palm oil	C18: 2 tt
			C18: 2 tc
		Soybean oil and olein	C18: 2 (n-6) Linoleic
Creole	1.2	palm	C18: 3 ttc
			C18: 3 tcc
Total	100		C18: 3 (n-3) Linolenic

Source: Research Group

Table.10 Average values of the characterization of domestic used vegetable oil

Parameter	**Average**	**± DS** *
Humidity	0.068%	± 0.030
Relative density	0.9441 g / mL	± 0.0022
% free fatty acids	0.49%	± 0.04
Soap content	0%	
Saponification index	192.48 mg KOH / g	± 1,67
Acidity index	1,13 mg KOH / g	± 0.14
Esther Index	191.35 mg KOH / g	
Unsaponifiable matter	0.471%	± 0.023

Source: Research Group
DS * standard deviation

% deposited with the rest of the garbage, 23.65% waste by the drainage or streams, 21.36% used as animal feed, gave away, sold or kept, that is a total of 78% of these wastes are converted in pollutants, this percentage is higher than obtained, and as estimated by Gonzales (Gonzales *et al.*, 2015) the depuration of one liter of vegetable oil has a cost of € 460 / m^3, also using these wastes for animal feed involves risks to the health of the animals and the people who feed them, consume by bioaccumulation (Yague Maria de Los Angeles, 2003).

Generally in Riobamba households the person in charge of buying the oils is the one who prepares the food, and therefore is in charge of handling the oils and their residues, so it was considered important to know how much this person knows about the topics presented in table 7: the oil to burn is toxic and harmful, the greater the purity of the oil, the lower the temperature at which it is burned, the temperature at which the oils begin to smoke is less than the temperature of deterioration of the oil. Non-stick, answered that if they knew in frequencies of 199, 121 and 125 respectively, values that differ significantly (P <0.01), in general 40.30% if you know, 15.64% know something and 44,10% do not know about these aspects so it is necessary to socialize this information and / or train the public on these issues that directly affect health, as well as raise awareness about the proper handling and collection of these waste to avoid water contamination and soils, as indicated by World Health Organization (WHO), a liter of spent cooking oil waste (of vegetable origin) contaminates a person's water consumption for 1.5 years.

Because in Riobamba there is no culture to recycle the AVUD, it was sought to know at least the intention of the generators of these oils, once they had more information on the subject (table 7), it was established that of the 555 responses the 70.97 % intends to collect the oil, 292 would do so with no fines, and 263 with fines, will continue to discard 207. According to the INEC (INEC, 2016) in 2016 at national level only 0.63% of households brought to a center. storage or special container vegetable oil waste, this reveals the need for campaigns focused on the proper management of vegetable oils, and the recycling and reuse of these household wastes, but above all accompanied by policies and actions that avoid the dangers to health, pollution and water purification costs, other cities in the country have programs to collect these wastes (Secretary of Environment-Alcaldía, 2016) (The Universe, 2017).

Characterization of the used vegetable oil

Table 9 shows the brands and percentages of the AVUD collected, the brand with the highest consumption is Favorita, followed in decreasing form by Palma de Oro, El Cocinero and Sunflower and in lower percentages Alesol and Criollo, that is, a mixture of vegetable oils of soybean, African palm and its derivatives such as olein and stearin that are obtained from the fractionation of the same in percentage of 67 and 33% respectively, of sunflower seeds, of corn; Soy plus olein from Criollo and according to the labels: free of trans fatty acids, the oils are composed of the indicated fatty acids and their proportions vary according to the type of oil, the oils richer in oleic acids better avoid the processes of oxidation with respect to linoleic and linolenic acids (McCormick *et al.,* 2007), oleic acids are fatty acids monounsaturated omega 9 series of typical oils plant as the oil of olive, safflower, avocado; These types of oils have a higher price and do not appear in the homes investigated. The physical – chemical parameters of the AVUD mixture are shown in Table 10, these data are referents since before the process of obtaining biodiesel the AVUD mixture must be characterized to adapt operational conditions that optimize the synthesis of biodiesel.

The characterization results of the AVUD focused for

Obtaining biodiesel: humidity of 0.068% ± 0.03 its low value is positive because it prevents saponification from taking place by favoring trans esterification for the alkaline production of biodiesel, this value is due to the pre-treatment that included drying at 110^{o}C for one hour, the acidity index (IA) is likely to increase with the number of fryings to which the oil is subjected (Ayala Maria, 2011), the sample has AI of 1.13 mg KOH / g is high with respect to 0.10 of pure oils, the acidity is a product of the hydrolysis of the free fatty acids present in the oils and when interacting with the environment and the water triggers a series of reactions that diminish the stability of the oils, the higher the lower acidity is the conversion (Sayuri *et al.,* 2017), but even so the determined AI is lower than the recommended 2 mg KOH / g (Freedman *et al.,* 1984) (Sharma Singh and Upadhyay, 2008), therefore an acid pre-treatment prior to the trans esterification process is not required. In general, esterification is carried out under acidic conditions, while trans esterification, under alkaline conditions, the criterion for carrying out the reaction in two stages is the percentage of free fatty acids (FFA) greater than 1% (Helwani *et al.,* 2009), in this case the FFA are 0.49%. This means that esterification is not required under acidic conditions; the density for oils is generally between 0.920 g / L and 0.964 g / L, the density increases when the molecular weight decreases and increases with the instauration, it also increases approximately linearly with the increase in temperature, the mixture analyzed gave 0.9441 g / mL at 20^{or} C, is within the range.

Matter unsaponifiable 0.471%, this parameter is all matter contained in oils that are not fat, are known generically as gums and include some substances: polypeptides, phosphatides, lecithin, proteins, mucilagen, sterols, hydrocarbons, etc. All these compounds do not become biodiesel and can cause alterations in the functioning of the motor, in general, they are treated with an acid that is then neutralized together with the free fatty acids (Lenoir Christian, 2018). Elaborate biodiesel presents some advantages such as: avoids pollution, is used in mixtures of different proportions with diesel of mineral origin, with respect to diesel oil biodiesel leads you because it is not toxic like this, reduces the emissions of CO_2 net in 78%, CO_2 exhaust emissions are on average 48% lower, sulfur-free, 47% lower particulate emissions, 67% lower hydrocarbon emissions than hydrocarbon emissions from diesel engines, one disadvantage of pure biodiesel is the average increase of 10% of oxide emissions, there is currently technology and additives to reduce this disadvantage (University of Strathclyde, 2018), in addition, by-products such as glycerin are formed. The technologies advance and to avoid this formation Japan proposes a non-catalytic trans esterification at high temperatures and pressure. For every liter of used vegetable oil that is converted into biodiesel, there is a reduction of 2.5kg of CO_2 To the environment (EcoGuia Magazine, 2018), if the domestic used vegetable oil generated in Riobamba is processed, 687 977.95 Kg of CO_2 would be reduced, and taking 93% of the trans esterification yield, 255.9 m ^{3} of biodiesel would be obtained. year.

Elaboration of soaps: They are prepared by saponification processes, for this process the humidity% is not a limiting since the soda or potash dissolve in water, it is important the saponification index of the oil mixture for a correct calculation of the quantities of the indicated reagents, there are various methods: hot, cold, melting and pouring, reheating, used vegetable oils go from being non-biodegradable contaminants to soaps that are biodegradable salts and that do not produce accumulation as detergents. With a process at room temperature and 83% yield would be 213 356.4 Kg of soap / year. It is necessary to estimate the production of used vegetable oils from restaurants, hotels and fast food for data closer to the total production of the city. There are other alternatives to use the AVU.

The consumption of vegetable oil per capita in the homes of the city of Riobamba is 5.16 L / inhabitant / year, the generation of household vegetable oil is 1.52 L / inhabitant / year, the percentage that is eliminated as waste it is 29.38% with respect to the vegetable oil used, with 70.97% that expressed their intention to deliver this waste to a collector would have an estimated 255.9 m ^{3} of biodiesel / year, or 213 356.4 kg of soap / year. The handling of the oils in the preparation of the meals is not adequate, and there is ignorance of the dangers for the health, the high temperatures and their reuse. The characterizations of the mixture of vegetable oils used indicate that they can be used as raw material for biodiesel, soaps and other products. It is necessary to know the generation of used oils from other sectors to incorporate them into possible projects. It is urgent that at least there are collection and delivery programs of this waste to managers of other cities, and the ideal is to process this waste to boost productive activities of Riobamba.

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