



Technological prospection of aquafaba: a study of patent applications and trends in the food market

Ana Carolina Valle da SILVA¹, Gustavo Luis de Paiva Anciens RAMOS^{1,2*} , Patricia Silva FERREIRA¹,
Marcia Cristina da SILVA¹

Abstract

Aquafaba, a liquid from the cooking of chickpeas, has technological properties that have been increasingly used in the food sector, such as emulsifying, foaming, and gelling properties. Its application occurs mainly in mayonnaise and meringues, replacing the egg. This study aims to carry out the technological prospection of aquafaba through the study of patents in national and international databases, seeking to assess current and future market demand, and thus gather relevant information that allows attracting the interest of the food industry to the use of this new functional and sustainable food. Few related patents are reported, and they are concentrated in a few countries, indicating a promising way of exploring this product.

Keywords: chickpea; emulsifying property; food innovation; vegan foods.

Practical Application: The study synthesizes relevant information that allows attracting the interest of the food industry to expand the application of aquafaba.

1 Introduction

The demand for the discovery and development of rheological additives to replace egg and milk has grown, following the growing concern with sustainability. Rheological additives of vegetable origin already discovered and frequently used are based on vegetable proteins, soy milk, bananas, and starch, among others (Naeem et al., 2022).

However, a perfect substitute of plant origin has not yet been found, since it is not possible to obtain the same characteristics when using egg or milk, with a loss of consistency, a significant change in texture, and lower sensory acceptance (He et al., 2021). Given this fact, the vegan public began empirically to seek solutions to this problem, focusing on the use of substitute products that reached the result of egg whites, without any addition of animal products (van der Meer et al., 2023).

Aquafaba is the viscous liquid obtained from the cooking of chickpeas, which has an interesting nutritional composition and relevant technological properties. Aquafaba emerges as a promising alternative concerning substitution as a rheological additive in foods since it exhibits several desired properties in their production, such as its foaming, emulsifying and gelling capacity, in addition to exhibiting high stability under various conditions, such as freezing and boiling. In addition, aquafaba is highly sustainable, as it is a by-product of canned chickpeas, has a low planting cost and high productivity, representing up to a third of the total volume of the product can that would be discarded (Shim et al., 2018).

Its application has been increasing, especially as a vegan, gluten and cholesterol-free additive, in various types of foods, such as ice cream, whipped cream, mousse, meringues, and egg-free mayonnaise. Cooking water from other grains are also used, but aquafaba has better applicability and sensory results among these options when compared to products made with eggs (Stantiall et al., 2017).

Aquafaba has a lower protein and vitamin content compared to egg or milk, and this can be an obstacle to convincing certain consumers to purchase substitute products. Also, the processes related to canning chickpeas are not standardized for the production of aquafaba, in addition to having additives such as salt and calcium chloride to reduce the cooking time, which can change its functionality (Shim et al., 2018).

The prospection study is of fundamental importance in the innovation process, as it helps in the mapping of efficient scientific and technological processes, contributing to the anticipation of innovations in the market, optimizing time in the development of new products, and with greater assertiveness in the execution and launch of these in the market. The patent analysis makes it possible to find the state of the art for a particular product or technology, helping the inventor not to infringe or plagiarize the information available there. In this way, inventors can have access to information that can generate better solutions than those that were consulted, and so technologies are always renewed. The results of patent mapping contribute in a very relevant way to the innovation sector of any country. It is possible to generate

Received 30 Sept., 2022

Accepted 06 Dec., 2022

¹Instituto Federal de Educação, Ciência e Tecnologia do Rio de Janeiro, Rio de Janeiro, RJ, Brasil

²Faculdade de Medicina Veterinária, Universidade Federal Fluminense – UFF, Niterói, RJ, Brasil

*Corresponding author: gustavoanciens@id.uff.br

reports with information on the prior art of the technique, outline the technological routes and improvements of existing products, predict new products on the market, monitor competitors, and even reduce infringements of new patents.

This study aims to carry out the technological prospection of aquafaba through the patent study in national and international databases, understanding the current and future market demand from the existing patent deposit, and thus gather relevant information that allows attracting the interest of the food industry for the use of this new functional and sustainable food.

2 Material and methods

Based on a qualitative and exploratory study, the results are the sum of two parts: the bibliographic research and the state-of-the-art research (patent search), both carried out between 2019 and 2021. The methodology is based on Ribeiro (2018) definition, which mentions that the technological mapping consists of the steps of defining the databases, construction of the research scope, search and selection, removal of duplicates, and preparation of spreadsheets for quantitative and qualitative studies.

Initially, a search for scientific articles was carried out in the Google Scholar, Science Direct, and Scielo databases, with the main search term the word “aquafaba”, filtering through the years 2015 to 2021, with 2015 being the year after the discovery of aquafaba. These articles were important to provide information on the first studies of technological properties, application in food, sensory analysis, and ways of obtaining aquafaba. Figure 1 shows the layout of the study.

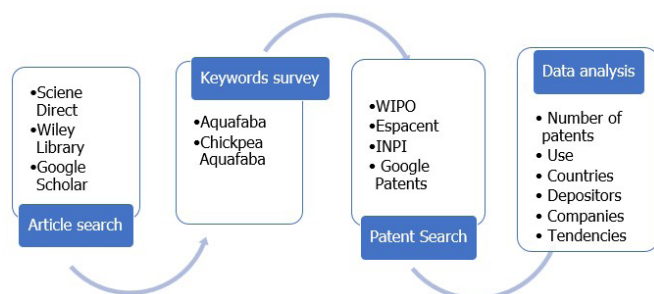


Figure 1. Study layout.

The search for patents was carried out according to a methodology that comprised three phases, as shown in Table 1.

The keywords used were extracted from related scientific articles in English and translated into Portuguese, for use in both languages. In the context of keywords, the main name of the product was considered, “aquafaba”, and words were added that associate main technological functions, practical use in food, and/or mention the replacement of animal proteins in food. They were classified into primary, secondary, and tertiary keywords so that their junction was characterized as the main search strategy for searches in both languages. Then, Boolean operators were added together with the truncation strategy, which increase the quality and scope of the search.

Nine combinations of keywords were used for research in all databases chosen for the study. The documents obtained were organized in a Microsoft Excel spreadsheet. To select the relevant documents, the patent summaries were read. Then, the patent was read in full for those who were classified within the study to then obtain the objective information of the study.

3 Results and discussion

Technological prospection is an important information tool for strategic decision-making for investment in studies for insertion in a very competitive technological environment. Thus, it is possible to anticipate future changes and take a stand against them. The results of searches in the scientific literature reveal that only from 2017 onwards there was scientific interest in the study of aquafaba since it was discovered in 2014. Twenty articles related to the topic were found, with their publications between the years 2017 and 2021 (Figure 2).

The year 2020 had the highest incidence of published articles, with an increase from 2018, the date of the first peer-reviewed scientific study (Shim et al., 2018). This research carried out electrophoresis and fingerprint analysis of peptide mass in aquafaba from canned chickpeas and thus study the components that make it a functional food with foaming capacity for use in food production. In the case of this search, the year 2021 does not represent a decreasing line in the research on the subject, but the limited year of the research added to the pandemic period, where there was a slowdown in the types of bench studies required for analysis of the characteristics of aquafaba.

Table 1. Methodology used in the search for patents.

Phase 1: Definitions	<ul style="list-style-type: none"> - Definition of free patent search sites: WIPO, ESPACENET, INPI and Google Patents - Brainstorming of keywords used in searches, based on reading scientific articles - Selection and organization of words in Portuguese and English
Phase 2: Research and data collection	<ul style="list-style-type: none"> - Keyword search application - Selection of documents of interest - Reading abstracts of selected patents - Duplicate removal - Qualitative weightings indexed in spreadsheet
Phase 3: Data Analysis and results	<ul style="list-style-type: none"> - Preliminary analysis of dates, countries, inventors, patent status, country of deposit and country of protection - Analysis of data relating to the food market in Brazil and worldwide

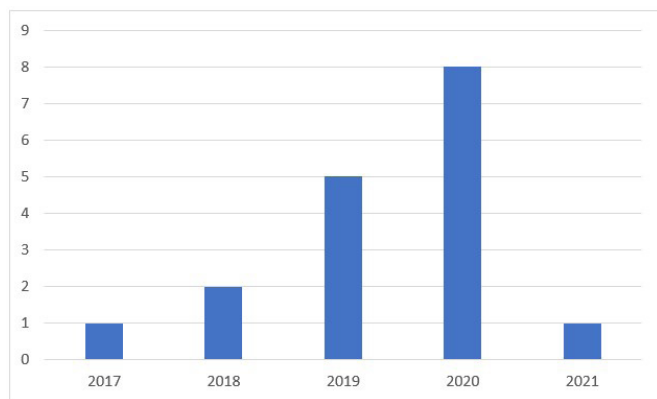


Figure 2. Scientific articles found by year of the period evaluated.

Among the articles found, we can note that there are different studies testing aquafaba in different ways. One of the first studies found by Stantiall et al. (2017) studied the properties, chemical composition, and effect of aquafaba from different pulses (chickpeas, lentils, peas, and beans) on the production of eggless meringue, performing a sensory analysis of acceptance in relation to meringue produced with eggs.

Mustafa et al (2018) performed a thorough analysis of the composition, emulsifying capacity, and stability of aquafaba foam from canned chickpeas from 10 different commercial brands, with consistent results. From this study, tests were increased to validate the use of aquafaba in bakery recipes, use for the production of mayonnaise, in addition to the application of technologies such as ultrasound to analyze the behavior of aquafaba in different scenarios.

Ninety-seven results were found in the patent search, using the keywords in English in the search databases. Of these, 54 (56%) come from Patentscope and 43 (44%) from Espacenet search. No results were found for any keyword applied in the INPI data search. This result includes the total number of patents, which are repeated in the databases and some are deposited in several countries, adding to this total. The distribution of the number of patents for each keyword is shown in Table 2.

Then, the patent summaries were read to assess their relevance to the current study, and nineteen with possible relevance to the topic were selected. After a detailed reading, four were excluded because they were not associated with food production, surprising how multifunctional this residual liquid is usually discarded. Thus, 15 patents were selected to continue the study.

Among the countries that have filed patents on aquafaba, the United States stands out with eight patents. Russia presented three, followed by China, Denmark, France, and the United Kingdom with one patent each (Figure 3).

The United States is currently a large consumer market for plant-based foods, which has been growing exponentially. According to the Plant Based Foods Association (PBFA) and The Good Food Institute (GFI), there is an increase in the sale of plant-based foods in the United States, with an increase of 6.2% compared to 2020, accumulating a record \$7.4 billion dollars.

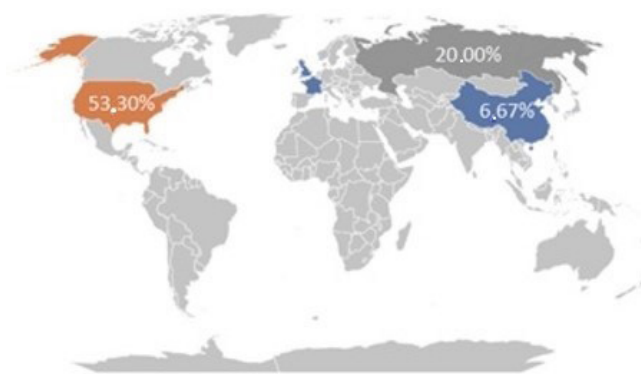


Figure 3. Distribution of patents classified by country of origin.

Table 2. Distribution of the number of patents.

Keyword	Espacenet	Patentscope	INPI
<i>aquafaba</i>	9	10	0
<i>aquafaba and egg replacer and foam capacity</i>	4	5	0
<i>aquafaba and vegan meringue and egg white substitute</i>	2	6	0
<i>aquafaba and vegan foam</i>	5	4	0
<i>aquafaba and vegan meringue</i>	2	3	0
<i>aquafaba and baking product</i>	3	3	0
<i>aquafaba and sponge cake</i>	3	2	0
<i>aquafaba foam</i>	15	13	0
<i>aquafaba and emulsify planted based</i>	0	8	0
Total	43	54	0

The PBFA also cites that, in 2020, 50% of American families purchased products from this category, showing the increase in this lifestyle (Plant Based Foods Association, 2022). A survey by Meticulous Research indicates that this market should move US\$ 95.52 billion by 2029, with a growth rate of 12.45% in the period, reaffirming the power of this consumer market.

Only three patents were granted, all of Russian origin, on the production of aquafaba-based mayonnaise. This fact can be justified by the innovation in the market, since it is the only patent for mayonnaise without eggs and with aquafaba, reporting the manufacturing methods. This patent was granted within five months of its filing, a very quick time compared to patent concessions made by the INPI, which can take up to 10 years to be granted. The faster process of granting patents in Europe encourages inventors and applicants to protect their inventions with patents, which is not the case in Brazil, which has low numbers of patent filings.

The International Intellectual Property Index (IP Index) presents the performance of countries in the global innovation scenario. The Index covers the analysis of around 80 indicators, considering the political environment, education, infrastructure and knowledge creation of each economy favorable to product

innovation for the world market. In it, countries with the highest number of patent filings, such as the United States, China and Japan, stand out, also corroborating the results of the study in relation to the United States.

The acronym IPC stands for International Patent Classification divides technologies into eight sections, with about 70,000 subdivisions, each with a symbol composed of Arabic numerals and Latin alphabet letters (WIPO, 2022). The eight sections of the CIP are identified by the letters A to H and cover all areas of human technological development. The complete CIP symbol is an alphanumeric code, consisting of symbols representing the Section, Class (two-digit number), Subclass (capital letter), group, and Subgroup. In the research results, 48 IPCs were observed, in a universe of 19 patents. Among these, 33 (68.80%) are included in section A, which represents human needs, where food products in general fit. Classes 23 and 21 had the highest prevalence among the analyzed patents, with 68.81% and 23%, respectively. Class 23 corresponds to “Food or foodstuffs; treatment, not covered by other classes”, demonstrating that aquafaba is a product with innovative technology, whose patents are segmented into differentiated classifications. Figure 4 displays the predominant IPCs observed in the study patents.

It can be seen that sections L and D have a higher incidence within the technological prospecting of the study. Section L represents foodstuffs and non-alcoholic beverages that have undergone nutritional quality modification processes, physical treatments, and foods not covered by another subclass. Section

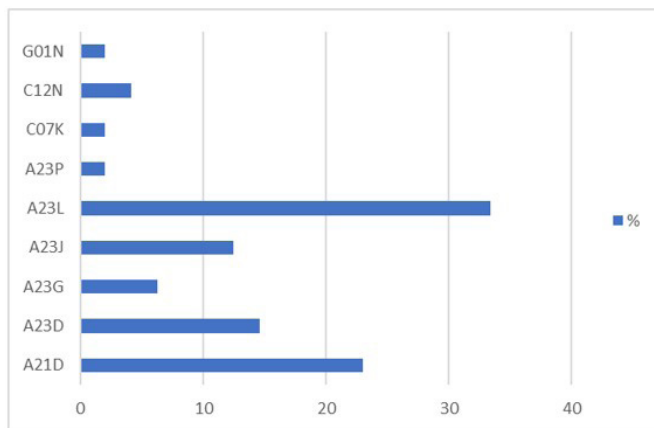


Figure 4. Predominant IPCs observed in the study patents.

D is characterized as edible oils or fats, refined or hydrogenated cooking oils, such as margarine and mayonnaise. In this context, this is the most promising market for the use of aquafaba, given the association of its emulsifying capacity and the innovation of technology when using products of animal origin, reinforcing the trend of consumption of foods intended for vegans, vegetarians, and flexitarians.

As for the depositors, it is observed that of the 15 patents, 8 (53.3%) were filed by companies, and 7 (46.66%) mentioned only the inventors in the documents. The companies were described in Table 3, to understand which products they work with, if they are innovating in the launch of new products or if they are new companies, startups, or academic spin-offs.

There are aquafaba products already on the North American market, such as aquafaba Poder (powdered aquafaba), Fabanaise mayonnaise from the American company Sir Kingston, sauces with different flavors, and organic vegan mayonnaise sold by the American company Fabalish. Also, the plant-based butter containing aquafaba called Fababutter was created and marketed by the company Fora, with a production plant in the United States and Europe. Other products such as aquafaba *in natura* are sold by Haden's and Oggs and VOR, also American.

The patent of the company A-Z Human Nature Ltda brings to light the dry aquafaba powder so that the consumer can produce the aquafaba at home and take advantage of the foaming characteristic. The Russian patents that have been granted are not linked to companies, only to inventors. This technology can likely be sold to companies in the sector interested in innovating in the planted-based market. Most inventors are associated with a company inserted in the interesting market, in order to bring technical knowledge in the development of new products or improvement of those already on the market, following the trend guided by technical-scientific prospection.

In the Brazilian scenario, no patents related to aquafaba were found, but there are products in the Brazilian market such as plant-based mayonnaise based on aquafaba. The fact of not filing patents for innovative products within a market can be explained by the companies' option to maintain the industrial secret of their products and also by the long period that the INPI takes to grant patents, which can reach up to 10 years. Thus, allied to this slowness there is the important fact of the technological cycles of the products that quickly change within the national scenario.

Table 3. Companies applying for the evaluated patents.

Company	Activity	Country of origin
Alternative Foods London		United Kingdom
Taste for life LLC	Dietary supplements, mostly plant-based	United States
Ther Hersheys Company	Chocolate and other products including bakery	United States
The Aquafaba Company Genialis	Vegan products from FORA foods company	United States
Praide Tire Diversified Inc Clara Foods Co	Protein of plant origin through precision fermentation to be used in different applications	United States

4 Conclusion

The description of the patents studied shows that aquafaba, among its applications, appears more frequently as an emulsifying and foaming agent to modify the consistency of foods. It shows itself as a growing and promising market with products consolidating in the vegan, vegetarian, and flexitarian consumer markets.

References

- He, Y., Meda, V., Reaney, M. J., & Mustafa, R. (2021). Aquafaba, a new plant-based rheological additive for food applications. *Trends in Food Science & Technology*, 111, 27-42. <http://dx.doi.org/10.1016/j.tifs.2021.02.035>.
- Mustafa, R., He, Y., Shim, Y. Y., & Reaney, M. J. T. (2018). Aquafaba, wastewater from chickpea canning, functions as an egg replacer in sponge cake. *International Journal of Food Science & Technology*, 53(10), 2247-2255. <http://dx.doi.org/10.1111/ijfs.13813>.
- Naeem, M., Un-Nisa, M., Ahmad, N., Imran, M., Anwar, H., & Manzoor, M. F. (2022). Preparation of weaning foods by replacing plant proteins with egg protein. *Food Science and Technology (Campinas)*, 42, e44920. <http://dx.doi.org/10.1590/fst.44920>.
- Plant Based Foods Association – PBFA. (2022). *U.S. plant-based food retail sales hit \$7.4 billion, outpacing total retail sales, despite supply chain interruptions and pandemic restrictions creating widespread volatility in the food industry*. Retrieved from <https://www.plantbasedfoods.org/2021-plant-based-retail-sale-data-release/>
- Ribeiro, N. M. (2018). *Prospecção Tecnológica*. Retrieved from <http://www.profnit.org.br/wp-content/uploads/2018/08/PROFNIT-Serie-Prospeccao-Tecnologica-Volume-1-1.pdf>.
- Shim, Y. Y., Mustafa, R., Shen, J., Ratanapariyanuch, K., & Reaney, M. J. T. (2018). Composition and properties of aquafaba: Water recovered from commercially canned chickpeas. *Journal of Visualized Experiments*, 2018(132), 1-14. <http://dx.doi.org/10.3791/56305>. PMID:29553544.
- Stantiall, S. E., Dale, K. J., Calizo, F. S., & Serventi, L. (2017). Application of pulses cooking water as functional ingredients: the foaming and gelling abilities. *European Food Research and Technology*, 244(1), 97-104. <http://dx.doi.org/10.1007/s00217-017-2943-x>.
- van der Meer, M., Fischer, A. R., & Onwezen, M. C. (2023). Same strategies–Different categories: an explorative card-sort study of plant-based proteins comparing omnivores, flexitarians, vegetarians and vegans. *Appetite*, 180, 106315. <http://dx.doi.org/10.1016/j.appet.2022.106315>. PMID:36162538.
- WIPO (2022). *International Patent Classification (IPC)*. Retrieved from <https://www.wipo.int/classifications/ipc/en/>