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REVIEW
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Trends in Sieving and Its Applications in Cereals. A Literature Review

Nevardo Sanchez-Suarez, Gina Lia Orozco-Mendoza, Jhon Wilder Zartha-Sossa, Delcy Camila Gafaro-Garcés, Lourdes Gladys Melchor-Cahuana and Cristian Gonzalez-Tovar*

Faculty of Agro-Industrial Engineering, Universidad Pontificia Bolivariana, Medellín, Colombia

In the agroindustry, sieving is a unit operation of great value, this work aims to make a literature review on sieving in cereals, a search equation was carried out in the Scopus database with the keywords sieve, screen, food process, and cereal that resulted in 132 articles and 174 patents. Of the articles, 44 were directly related to sieving and 14 more had something to do with sieving; of the patents, in the last 10 years only 7 were directly related to sieving. To find new trends, raw materials, patent analysis, and information analysis, tables were built with name, year, author, keywords, countries, quartile, journal, relationship with the agroindustry, and purpose. Among the most important conclusions was the application of sieving in raw materials such as Rice, Corn, Wheat, Cotton, Millet, Quinoa, Almonds, Barley, Potato, Yucca, Microorganisms, Oats, Cotton, Protein, Peppers, and Chia Seed. Furthermore, the use of rotating and vibrating sieves was identified, and also their positive effects on the physicochemical, standardization, and classification of raw materials were identified. The different types of equipment or methods focused on sieving, that has been granted use or design patent, were also recognized.

Keywords: sieve, screening, cereals, agroindustry, applications, patent

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****Correspondence:***
Jhon Wilder Zartha-Sossa
jhonzarthasossa@gmail.com

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INTRODUCTION

Sifting in food and nonfood agroindustrial products is a unitary operation of great importance both at a business level and at an academic and research level, since the application sectors are quite wide, such as seed selection, flour classification, and mineral classification among others (Warren McCabe, 2007). It is considered one of the simplest methods for particle size classification in laboratories and in industries in general, where the process occurs mainly by separating the product into two parts, the larger particles remain on the upper sieve and the other particles fall. To achieve more effective sieving, it is very common to order a series of sieves with the widest openings at the top, so that the product can be obtained with the desired size and the large particles can be brought back to a grinding process, that is why it is normally used as a complement to many size reduction operations (Foust, 1990). It is very important to know the diameter of the product you want to obtain because, in this way, it will be much easier to arrange the sieves with the right diameter. At present, there are some series of sieves one of the best known is the series of Tyler sieves in which, as the number of the sieve increases the diameter of the openings of this decreases (Arndt et al., 2020). The article seeks to answer the following questions: What raw materials are screened? What is the purpose or applications of the new patents that have been granted on screening? And what are the applications of the sieving process in the processes?

To answer the three questions posed, this document is composed of four phases. In the first phase, a theoretical conceptual framework is presented that relates the main concepts or definitions of the unitary operation of screening; in the second phase the methodology is explained, emphasizing the search equation used in Scopus; and in the third phase, the results are explained in terms of countries of origin of the publications, type of journal, time series of the articles and topics, raw materials evaluated in the articles, and the mathematical models. The last phase contains a discussion, patent analysis, and contributions that will answer the questions raised as the main focus of this article.

CONCEPTUAL FRAMEWORK

In the food industry, it is very common to seek to standardize the size of different products to offer the customer the same type of product always, and for this, the sifting or screening has shown great potential (Arndt et al., 2020), which represents one of the most important methods used for years in the agroindustry allowing to retain particles of different sizes according to the purpose of screening (Uriarte-Aceves et al., 2020). The term screening refers to the method of separating particles based solely on their size. When industrial screening is carried out, the solids are placed on the screen surface. Small particles, also called fines, can be found passing through the screen openings; while larger particles, also called tails, do not pass (Warren McCabe, 2007).

A sieve or screen apart from sieving can help to prepare the samples of different products for performing a later analysis, this can be done since with sieving impurities are being removed from the samples and at the same time, the product is being homogenized to be taken to other equipment, in which it is very important to take the sample as homogeneous and clean as possible, to determine different compositions (Sirohi et al., 2020). A sieve or screen can be defined as a surface containing a certain number of openings of equal size, and whose surface can be flat (horizontal or inclined) or cylindrical. These openings refer to the space between the individual wires of a wire mesh sieve and are related to the mesh number of the sieve, which is the number of openings per linear inch. Industrial sieves are made with metal bars, sheets, and perforated cylinders or with fabrics and woven wire. Materials for the construction of the sieves for separating food include stainless steel and nylon fabrics (Velásquez, 2011).

Drum sieves are rotating cylindrical sieves mounted almost horizontally. The sieving surface can also be made of wire mesh or a perforated plate (Velásquez, 2011). It is also important to consider that sieving is largely used as a posttreatment, mainly, in grinding and drying operations where the standardization of the worked products is being sought to offer high quality to the customer (Geankoplis, 1998).

Vibrating screens consist of a frame that supports a grid or perforated plate, which is shaken mechanically or electromagnetically, and the resulting movement pulls the products over the surface of the screen. They are generally slanted from the horizontal, and can also be multiple layers or series mounted one below the other, thus separating the load into several size intervals (Velásquez, 2011).

Bearing in mind that sifting is a method of particle separation based on size difference only. In the processes of sifting in the industry, the solids are poured onto a perforated surface or sieve, which allows the small particles, or "fines," to pass through and retain those of larger sizes, or "rejects." A sieve usually only can make one separation into two fractions, the importance or usefulness of putting different series of sieves in the same process to obtain different fractions, these fractions are called unspecified size fractions, because, although the upper or lower limit of the size of the particles is known only the average size of the particles can be found, so the real size is unknown, but an approximate (Foust, 1990) is known.

The different types of sieving that are found in the industry help in multiple tasks in the transformation processes of raw materials, namely, elimination of impurities and homogenization among others. The important thing about the operation is those producers can select and standardize the sizes of their products (Rocchetti et al., 2019) and also select the sieve that more fits your process and achieves the capacity of the company, because apart from efficiency, capacity is an important component in industrial sieves, and this capacity is measured by the mass of material that can be received as feed based on time and surface unit (Zartha Sossa, 2011).

Considering the previous assessments, it can be said that the distribution of the sieves is given by the size that you want to obtain in the given sieve or process, taking into account that the sieves with wider holes will be in the upper part, allowing for gravity the smaller particles descend to sieves with smaller openings. However, there is equipment such as "elutriator-centrifuge" where each of the granulometric fractions is formed according to the density of its particles, but the granulometry of its particles lacks homogeneity. This process is carried out by suspending the sample in an airflow allowing the coarser particles to fall while the finer particles are transported by an airflow (Frías et al., 1990) indicating greater effectiveness of classification of particles in a sieve if the sieves are properly distributed.

METHODOLOGY

To obtain good results in the reading, the work was divided into 4 stages as follows:

- **Stage 1:** Search and selection of the theme to work on. The topic of screening was chosen because it is a method widely used in history for the classification of products and that today is very useful for the industry. Subsequently, agroindustrial engineering students were contacted who had already made progress in technologies of sifting.
- **Stage 2:** Elaboration of a search equation to obtain articles to expand the topic, the keywords used for the equation were sieve, screen, Food process, and cereal giving, as a result, the following equation: "TITLE-ABS-KEY (sieve OR screen*)" AND "food process AND cereal*," the period was openly left to widen the search. The above search equation yielded a total of 132 articles and 174 patents. With the previous keywords we

made a news search in Google news to know what trends exist in the area of screening, for this we worked with the following equation: "Ultrasonic Sieves and food."

- **Stage 3:** Reading and selection of the articles found to focus a little more on the topic. Once the 132 articles were reviewed, 74 were discarded that had nothing to do with the screening issue a format in Excel was constructed that contains the following aspects year, title, authors, country, journal, cite score, quartile (Scimago), keywords, summary, relationship with agroindustry, worked product, mathematical model, purpose, and conclusion.
- **Stage 4:** Evaluation of patents related to the search equation of stage 2, for the period of the last 10 years, finding 7 patents directly related to the screening topic identifying the patented equipment or methods, the agroindustrial products, and the companies or patent applicants and the countries.

These stages can also be seen in **Figure 1**.

RESULTS

Graphics Obtained

To analyze the basic information found in the articles an Excel table was built in which the year, title, authors, country, journal, cite score, quartile, keywords, and a summary were compiled, then the information was sent to be analyzed by the VANTAGE POINT software that the UPB has, the software was in charge of finding the different correspondences and trends among the information of each paper read. Each graph allows us to visualize the research trends in each country, the journals, and the articles read. VantagePoint is a text mining-based analysis tool with database structured text processing capabilities, extracting trends, patterns, and relationships, it is a text-mining tool for discovering search results from patent databases and academics. The software allows you to generate relationships, find critical patterns, and contains 5 important capabilities: import, clean, analyze, generate reports, and automate, also allows the creation of lists, maps, and matrices, and uses various techniques such as natural language processing, analysis of cluster, and co-occurrence matrices.

Figure 2 shows on the vertical axis the journals where the most publications of articles read were found and on the horizontal axis the countries of origin of these journals, taking orders in the upper left part as the point with the highest number of publications. In the figure, it is possible to appreciate that the journal with more publications in the research is the journal of food processing and preservation, cereal chemistry, and the journal of food engineering. These journals are important because with this information you can analyze possible journals in which the current article can be published, and based on this you can make a more precise search for future research.

Figure 3 shows the relationship between some of the most used keywords and some authors, being the names of the authors in the blue dots and the keywords in the brown dots, generating a line between these being able to identify that some of those words are incorporated repeatedly by different authors in their papers, some of those words are sieves, modeling, food metabolomics, and gluten-free, in this way it is possible to appreciate which are the main subjects treated in the different consulted papers.

Figure 4 shows the relationship found between the journal and the keywords with the highest number of mentions in each of these journals, with the blue dots corresponding to the journals and the brown dots to the keywords. In addition, it can be seen that some journals have links with more than one keyword. The journal with the highest ratio among keywords is the journal of food processing and preservation these journals and keywords

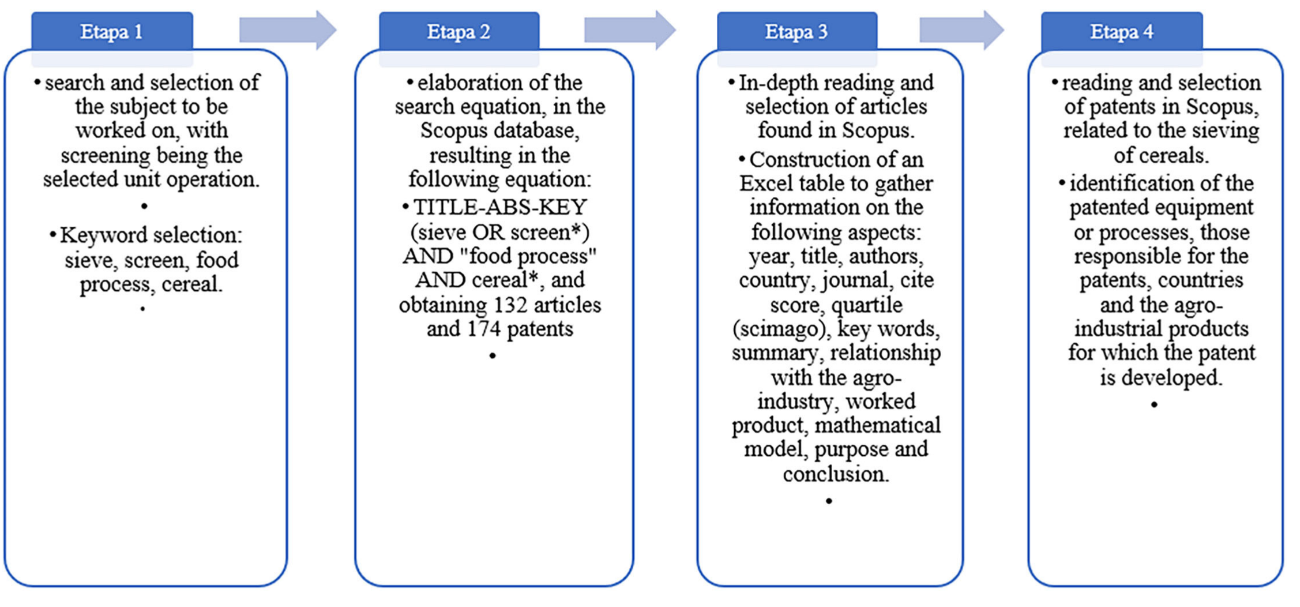

FIGURE 1 | Stages of paper creation. Source: The authors.

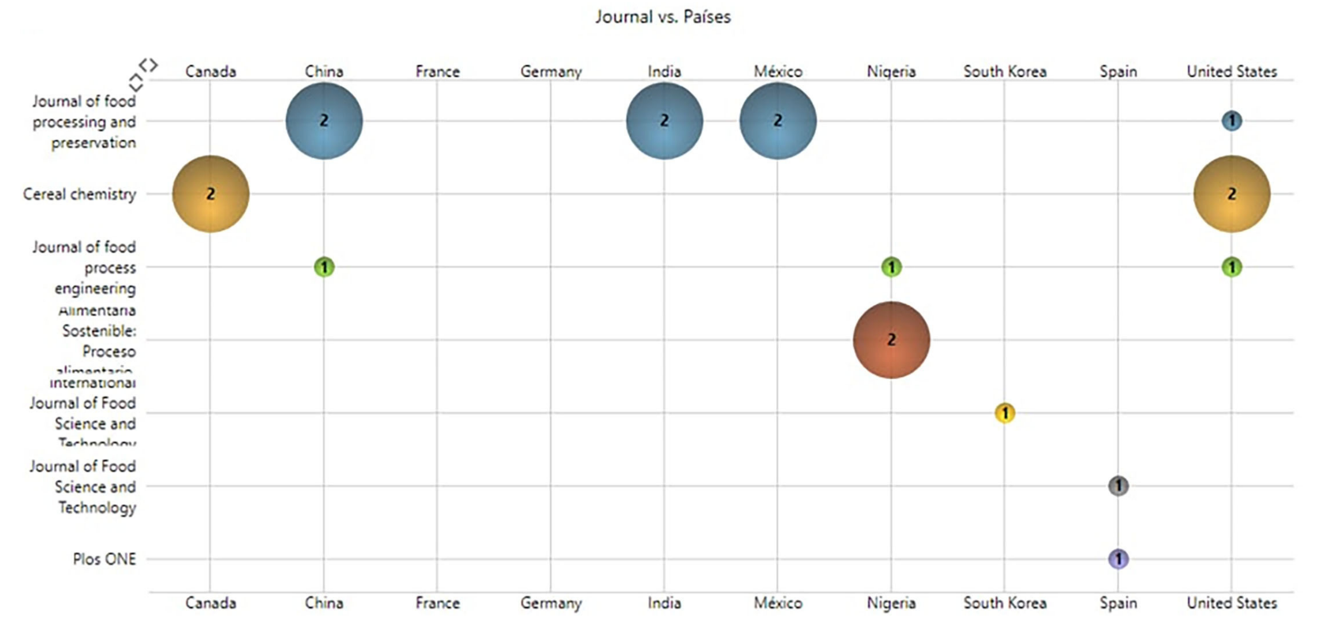

FIGURE 2 | Journal vs. countries of origin of the paper. Source: Vantage point software (through information provided by the authors).

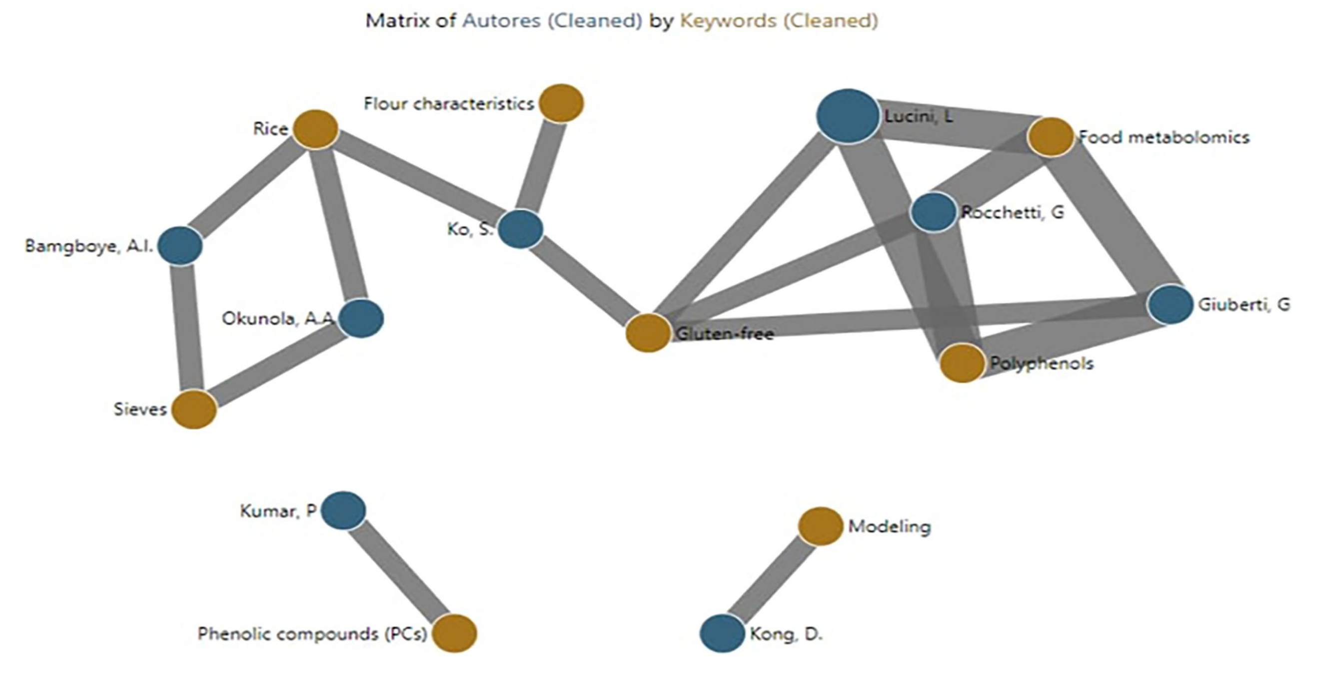

FIGURE 3 | Matrix of authors by keywords. Source: Vantage point software (through information provided by the authors).

represent some of the trends on which future research can be focused.

Figure 5 shows the relationship found between the keywords and the countries that published the different articles. On the vertical axis, the most used keywords in publications of articles read, and on the horizontal axis are the countries where they were applied. It shows which keywords are used according to the country where the paper was published and, based on this, it is possible to determine the focus of research on the topic in each country that publishes.

Figure 6 shows the main phrases found in the abstract of each paper and is represented based on the number of times it is found

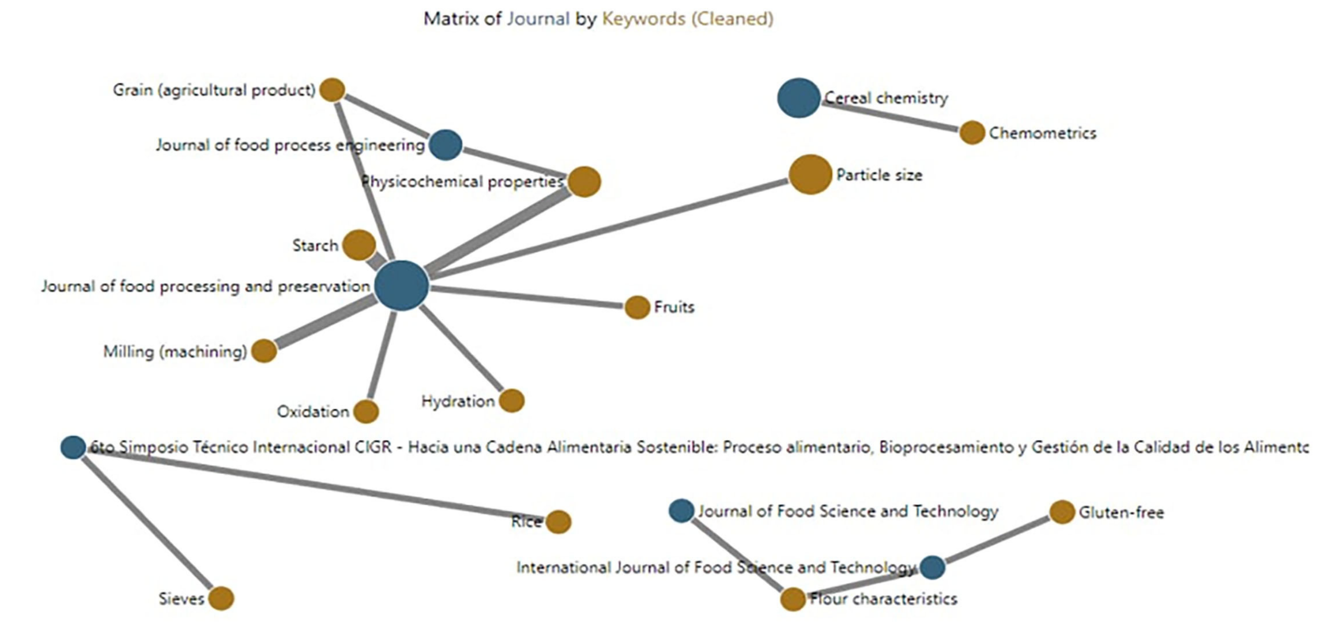

FIGURE 4 | Journal matrix by keywords. Source: Vantage point software (through information provided by the authors).

FIGURE 5 | Keywords vs. paper source countries. Source: Vantage point software (through information provided by the authors).

in the different papers, in this way the phrases with a greater number of repetitions or the most important are shown in a larger size than those that are repeated more rarely, in this sense the most important phrase or the one that is repeated the most is practical applications followed by particle size, moisture content, and particle size distribution.

The cluster of authors is presented in **Figure 7**, in this figure can be seen the authors present a greater number of publications within the readings made, and therefore they represent the main advances in research about the sifting topic.

The keywords are an important part of an article since just by reading them we can induce the subject of the article and allow finding the articles in the databases more easily, for this reason in **Figure 8**, a compilation of keywords of the evaluated articles is shown, the keywords that were found most are presented in larger font size, according to this the main keywords

FIGURE 6 | List of sentences found in the different abstracts. Source: Vantage point software (through information provided by the authors).

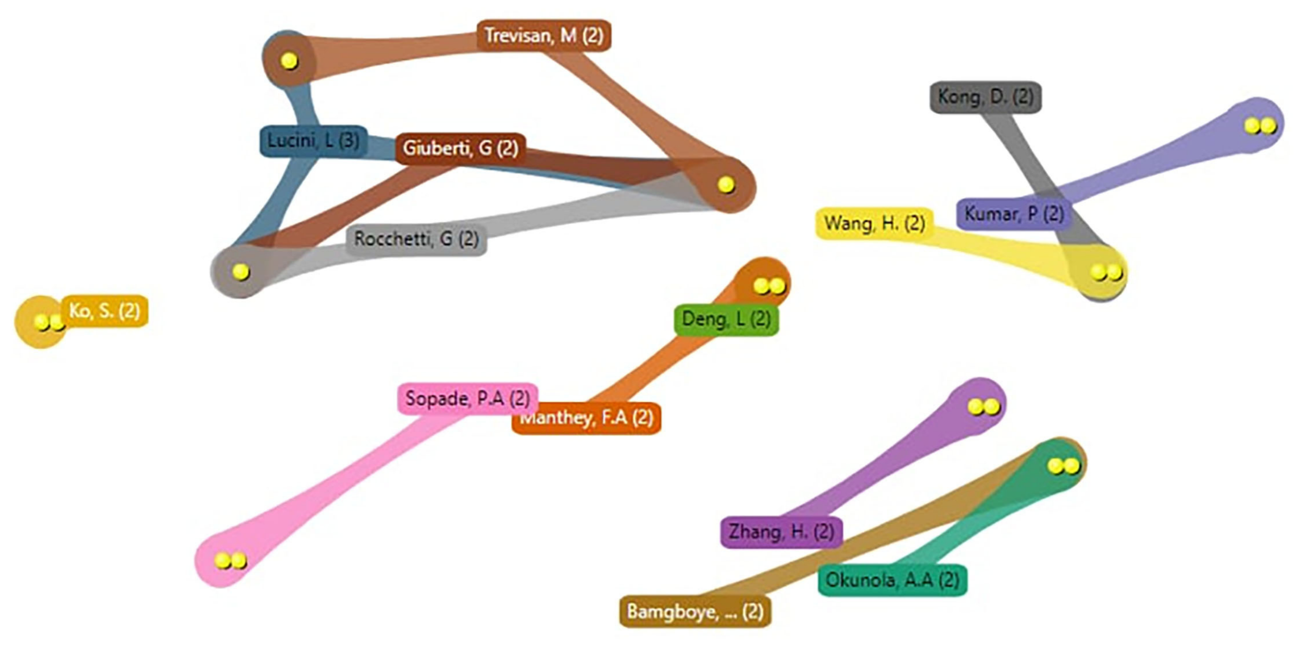

FIGURE 7 | Authors' poster. Source: Vantage point software (through information provided by the authors).

of the research are particle size, physicochemical properties, and starch.

S-Curves

S-curves are divided into different phases focused on changes and their future opportunities. Zartha et al. (2016) explain it in "S-curves, application in innovative products in the Colombian agroindustrial and chemical sector":

Phase1: Freely available knowledge.

Phase 2: Growth.

Phase 3: Late growth, property rights preventing new market entrants.

Phase 4: Maturity.

In addition, in 2016, S-curve analysis was applied with Sigmaplot software in the article. Technology watch and analysis of the life cycle of technology: usability evaluation techniques, metrics, and tools in the ICT sector; taking as data the inflection points obtained from a nonlinear regression of the sigmoid curve or S-curve, and the time series of technical and scientific production, expressed in articles.

In 2012, the S-curve was used as a tool for the measurement of product life cycles. This article exposes the trend in technological innovations to reduce the time in the CVP (reach early obsolescence) due to market demand. The key point for

FIGURE 8 | Keywords. Source: Vantage point software (through information provided by the authors).

decision-making and marketing strategies should be based on the information obtained from the analysis of the CVP, that is, the inflection point according to the S-curves (Aguilar et al., 2012).

In statistical analysis, various methods and tests are commonly used to determine the correlation of variables and therefore the affirmation and/or negation of hypotheses. One of the most used tests is the Durbin–Watson test, a test that detects autocorrelation defined by the ordinary least squares residuals function, however, a disadvantage of this test is that it is not useful for large statistical samples (Stanislaus, 2020).

Other statistical values used are the t value and p value. The p value is the probability of obtaining, by chance, a difference as large or larger than the observed one, being fulfilled that there is no real difference in the population from which the samples come. It was established that if this probability value is $<5\%$ (0.05), it is sufficiently improbable that it is due to the chance to reject with reasonable certainty the null hypothesis and state that the difference is real. If it is $>5\%$, we will not have the necessary confidence to be able to deny that the observed difference is the work of chance (Molina, 2017).

On the other hand, the t value allows us to know the probability of obtaining a value like the one obtained or farther away from null, simply by chance. If the probability is high, we will say that the difference is due to chance and that it is not likely to be fulfilled in the population. But if the probability of obtaining this value by chance is very low, we will be able to say that, probably, a real difference does exist (Molina, 2017).

Regarding the use of the S-curves methodology and the calculation of the inflection point in papers in the **Table 1** and patents in the **Table 2**, although the nonlinear regression models used did not generate statistical significance, they did provide important information for the decision-making of the stakeholders related to sieving in cereals, since the calculations did not yield inflection point data before 2022, on the contrary, future data were obtained, that is, there is still a high dynamic of patenting and publication on the subject, providing useful information on the importance that still has the subject in the technological and commercial patents, and in the scientific papers.

In the **Table 1** it is shown that none of the 13 models was valid for papers on cereal screening, Chapman's model was discarded because its turning point did not apply to the present study, and the remaining models all gave then of 2041, furthermore, all D-W gave below 0.2906.

In the **Table 2** it is shown that none of the models were adjusted, there is no validity of the models, the Chapman, Hill 4, and Logistic models were discarded because their turning point did not apply for the present study, and the points of inflection from the remaining models will be to future plus ahead of 2031 and the D-W dan below 0.2428.

DISCUSSION

For the discussion, the axes of raw materials and applications in the screening of cereals were chosen, and as a complement to the analysis of patents in screening, these axes are presented below:

Raw Materials Used in Screening

To identify which are raw materials mostly submitted to the screening process, it was obtained from the search equation used in Scopus years, authors, materials premiums, and purpose. According to studies, at least 27% of raw materials are screened to obtain flour, 21% of those users are wheat, 9% are corn, and rice corresponds to 14.63%. Also, these products (wheat, corn, and rice) are used in many industries for the production of flours, in **Table 3** is presented each raw material with the author that worked on it, the year in that he worked with the raw material, and the purpose of the investigation. This table is important since it allows to identify in a way more direct that is working in the area of sieving.

The investigations found in the review have different purposes, but one thing in common is to perform some analysis

TABLE 1 | Nonlinear regression models for papers in cereal screening.

Model		t	*P*	D.W.	R∧2	Turning point
Sigmoid 3P	a	0.0041	0.9967	0.1695	0.9869	2,068
	b	10.9716	<0.0001			
	X0	1.2705	0.2128			
Sigmoid 4P	a	0.009	0.9929	0.2899	0.9938	2,057
	b	10.1019	<0.0001			
	X0	3.177	0.0033			
	Y0	5.34	<0.0001			
Sigmoid 5P	a	2.65E-06	1	0.2906	0.9936	2,041
	b	1.02E-05	1			
	c	1.02E-05	1			
	X0	0.0009	0.9993			
	Y0	5.2384	<0.0001			
Logistic 3P	a	0.00E+00	1	0.0394	−0.0606	2,294
	b	0.00E+00	1			
	X0	0.00E+00	1			
Logistic 4P	a	0.00E+00	1	0.0394	0	3,090
	b	0.00E+00	1			
	X0	0.00E+00	1			
	Y0	0.00E+00	1			
Weibull 4P	a	0.0002	0.9999	0.1689	0.9938	2,074
	b	0.0093	0.9926			
	c	0.0086	0.9932			
	X0	0.0558	0.9559			
Weibull 5P	a	0.0006	0.9995	0.2867	0.9971	2060
	b	0.0154	0.9878			
	c	0.0136	0.9892			
	X0	0.205	0.8389			
	Y0	2.8359	0.008			
Gompertz 3P	a	0.0613	0.9515	0.1441	0.9915	2271
	b	0.8843	0.3829			
	X0	5.6815	<0.0001			
Gompertz 4P	a	0.0793	0.9373	0.2247	0.9962	2197
	b	0.991	0.3291			
	X0	8.6192	<0.0001			
	Y0	5.4446	<0.0001			
Hill 3P	a	0.0089	0.9929	0.0654	0.7785	2139
	b	13.8068	<0.0001			
	c	0.8176	0.4195			
Hill 4P	a	0.0323	0.9744	0.1072	0.9134	2115
	b	30.5814	<0.0001			
	c	2.9224	0.0063			
	Y0	−2.588	0.0144			

Source: The authors (adapting data obtained through Sigmaplot software).

related to moisture content, subsequent product performance, and water-holding capacity among others, one of the products most worked and investigated is the rice with which was worked to measure the performance of a grader (Fabiyi et al., 2020; Ojediran et al., 2020), with this it is possible to identify new equipment that increases the speed of classification of different products. Another of the products that more is used for sifting is the grains of maize, the maize is widely used for animal feeding but on many occasions, this one remains with particles that diminish its quality and at the same time they can affect the animals, for this reason with the sifting it is sought to diminish the number of unwanted particles (Mugabi et al., 2019), also the sieving of corn is used to measure the kinetics of water absorption and wet milling of the same (Uriarte-Aceves et al., 2019, 2020) looking for which were the best conditions for the work of wet milling of corn. The wheat or flour of wheat is

TABLE 2 | Non-linear regression models for patents in cereal screening.

Model		t	*P*	D.W.	R∧2	Turning point
Sigmoid 3P	a	0.022	0.9825	0.1504	0.9966	2,094
	b	21.7565	<0.0001			
	X0	3.8111	0.0003			
sigmoid 4P	a	1.1928	0.2363	0.2428	0.9979	2,044
	b	21.8998	<0.0001			
	X0	188.813	<0.0001			
	Y0	7.249	<0.0001			
Sigmoid 5P	a	8.95E+00	<0.0001	0.2435	0.9983	3,019
	b	1.63E+00	0.1075			
	c	1.59E+00	0.1158			
	X0	1913.669	<0.0001			
	Y0	8.8576	<0.0001			
Weibull 4P	a	0.0017	0.9986	0.1489	0.9966	2,099
	b	0.0277	0.978			
	c	0.0262	0.9792			
	X0	0.297	0.7672			
Weibull 5P	a	1.5585	0.1229	0.2392	0.9979	2,031
	b	0.0563	0.9552			
	c	0.0563	0.9552			
	X0	253.3371	<0.0001			
	Y0	7.4125	<0.0001			
Gompertz 3P	a	0.1537	0.8782	0.105	0.9955	2,399
	b	1.9746	0.0515			
	X0	8.7121	<0.0001			
Gompertz 4P	a	0.2229	0.8241	0.1995	0.9976	2,307
	b	2.4618	0.0158			
	X0	13.5514	<0.0001			
	Y0	7.8576	<0.0001			
Hill 3P	a	0.0318	0.9747	0.0259	0.9421	2,137
	b	40.6346	<0.0001			
	c	2.9016	0.0047			

Source: The authors (adapting data obtained through Sigma plot software).

another of the products that más is sifted, with the wheat, it is sought to find the milling adapted for the obtaining of flour, a very important product in the elaboration of different foods (Deng and Manthey, 2017), in other investigations they were evaluating the properties of aggregation of gluten and the level of affectation in the properties of the same one (Bouachra et al., 2017; Deng and Manthey, 2019).

Knowing the products with which it has been worked in sieving it will be possible to identify much more easily which are the best options for someone who wants to implement a plant for a certain product and at the same time identify the variables that it requires, on the other hand, part, will be able to be used by someone who wants to investigate as for what has been investigated and what is missing and according to that determine the product or area in which it will be possible to focus.

Applications-Equipment for Sifting in Cereals

In **Table 4**, the equipment or applications of the sieving process in the last few years of the articles obtained in Scopus were identified, where the applications and equipment used for different classification processes and the analysis of different physicochemical properties in the raw materials were analyzed.

According to a study by Srisang and Chungcharoen (2019), by using a rotary sieve and not a fixed sieve for the parboiled rice process, processing times were reduced, quality and starch increased, and the percentage of cracks and whiteness value were also higher when working the process with a rotary sieve. Despite these factors (the increase of cracks), the rotary sieve could be considered a better option able to optimize and improve the yields and the quality of the products that are submitted to these processes.

Dry fractionation of quinoa seeds of the Atlas and Riombamaba varieties by grinding and subsequent sieving (in different sizes and with an air jet to obtain protein- and starch-enriched fractions) is a more sustainable and ecological process to produce starch- and protein-enriched fractions from conventional wet fractionation (Opazo-Navarrete et al., 2018).

TABLE 3 | Raw materials subjected to a screening.

References	Raw material	Purpose
Arndt et al. (2020)	Almonds	Conduct a systematic and in-depth comparison of various sample preparation techniques for classification
Sharma et al. (2020)	wheat	Identify and characterize the phenolic compounds present in 100 different varieties of wheat
Uriarte-Aceves et al. (2020)	Corn	Research on the water absorption kinetics of different yellow corn hybrids
Sirohi et al. (2020)	Wheat flour grains	The potential for conversion of reducing sugars through acid hydrolysis was investigated
Gertz et al. (2020)	Olive oil	Reduce the possibility of adulteration of olive oil
Maver et al. (2020)	Barley	Obtain new knowledge about the allelopathic traits of barley
Zhang et al. (2020)	Rice	Yellow rice causes serious economic losses for the grain industry. This study attempted to profile the volatile metabolites in rice before and after yellowing of five Chinese common rice cultivars
Xu et al. (2020)	Potato	Identification of potato flour varieties to produce noodles
Ojediran et al. (2020)	Rice	Design and performance verification of a rice grader
Kurian and Raghavan (2020)	Flours	Research is being conducted to improve heat transfer in conventional thermal methods using appropriate materials such as molecular sieves
Adeleke et al. (2020)	Yucca	Investigate the potential of cassava starch to be used as a substitute for corn starch for use in the production of salad cream
Fabiyi et al. (2020)	Rice	A novel method is proposed to automatically select and classify rice seed samples using a combination of spatial and spectral characteristics, extracted from high-resolution RGB and hyperspectral images.
Rocchetti et al. (2019)	Different flours	We are looking for the transformation of polyphenols present in different flours
Lin et al. (2019)	Micro-organisms	He evaluated the physicochemical and physiological properties of microcapsules with various compositions and their potential for application in the encapsulation of probiotic microorganisms, such as *B. adolescentis* and *L. acidophilus*
Gurumallesh et al. (2019)	Banana	Screening, extraction, purification, and characterization of banana peel protease
Mugabi et al. (2019)	Corn	The performance of a hammer mill manufactured in Uganda was evaluated and optimal performance conditions were determined. The evaluation was conducted with mesh hole diameters (S) of 1.5, 2.0, and 3.0 mm, hammer tip velocities (H) of 68.12, 81.81, 102.17 ms −1 and hammer thicknesses (T) of 4.0, 5.0, and 6.0 mm for the determination of power consumption and geometric mean diameter (GMD) using a modified central composite (CCD) split-plot experimental design.
Deng and Manthey (2019)	Wheat flours	To determine the level of affectation of the processing properties in the elaboration of pasta using two systems with the following grinding sizes (24,000 g with a mesh opening of 250 μm) and thicknesses (15,400 g, 1,000 μm)
Uriarte-Aceves et al. (2019)	Corn	The investigation evaluates the physical, chemical, and wet milling characteristics of several commercial white corn hybrids.
Srisang and Chungcharoen (2019)	Rice	The time and quality of the parboiled rice on a fixed sieve and a rotating sieve are compared.
Mudzingwa and Mushiri (2019)	Millet	The damages that are generated during the milling and when the grain passes to the sieving are analyzed, seeking to improve the costs and quality of the product.
Opazo-Navarrete et al. (2018)	Quinoa	Evaluate dry milling and subsequent screening (vibratory sieve) as an alternative to conventional wet extraction of quinoa, protein, and starch.
Ragavan and Das (2018)	rice, oats, barley, millet	Rice, oats, barley, finger millet, and pearl millet have been used along with alginate to encapsulate five possible probiotic yeasts. The screening was carried out by measuring the swelling index, the encapsulation efficiency, and the nutritional value of microcapsules encapsulated with alginate and gum.
Salimi Khorshidi et al. (2018)	Wheat grains and Flours	Information is provided on two emerging methods, i.e., low field nuclear magnetic resonance (LF-NMR) and low-intensity ultrasound, with the potential to assess wheat protein content and quality

(Continued)

TABLE 3 | Continued

References	Raw material	Purpose
Espinosa-Moreno et al. (2018)	Banana flour	Bananas resistant to 3 diseases were taken, processed into banana flour, dried, and sifted. Analyzing its properties.
Kong et al. (2018)	Harina de semilla de algodón	Study the relationship of specific heat and the effect of moisture content, temperature, and particle size of the grinding
Wali et al. (2017)	Protein	The effects of multi-frequency ultrasound pretreatment with various frequency modes on the enzymolysis of rapeseed protein and its mechanism were studied
Deng and Manthey (2017)	Wheat grains and flour	Finding the right milling to obtain wheat flour
Becker et al. (2017)	Hieracium Pilosella L.	To determine the influence on the phytochemical properties of crushing and screening in Hieracium Pilosella L.
Bouachra et al. (2017)	Wheat flours	To evaluate the aggregation properties of gluten to samples of wheat flour with different solvents. Using a GPT(Glutopeak-test) method
Kelebek et al. (2017)	Vinegar	Analysis of the phenolic composition of kinds of vinegar and their antioxidant capacities
Barnwal et al. (2017)	Peppers	The industrial properties of the ground and sieved black pepper were studied.
Yadav and Prasad (2016)	Rice flours	See the variation of the different types of flour and the different grindings used.
Imran et al. (2016)	Chia seed	Analyzes the physical characteristics, oxidative and fatty parameters of the
Kong et al. (2016)	Corn and wheat, sorghum, and short-grain rice.	To evaluate the initial moisture content of the mixed powder for ground piglets with different sieve openings (Wet basis) and the size of the crushed particles
Dayakar Rao et al. (2016)	Wheat fiber	In particular, traditional ground sorghum flour of larger particle size (180 and 251 μm) resulted in higher quality sorghum cookies, as indicated by overall acceptability in sensory evaluation.
Mir et al. (2015)	Water chestnut	It should be noted that the sieve opening has greater flour retention than the others.
Moreira et al. (2015)	Dry corn grains	The rheological behavior of doughs will be discussed concerning certain physical and chemical properties of flours and compared with some gluten-free and gluten-free commercial flour doughs.
Kang et al. (2015)	Rice	The characteristics of rice flour and the baking quality of gluten-free bread
Adams et al. (2015)	Wheat	Show the resistance of the bread dough in freezing quality with the addition of gluten
Fistes and Raki'c (2014)	Commercial flours	To see the effect of the mill on the flour
Murtala et al. (2013)	Wooden pallets	See the densities as the pressure on the wood increases and the granules depend very much on the size ranges of the wood density.
Okunola and Bamgboye (2011)	Rice	Analyze different types of sieves to avoid rice grain breakage
Okunola and Bamgboye (2011)	Rice	Create a machine that will classify the rice of good quality, this with some sieves and a current of air to remove light particles
Le Deschault De Monredon et al. (1997)	Beet sugar	Study the feasibility of using a constant stream of water in fiber screening

Source: The authors.

Likewise, in (Geankoplis, 1998) the physicochemical properties of *Hieracium pilosella* L. were analyzed. After grinding and sieving, through vibrating sieves, it was concluded that the smaller particles had a higher content of bioactive compounds and antioxidant capacity.

In another study, the engineering properties of the ground and sieved black pepper were analyzed, and it was found that the density in the different grades of sieves vibratory varied (Barnwal et al., 2017). This analysis can be identified as the variation of some properties of the product when a screening process is applied.

Analysis of Patents

To identify the usefulness and implementation of the sieving systems in cereals, the patents applied for and obtained in the last years were reviewed, for this purpose the search equation "TITLE-ABS-KEY (sieve OR screen*)" AND "food process AND cereal*" is run again in SCOPUS obtaining 174 patent results in all the years. To reduce and update the search, to identify the newest and most current inventions, we chose to work with the last 10 years in which a total of 101 patents were found, of which only 7 patents are directly related to some type of sieving in food, the great majority of which were not related to methods or sieving systems. After analyzing the 7 patents directly related to the topic,

TABLE 4 | Equipment used for screening and its purpose.

Sieve type	Purpose
Rotary sieve	Improve or decrease process times, increase the quality and quantity of product obtained, and obtain greater performance in the processes in general.
Vibrating sieve	Through the vibration, it is sought to improve the yield of the process with bigger particle sizes and besides looking to obtain a better product for analysis.

Source: The authors.

TABLE 5 | Patent analysis, complement.

References	Country	Purpose	Mechanism of action
Liu (2019)	CHINA	Elimination of impurities and product standardization	The system allows the extraction of unwanted particles, retaining them in the first meshes while the product passes until it reaches the mesh of the desired size.
Dubois and Rafael (2020)	The United States	Product standardization for higher final yield.	In the application of flavorings or the addition of vitamins, minerals, or other substances, it is very important to have a standard size and this equipment allows the standardization and improvement process to be carried out.
Mordejai (2019)	The United States	Medicinal particles for oral administration	Being elements for oral administration, care must be taken with their size, the equipment, in addition to preparing the particles, allows determining the size and reprocessing those that do not comply with this
Klein and Air (2017)	The United States	Final product standardization	The process of adding proteins to the food integrates a sieve at the end of it, in this way it allows offering a standard product and reprocessing the one that does not meet the size.
Hang et al. (2017)	The United States; China	Preparation of ferulic acid	In the preparation of antioxidants, it is required to separate impurities and for the solid-state of the raw material, sieving presents good results.
Horgan et al. (2015)	The United States	Preparation of feed for animals with low water activity	Animal feed must have little water activity to avoid bacterial or fungal contamination. By standardizing the product, heat is applied to ensure complete drying.
Bakos et al. (2013)	The United States	Avoid waste loss	In the food coating process, particles remain that become waste, these are extracted in a tray with a vibrating sieve, to be reused later.

Source: The authors.

consolidation of information was made as it is shown in **Table 3** where the author, the year, the country, the equipment or method, the application, and the applicant company are presented.

In **Table 5** and complement it can be seen that the main products to be sifted are flours (Bakos et al., 2013; Horgan et al., 2015; Liu, 2019; Dubois and Rafael, 2020). Other applications that were found in the area of animal medicine with the preparation of particles and protein foods (Klein and Air, 2017; Mordejai, 2019) and another one for the preparation of ferulic acid (Hang et al., 2017). Sifting in these products is done more to complement a larger method or system. As for the companies, they are more diversified since no company has two patents. Most of the patents correspond to methods that seek to improve some characteristic or standardize the different products mentioned.

CONCLUSIONS

It was possible to identify the importance of sieving in the different agroindustrial processes, and the main raw materials that are subjected to sieving and the purpose of applying a sieve to these raw materials. This information is important because it allows a better approach to a unitary agroindustrial operation that is very useful when it comes to standardizing and eliminating impurities from some products used in the agroindustry.

Among the applications in agribusiness in the last 10 years, the papers highlight the screening of Rice, Corn, Wheat, Cotton, Millet, Quinoa, Almonds, Barley, Potatoes, Cassava, Microorganisms, Oats, Cotton, Protein, Peppers, Chia Seed, and Beet Sugar. This information can be used as an input in the decision-making process of the stakeholders of the agroindustrial chains related to each product.

Concerning the patents, the applications turn around to equipment to eliminate impurities, methods to standardize products and to produce or to obtain foods rich in proteins, and apparatuses for the cleanliness and retention of raw materials that leave other processes, it is important to know the granted patents since this allows to identify that it has been done and that it is necessary to investigate and also it serves as input for the different groups of interest.

In the agroindustry, it is known that it is important to standardize the products to be able to offer the clients the same quality and type of product, according to this, the sifting becomes a unitary operation plus easy to use because of its structure and equipment it does not require great academic knowledge, besides, it allows to obtain the product with the above-mentioned characteristics.

A common factor found in the articles was the use of vibratory sieving, analyzing the optimization in time and quality of the products that used this sieving process such as parboiled rice, quinoa, and different flours, conserving all the physical-chemical properties and a greater yield, and comparing the final product when using different types of sieves.

The information regarding keywords, countries of origin of the papers, authors, journals, main phrases, and others, is important to know because, in this way you can have more clarity about what has already been done or researched and what is missing, like-wise, you can identify the main exponents of the subject with which you can have contact and advice for possible future research.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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