THE INVENTIVE ACTIVITY IN THE PROCESSING AND TREATMENT OF WASTE VEGETABLE OIL

MARYURIS CHARRIS-POLO
Universidad del Magdalena / Santa Marta, Colombia
mcharris@unimagdalena.edu.co

GERARDO ANGULO-CUENTAS
Universidad del Magdalena / Santa Marta, Colombia
gerardoangulo@unimagdalena.edu.co

LUZ CADENA
Universidad del Magdalena / Santa Marta, Colombia
luzkdena18@gmail.com

ELVIS NUÑEZ
Universidad del Magdalena / Santa Marta, Colombia
elvis20nz@gmail.com

ABSTRACT

The following article was written to identify solutions to the environmental problems generated by vegetable oil residues that are used in domestic and commercial kitchens. Thus, the paper has as a purpose to publicize, through a patent analysis, the main global technological trends related to the exploitation of waste vegetable oil.

Within the analysis exposed in this study, the patents related with the processing of waste vegetable oil were studied, using the documents published between the years 2010 to 2016; as a result of this study, it was determined in which phase of the life cycle is this technology in, besides, the geographic area that was most interested in producing and protect the inventions was identified, and the leading applicants were recognized through the analysis of the type of applicants and the relations of industrial impact and technological variability.

Finally, world's technological trends were profiled through an analysis of the numbers of inventions and publications by each subclass of the international patent code, as well as an analysis of the industrial impact of inventions. As the main result of this study, it was found that the technological trends that were identified, are focused in biofuels production, proposing technologies for the treatment of raw materials and the optimization of the productive processes involved.

Key words: Vegetable Oil, Residues, Patents, Trend, Technology

INTRODUCTION

Waste Vegetable oil, which is obtained as a residue from food frying processes at both the domestic and commercial level, is a highly polluting material which, if it’s not properly managed, could be harmful not only for the environment, but

also for human health (Echavarría Restrepo, 2012). In some countries, such as Colombia, although there are public policies in the agricultural and health sectors that could regulate the management of these wastes, currently there is not a known adequate disposal or proper treatment for them (Echavarría Mejía, 2012).

It is well known that this particular waste (vegetable oil waste) can be used and processed, as a recycling material, for the production of consumer products. One of these products is the fuel in the form of biodiesel (Chiappella, 2008), which is obtained by transesterification, and is highly attractive for being considered the best substitute for diesel for its economic and environmental advantages (Lafont, Paez, Torres, 2011). On the other hand, there are the soaps; these ones can be found in both liquid and solid state and are obtained by saponification (Torossi Baudino, 2006).

Using and taking advantage of used vegetable oil could mean an opportunity for innovation and scientific research, as well as an efficient way of solving the final disposal problems that arise with this waste. It is for this reason that this research was carried out, whose main purpose is to know the technologies that have been developed in the world related to the processing and treatment of waste vegetable oil, in order to detect opportunities for the solution of the environmental problem through innovation and research.

Knowing that patents, besides being an innovation indicator (Morales and Sifontes, 2011), are also documents that have valuable information about the new technologies (Ozcan and Islam, 2017), an analysis of patents was made in which it was wanted to know the main characteristics of the inventions developed during the years of 2010 to 2016 related to the processing and treatment of discarded vegetable oil and by this way discover the technological trends worldwide in this field. In addition, it is expected to know in detail the trends and determine which of them may be useful for innovation and scientific research.

METHOD

Looking forward to know the technologies of interest for the study, it was necessary to propose a methodology that would allow to make a detailed analysis of the inventions related to the processing and treatment of waste vegetable oil. The methodological process begins with the search for information in a patent database, and ends with a detailed study of the most outstanding inventions.

The phases of the proposed methodology are described below.

i. Search in the patent database: in the search phase it is determined which databases are useful for the study, and then it is designed a search equation that can obtain the patent information related to processing and treatment of waste vegetable oil developed and published between the years 2010 and 2016. Finally, the information was downloaded for statistical analysis.

ii. Analysis of the technological development at global level: with the information of the databases, an analysis of important characteristics of the patents in general is made. Aspects such as the life cycle of inventions, their place of origin and the main applicants and their interaction, are studied at this stage of the research.

iii. Identification and description of technological trends: after analyzing the general aspects of the inventions, an attempt is made to identify the most important technological trends and to study them in detail. This part of the identification and analysis of technological trends is done with the purpose of knowing the types of technology that are most developed related to the topic of utilization of used vegetable oil and from there propose ideas for future innovations and investigations.

In addition, it is explained the content of each technological trend and show details related to the leading applicants of the technologies and years of greater activity of invention.

FINDINGS

Databases and search equation

Databases selected

The PATENTSCOPE database is a free database of the World Intellectual Property Organization (WIPO), a global forum aiming to develop an international intellectual property system, which allows processes of creativity innovation for the benefit of all. This patent database makes possible to search over 64 million patent documents, and WIPO provides a document called "PATENTSCOPE User's Guide", which explains precisely how to search for information.

Taking into account the above, PATENTSCOPE was selected for the searching of the patent documents. Although this database is considered appropriate for document search, the information that is downloaded from it is not complete and does not provide data that is indispensable for the study; for this reason, the LENS.ORG database is used.

The LENS.ORG database is a patent database that belongs to an open global cybernetic structure that drives more efficient, fair and transparent innovation systems. LENS.ORG offers in an open and free way the information of almost all the documents of the patent of the world, the information is much more complete and detailed that the one offered by the PATENTSCOPE database.

Construction of the search equation

As it was mentioned before, the database selected for the search of the patent documents was PATENTSCOPE. In its search options, the database provides the option to do an advanced search, which through a search equation allows to find the documents using keywords related to the thematic of the technology in study.

After identifying the keywords and establishing the time intervals and an approximate of the patents needed for the study, the following search equation was made.

EN_ALLTXT:((Process* OR treatment) AND "wasted oils”) OR EN_ALLTXT : ((process* OR treatment) AND "wasted cooking oils") OR((Process* OR treatment) AND "Brown grease") OR ((Process* OR treatment) AND "Yellow grease") AND (AD:[2010 TO 2017] OR DP:[2010 TO 2017]) ANDNOT EN_TI: ("amino acid" OR "nucleic acid” OR "algae")

The equation above was designed to yield a result of about 1000 patent documents that were published between the years 2010 to 2016. It was considered that an approximate amount of 1000 documents would be ideal to do a statistical study of the general characteristics of the inventions and simultaneously to make a deeper analysis of the outstanding patents.

Technology life cycle

The graph shows that the patents related to the processing and treatment of waste vegetable oil published between the years 2010 to 2016 have their beginnings in the year 2000, where the first invention for this technology appears and it is the only one for that year. After the year 2000 and until 2006, the registration of inventions remains constant until the year 2007 where eight inventions are presented and from there the patent registration increases considerably with the passing of the years. 2011 was the year with the highest patent registration, with 161 inventions for that year and a cumulative of 507 documents.

After the year 2011 the inventive activity of the technology related to the utilization of used vegetable oil begins to decrease, and does not present again a considerable increase. By 2016 the development of technology related to the treatment of vegetable oil is in decline.

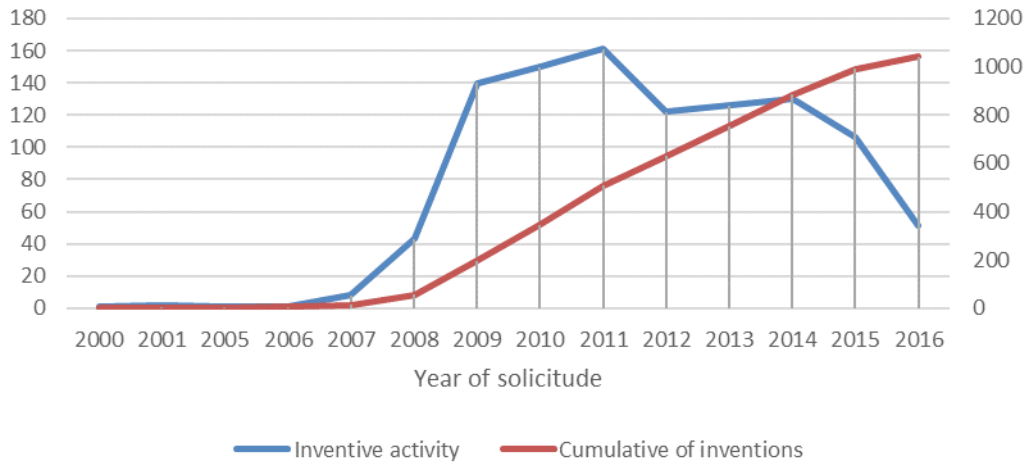
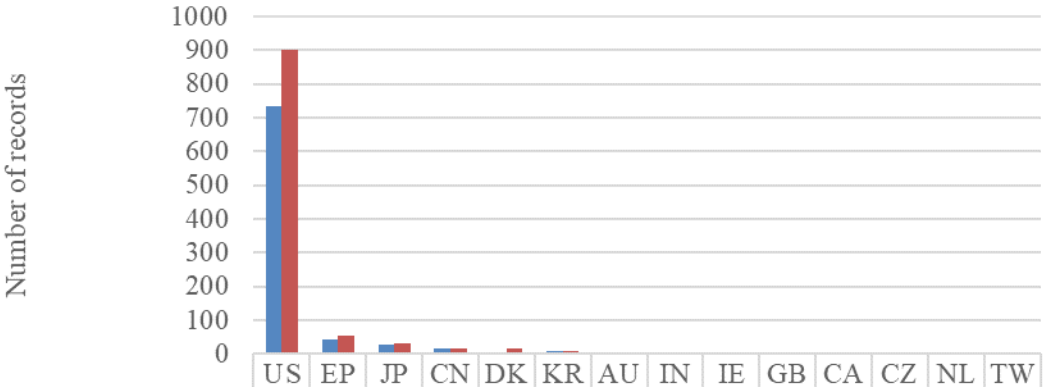


Figure 1: Life cycle of the technology in the processing and treatment of waste vegetable oil, based on the inventive activity, Source: Own elaboration using lens.org

Leading countries in the production of technology according to inventive activity and patenting

An analysis of the place of origin of the inventions found that the leading country in the production of technology related to the processing and treatment of waste vegetable oil is the United States, which has produced over 86% of the inventions and is owner of about 86% of all publications; The remaining 14% of inventions and publications are distributed in 13 geographic locations, including European countries, Japan, China, Denmark and South Korea.



	US	EP	JP	CN	DK	KR	AU	IN	IE	GB	CA	CZ	NL	TW
Inventive activity	734	42	29	17	4	8	3	2	0	3	2	0	1	1
Patenting activity	903	53	30	17	16	8	5	3	3	3	2	2	2	1

Figure 2: leading countries in the development of technology related to the processing and treatment of discarded vegetable oil based on inventive activity and patenting, Source: Own elaboration using lens.org

Leading offices of destination according to the presentation activity

The leading offices in the protection of inventions related to the waste vegetable oil exploitation are the offices of the United States of America and the world intellectual property. The 1048 patent publications found are protected and distributed in five patent offices; the first one is the United States of America office which has protection of approximately 48% of the inventions studied, and is followed by the office of the world intellectual property organization with about 34% of the documents.

The third, fourth and fifth places are occupied by the European Patent Office, the Canadian Office and the Chinese Office respectively, which in total protect the remaining 18% of inventions in this technology. With the chart it was possible to note that although the United States produces more than 80% of the vegetable oil treatment technology, it is not its office that protects all the technology, indicating that other offices, such as the European patents office and the Canadian office might be protecting US inventions, this is evident if it is observed that, although European countries register 53 patents, the European office protects 110, so does Canada with 17 patents, but its office protects 70.

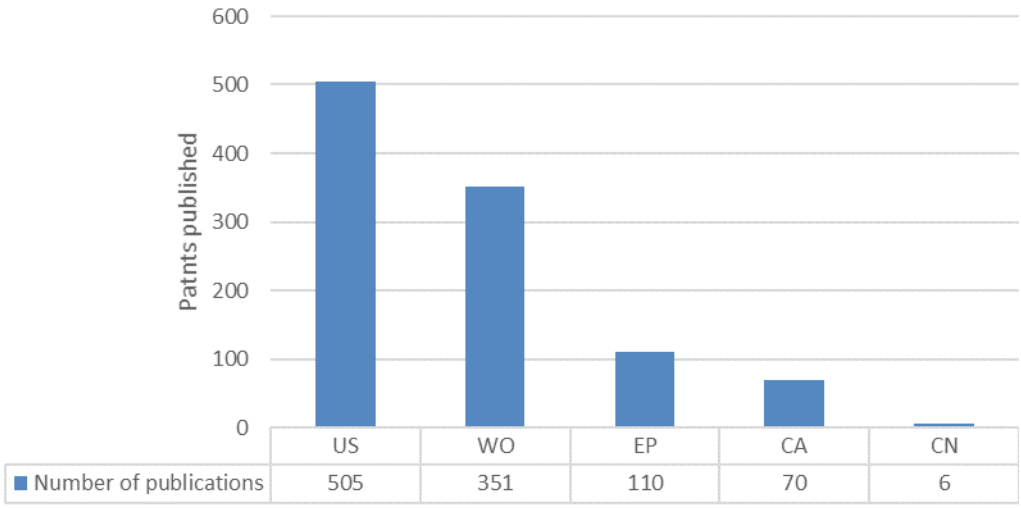


Figure 3: leading offices of patents related to processing and treatment of waste vegetable oil from the presentation activity, Source: Own elaboration using lens.org

Types of applicants for technology

Of the 1048 inventions studied, it was found that the applicants for the protection of 922 of them are companies, universities or academic organizations, while the applicants of the remaining 126 inventions are natural persons. This demonstrates the great interest of legal entities in developing technology that allows the use and exploitation of waste vegetable oil to generate products or byproducts useful in the business field and in the researching field.

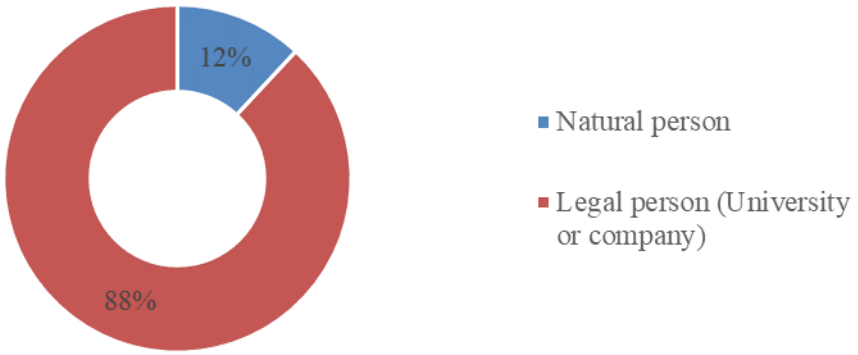


Figure 4: Types of applicants for the protection of technology related to the processing and treatment of waste vegetable oil, Source: Own elaboration using lens.org

Leading applicants identified from the relationship between inventive activity and industrial impact

Using the information related to the relations between inventive activity and industrial impact, it was possible to identify that the leading applicant, from the group of the most outstanding applicants, is ELEVANCE RENEWABLE SCIENCES, who is the applicant that registers a high inventive activity and a high industrial impact.

The group of eight applicants shown in figure 5, stand out because of their high industrial impact, but there are differences between them in the inventive activity, which is why it is observed that, while the leader applicant registers 137 inventions and 110 citations, the other prominent applicants register between 6 and 10 inventions and between 49 and 86 citations.

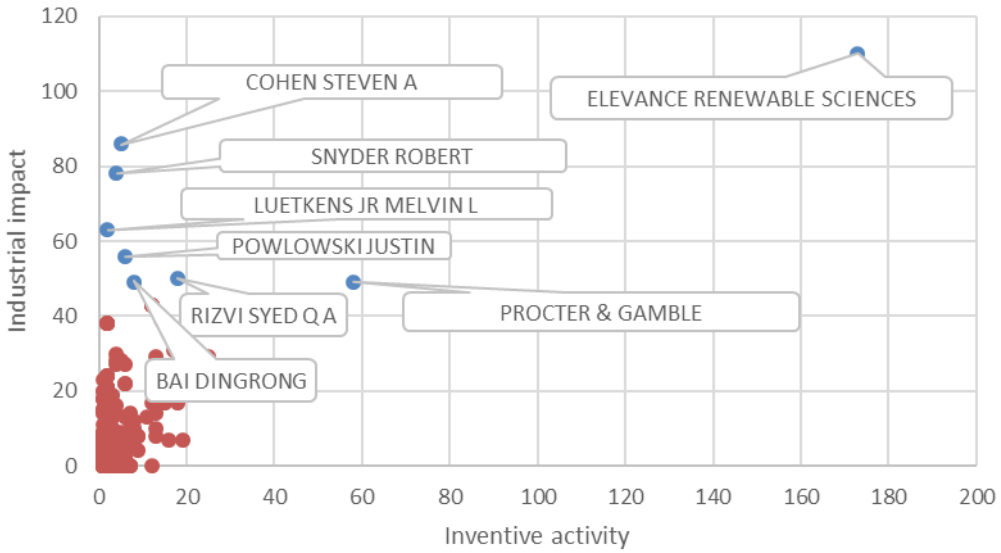


Figure 5: leading technology applicants identified from the relationship between inventive activity and industrial impact, Source: Own elaboration using lens.org

Leading applicants identified from the relationship between inventive activity and technological variability

In terms of technological variability, leading applicants are identified using the number of subclasses of the international patent code in which their inventions are classified; As shown in figure 5, ELEVANCE RENEWABLE SCIENCES is a leader in technological variability by producing 33 types of technologies related to the use and exploitation of waste vegetable oil.

On the other hand, the graph shows a group of eight applicants, among whom are companies, universities and natural persons, who despite of not presenting a technological variability as the leading applicant, stand out from a larger group marked in orange color, since they register their inventions in between 10 and 12 different subclasses.

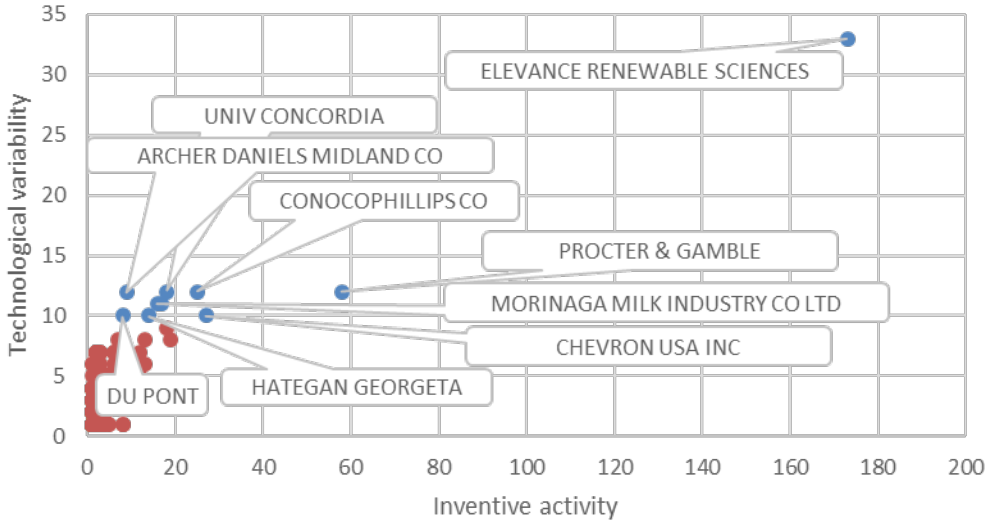


Figure 6: leading applicants of technology identified from the relationship between inventive activity and technological variability, Source: Own elaboration using lens.org

Identification of technological trends

To identify technological trends at an international level, it was necessary to make an analysis of the international patent classification code of each of the patent applications found, in this analysis the patent applications were grouped by subclasses.

With the above it was possible to determine that approximately 80% of the inventions studied are classified in seven subclasses of the international patent code (C07C, C10L, A61K, C11C, C10G, C11D and B01J), which could be considered previously as the technological trends in the processing and treatment of residual vegetable oils. However, to define the technological trends, it was necessary to take into account other aspects.

Besides of the number of registrations, the industrial impact of patents has a lot of relevance when it comes to establishing the technological trends that were studied in detail.

Preliminary selection of technological trends

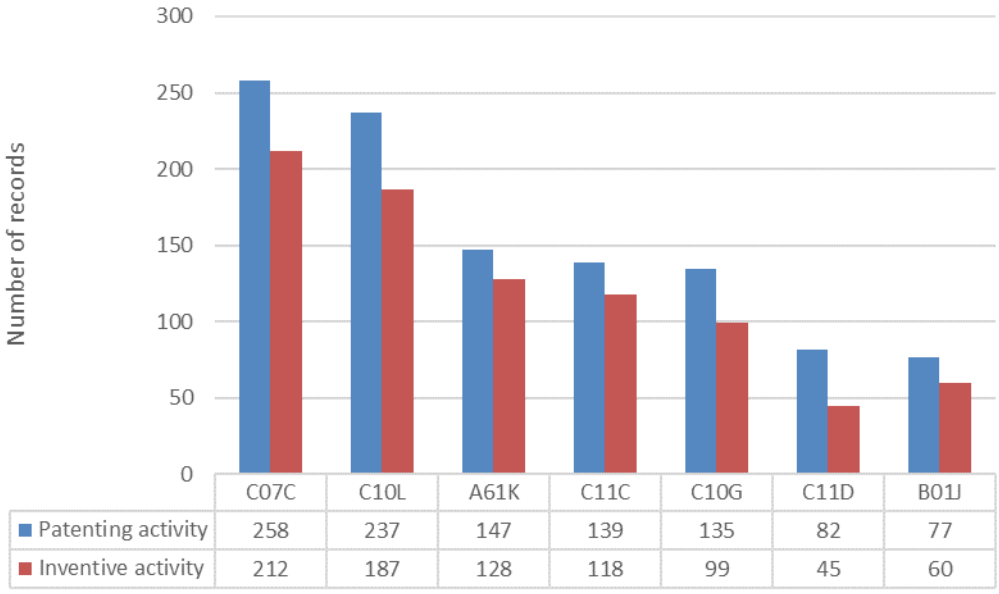
From the constructed search equation, a total of 1048 patent applications were found related to the processing and treatment of waste vegetable oils. According to international patent classification codes, seven major technology trends were identified previously, which were selected taking into account the number of registrations per subclass

Note that this graph not only measures the total number of records for each subclass, but also makes comparisons between inventive activity and patenting

activity, then it is possible to observe how the first two trends, C07C and C10L, are the most outstanding in both inventive activity and patenting activity, which could mean that they are the strongest trends in processing and treatment of waste vegetable oil.

The graph also shows that the following three subclasses (A61K, C11C and C10G) have similar amounts of registrations in both inventive and patenting activity, so it was necessary to compare the industrial impact of patents to identify which of them is actually a predominant trend.

For the last two subclasses (C11D and B01J), it was necessary to analyze how strong their industrial impact is, and consequently, and it was determined if technological trends can be considered or not.



	C07C	C10L	A61K	C11C	C10G	C11D	B01J
Patenting activity	258	237	147	139	135	82	77
Inventive activity	212	187	128	118	99	45	60

Figure 8: technological trends according to inventive activity and patenting, Source: Own elaboration using lens.org

Analysis of the industrial impact of the selected types of technology

As it was previously mentioned, with the aim of selecting the technological trends related to the processing and treatment of waste vegetable oil that were studied in more detail, it was necessary to use the industrial impact of each type of technology, since with the indicator of the industrial impact it was possible to identify which technological trend is more accepted by the industry and the market, and this represents an aspect that is important when it comes to thinking about future processes of innovation and scientific research.

By analyzing the industrial impact, it can be observed that the two main trends in inventive activity C07C and C10L are also the tendencies with the greatest industrial impact, with C10L being the predominant trend, having fewer inventions with a high industrial impact.

The two following trends into the inventive activity A61K and C10C are subclasses that could be said to have an industrial impact proportional to the number of inventions they record.

Now, for the subclasses marked with red color (C10G, C11D and B01J), it was possible to conclude that the subclasses C10G has a low industrial impact considering the number of inventions it registers, for that reason it cannot be considered a technological trend; in contrast, the subclasses C10D and B01J have a considerable industrial impact; they register a low number of inventions, however it was not possible to consider them technological trends since the number of inventions is very low in comparison with the other tendencies.

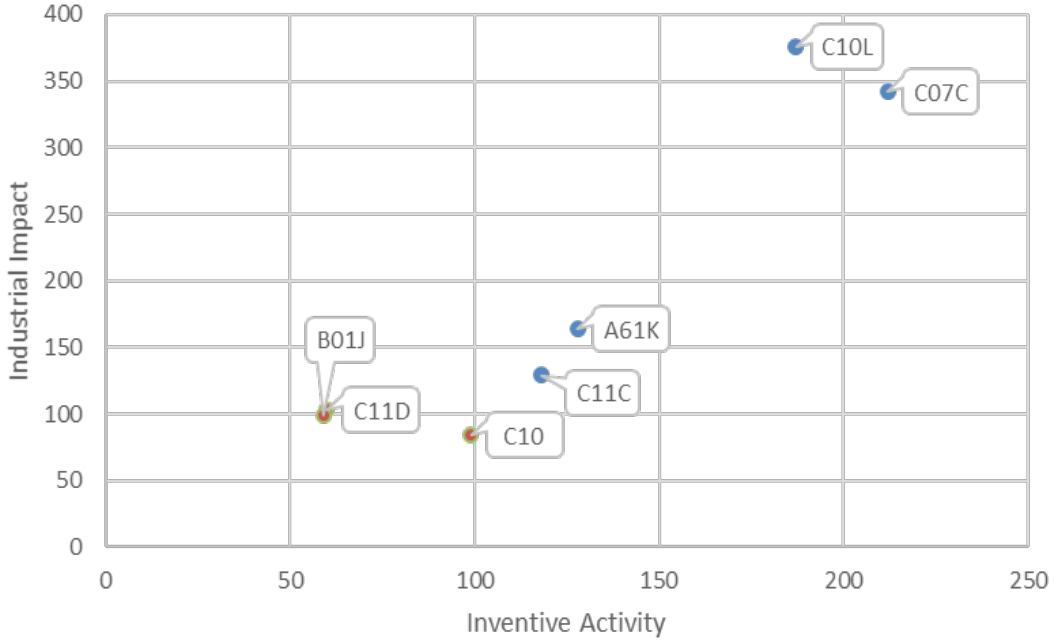


Figure 9: Relationship between the inventive activity and the industrial impact of technological trends, Source: Own elaboration using lens.org

Names for technological trends

The following table shows the technological trends identified in the previous process with their respective names, these were established from a preliminary inspection in which samples of inventions were taken for each type of technology and studied in detail with the purpose of understanding what each invention consists of and find, for each subclass, factors in common that could be useful when it comes to tittle each technological trend.

Table 1: names for each of the technological trends from the preliminary analysis of the inventions found

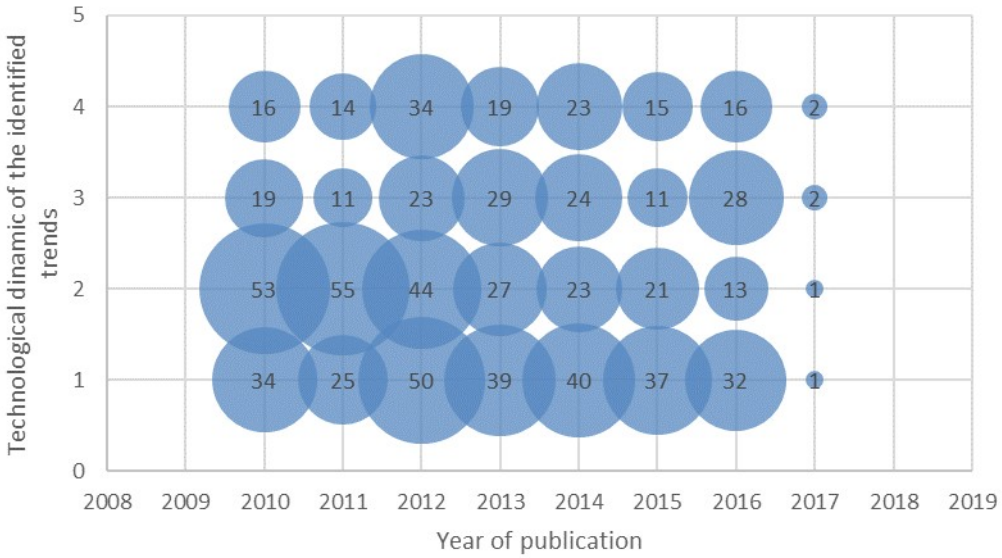
Subclass	Proposed name for the technology trend
C07C	Raw material treatments.
C10L	Production of biofuels.
A61K	Methods and formulations for food processing, cosmetics and fuels.
C11C	Improvements in the production of waxes and fuels.

Chronological evolution of the selected trends

With figure 10, it is easy to detect that in general the year with the highest number of publications was 2012, and the year with the lowest number of applications is 2016.

Analyzing each of the trends individually, it was observed that for trend one ("Raw material treatments") the years with the greatest number of publications are the years 2012, 2013 and 2014, with 50, 39 and 40 publications respectively, although the number of publications for the remaining years are values not too far from these. For the second trend ("Production of biofuels"), the years with the greatest number of publications are the years 2010, 2011 and 2012 with 53, 55 and 44 inventions respectively; From the year 2013 the number of publications decreases drastically for this trend.

With respect to trends three and four ("Methods and formulations for food processing, cosmetics and fuels" and "Improvements in the production of waxes and fuels"), they are quite stable over time, but in both cases there are years in which the number of publications is remarkable. For example, in trend A61K the most representative years are the years 2013 and 2016 with 29 and 28 inventions respectively; while for trend C11C the most representative year is the 2012 with 34 publications.



1. Raw material treatments. 3. Methods and formulations for food processing, cosmetics and fuels.
2. Production of biofuels. 4. Improvements in the production of waxes and fuels.

Figure 10: technological dynamics of the identified trends, Source: Own elaboration using lens.org

Description of technological trends

Below, each technological trend, its characteristics, main applicants, key years and other relevant aspects are presented in detail.

Treatments of raw materials

The trend named as "treatment of raw materials", include all those patents that describe chemical or thermal reactions that look for making treatments and improvements of the discarded vegetable oils, so they can be useful as raw materials for the elaboration of different products, in which biofuels and hot melt materials stand out.

The following table provides detailed information about the "raw material treatments" trend, more precisely, data related to the leading applicants for this trend and the years in which there was the highest inventive activity.

Table 2: main patent applicants in "raw material treatments"

Treatment of raw materials		
Trends	**Main applicants**	**Years with greater inventive activity.**
CIP Code / # of inventions.	**Name of applicants/ # of inventions.**	**Year / # of inventions**
CO7C [257]	ELEVANCE RENEWABLE SCIENCES [75]	2015 [23]
	CHEVRON USA INC [17]	2011 [9]
	STEPAN CO [12]	2009 [12]
	UOP LLC [4]	2012 [4]
	CONOCOPHILLIPS CO [6]	2010 [6]

Production of biofuels

When talking about the trend "biodiesel production", this refers to all those patents that propose methods, procedures and machinery for the production of biodiesel and combinations of this, using as main raw material discarded oils of organic origin including vegetable oils. Within the outstanding inventions, they

were found modifications in chemical reactions, pretreatment of oils and the design of equipment for the procedures.

As in the previous technological trend, the following table shows detailed information of the leading applicants in "biodiesel production", which were identified taking into account the number of patented inventions.

Table 3: main patent applicants in "biodiesel production"

Biodiesel production		
Trends	**Main applicants**	**Years with greater inventive activity.**
CIP Code / # of inventions.	**Name of applicants/ # of inventions.**	**Year / # of inventions**
C10L [237]	ELEVANCE RENEWABLE SCIENCES [32]	2012 [13]
	CHEVRON USA INC [26]	2011 [10]
	EXXONMOBIL RES & ENG CO [16]	2010 [8]
	RIZVI SYED Q A [15]	2012 [13]
	MILLER STEPHEN J [12]	2011 [6]

Methods and formulations for the elaboration of foods, cosmetics and fuels

The main characteristic of this technological trend is that waste vegetable oils are not the main raw material for the production of these products, however, this becomes useful in some of the processes that are carried out in the proposed methods or are component of the formulations. It should be noted that the foods referred into the name of the trend, are animal fattening food products. In addition, for the manufacture of cosmetics (hair products), components of discarded oils that have been retreated are used.

The main applicants for protection of technologies related to "methods and formulations for the manufacture of food, cosmetics and fuels" are specified in the following table.

Table 4: main patent applicants in "methods and formulations for food processing, cosmetics and fuels"

Methods and formulations for the elaboration of foods, cosmetics and fuels.		
Trends	**Main applicants**	**Years with greater inventive activity.**

CIP Code / # of inventions.	Name of applicants/ # of inventions.	Year / # of inventions
A61K [147]	PROCTER & GAMBLE [42]	2013 [16]
	MORINAGA MILK INDUSTRY CO LTD [15]	2011 [8]
	PRICE KENNETH NATHAN [11]	2011 [11]
	SAUNDERS CHARLES WINSTON [11]	2011 [11]
	GREEN PHILLIP RICHARD [11]	2011 [11]

Improvements in the production of waxes and fuels

This technological trend is made up of patents that propose procedures, tools and compositions that improve the quality of the final products (waxes and fuels). Among the outstanding inventions related to this technology, it was found that most of them are focused on improving the process of making wax for candles and for that, chemical reactions such as metathesis and transesterification are used.

On the other hand, for the production of biofuels, there were found proposals focused on new processes.

The following is a table showing relevant information related to the leading technology applicants in "improvements in the production of waxes and fuels". The table also specifies the years of greatest invention.

Table 5: main patent applicants in "improvements in the production of waxes and fuels"

Improvements in the production of waxes and fuels.		
Trends	**Main applicants**	**Years with greater inventive activity.**
CIP Code / # of inventions.	**Name of applicants/ # of inventions.**	**Year / # of inventions**
C11C [139]	ELEVANCE RENEWABLE SCIENCES [45]	2012 [16]
	CHEVRON USA INC [9]	2011 [8]
	HATEGAN GEORGETA [7]	2012 [7]
	MILLER STEPHEN J [7]	2011 [6]
	RIZVI SYED Q A [7]	2012 [7]

CONCLUSIONS

After carrying out the study of patent analysis, and considering the results obtained in this one, it can be concluded that the technology in processing and treatment of waste vegetable oil is not an emerging or growing technology. It

was observed that, since 2014, the technology is in decline and until the year 2016 does not register any growth in the number of inventions with the passing of the years.

With respect of the origin place, it was found that the United States is the most interested country in producing technology related to the use of residual vegetable oil. This is evident since it can be noted that 90% of the patents analyzed in this study were of American origin; besides, the inventions produced by the United States are technologies of great acceptance globally; because offices such as The World Patent Office (WO), The European Patent Office (EP) and The Patent Office of Canada (CA) were found to protect technology produced in the United States.

An important aspect that could be analyzed is the type of applicant for technology protection; with this information, it was possible to understand that if the companies and universities request the protection of more than 80% of the inventions analyzed in this study, it is because there is a potential market for innovation in the subject of waste vegetable oil. On the other hand, it could be noted that ELEVANCE RENEWABLE SCIENCES is a leading applicant in the protection of technologies related to the processing and treatment of waste vegetable oil. This company is not only notable for the number of patents it registers, but also because they registered high values of industrial impact and high technological variability.

From the trends that were identified, the strongest were “Raw materials treatment” and “biofuels production”, the first trend is predominant in the number of inventions, however, the second trend has a greater impact in the industry. By the same way, it was found that the identified technological trends are mostly focused on the generation of renewable energy sources such as biofuels. This could indicate that a possible solution to the contamination problem generated by vegetable oil residues is to treat and process them to produce such energy sources. In contrast, regarding the technological trends, it was known about the elaboration of fattening food products and cosmetic products. That demonstrates the existence of other possible markets for the processing and treatment of waste vegetable oil.

RESEARCH LIMITATIONS

The limitations of this research are related to the information provided by the databases used, since PATENTSCOPE and LENS.ORG databases do not provide data on patents that may be useful to obtain more accurate and specific conclusions.

One of the data that does not show the bases of patents, is information about the inventions that are in the process of patenting; for this reason, it is not possible to determine the real number of inventions that are produced per year. The above affects the life cycle analysis of the technology.

On the other hand, the databases do not inform about the state of the patents, that is, it is not possible to know if the patent is of free use, if they are exploited

commercially at present or if there are more current versionsof the inventions. If you want to know this information, it is necessary to study patents individually.

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