Recent patent applications in beverages enriched with plant proteins

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Recently, many consumers have been adding plant-based beverages to their diets, due to different reasons. The addition of plant proteins to enrich these products in order to make them more nutritionally balanced has become a trend, mainly because of their lower prices and reduced environmental damage. Thus, the aims of the present patent review are to discuss the potential of, and challenges posed by, plant proteins to the beverage industry, as well as to check market trends, focused on raw materials and beverage types. Based on the results, pea, rapeseed, bean, peanut, chickpea, lentil, hempseed, sunflower seed, and cottonseed were among the most often addressed raw materials. Furthermore, this enrichment process is not limited to create products that mimic dairy, therefore expansion in plant proteins used to enrich carbonated beverages, sports drinks, or even juices is expected to happen. Thus, plant-derived proteins have been promising to high-quality beverage production, as well as to ensure food security, animal welfare, and low environmental impacts.

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INTRODUCTION

Nowadays, plant-based beverage consumption has been gaining significant relevance. This segment has been projected to exceed US$26 billion by 2023, in the global market. Environmental concerns and ethical awareness about animal welfare are factors often pointed out as motivation for the consumption of plant-based products, as well as a preference for a healthy lifestyle. In fact, plant matrices tend to present a higher amount of fiber and phytochemicals, when compared to animal matrices. One more reason for the health-promoting effect of a plant-based diet is linked to the lifestyle as a whole, since those who opt for this diet are likely to be more conscious regarding food and exercise habits, and as a result, acquire protective factors against chronic diseases. Moreover, the increasing incidence of individuals allergic to cow milk and intolerant to lactose mostly account for this issue can limit their acceptance by consumers. At the same of these bene

A wide range of plant-based products is available in the market, mainly when it comes to milk analogs. In technological terms, milk analogs are aqueous extracts from milled plant material that resembles cow milk. Soy-based beverages were the first of these products to become popular; however, they are currently facing rejection due to their allergenicity and genetic modifications. At the same time, other plant sources have emerged as alternatives to soy-based beverages, as among them one finds almond, rice, oat, coconut, sunflower seed, and hempseed. Because these raw materials are different from each other, the nutritional composition, appearance, and taste of final products can present considerable differences. Regarding nutrients, for example, protein is a nutrient that tends to be missing in these beverages, and this issue can limit their acceptance by consumers.

Indeed, people have been seeking protein-rich products. According to Mintel, 30% of consumers would buy more milk substitutes if they had an extra protein appeal. Plant source blends have been explored as the way to accomplish the nutritional adequacy and improvement of final products' technological aspects. However, the enrichment of products with proteins has become a major trend for this new beverage in the market, in order to make them even more nutritionally balanced. Such enrichment can be applicable not only to milk replacers, but also to other sorts of beverages, such as fermented beverages, sports drinks, soft drinks, or even juices, in case appropriate technologies are applied to their production process.

Legumes, pulses, seeds, and nuts are often highlighted as great sources of plant protein, mainly oil industry by-products, like press-cakes, which are protein-rich, but yet poorly explored as food. Leaves, aquatic plants, seaweed, and microalgae can also be used as raw materials for protein extraction. However, they require processing near the growing area, due to their high moisture and rapid deterioration. When correctly combined, plant proteins are comparable to animal-based proteins, as they can provide all essential amino acids in adequate amounts. It is also known that di and tripeptides can be absorbed by the gut, and, as well as animal proteins, plant proteins can be hydrolyzed in biopeptides which present health-promoting effects. Some of these benefits are, for example, anticancer, antimicrobial, antioxidant, anti-inflammatory, antianemic, antithrombotic, anti-hypertension, antiobesity, antidiabetic, and immunomodulatory activities. These biopeptides normally do not present bioactivity when encrypted in the parent protein, so the benefit only displays after the hydrolysis process. Depending on the peptide, they can be obtained by natural digestion process or by food processing, using trypsin, pepsin, alkalase, and biological fermentation to create functional peptide ingredients. Besides that, plant proteins account for costs lower than animal proteins; moreover, their production process is less damaging to the environment. On the other hand, dealing with plant proteins can be challenging, since their functionality-related aspects, such as color and taste, remain an issue. Furthermore, even if the total

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amount of protein is high, the presence of limiting amino acids and antinutritional factors in plants ends up compromising the quality of the protein15.

But as the challenges related to plant proteins use have been overcome and their potential has been perceived, patenting mechanisms now play an important role. The existence of patenting mechanisms is crucial in the current technological world because it allows exclusivity to use an invention for a certain period of time. However, it happens in exchange for the disclosure of detailed information about the topic23. Any technical or functional aspect of products and processes can be patented, as long as they meet industrial applicability, novelty, inventiveness, and patentable subject matter criteria24. Plant proteins properties modifications, specific temperature, and pH conditions used in processes, isolation, and purifying methods, as well as the final product itself can be protected by patents25. More than working as a competitive instrument, patents are valuable sources of technological information23; therefore, the aims of the current patent review were to discuss the potential of, and challenges posed by, certain plant proteins to the beverage industry, as well as to check market trends focused on raw materials and beverage types.

METHODOLOGY

The search for patents was based on the International Patent Classification (IPC) system and carried out in “Espacenet” since this database gathers the largest number of open access patents. It is better to use a patent classification system rather than the “keyword” strategy alone because it ensures the selection of patents belonging to a specific field and technology. Patents published between January 2015 and June 2020 were herein selected in association with the IPC subgroup A23J1/14, which describes the technologies and applicability of protein compositions for foodstuffs obtained from leguminous, other vegetable seeds, press-cake, or oil-bearing seeds (Fig. 1).

Patents presenting duplicate or triplicated titles applied by the same authors and coming from different origins were excluded from the research as part of the screening. It is important taking into consideration that when duplicated or triplicated patents were excluded, the newest ones were maintained in the sample. Patents that were presented in title terms such as “soy”, “hybrid”, or “variety” were also excluded from the study. Soy was excluded given its growing rejection by consumers, mainly because of its allergenicity and genetic modifications8. Likewise, titles with the words “hybrid” and “variety” were also excluded, since they are related to the production of new plants based on genetic engineering, which is not the aim of the current study.

The full reading of the patents was carried out and the following eligibility criteria were established to exclude: (1) patents with an unavailable description or no translation into English or Portuguese; (2) duplicated or triplicated patents by the same authors, from different origins; (3) patents that used soy as preferable raw material; and (4) patents that used animal origin components as preferable raw material.

The keyword search was carried out in the descriptions by combining the following terms: “beverage” or “juice” or “drink” or (“dairy” or “milk” or “yogurt”) and (“alternative” or “substitute” or “analog” or “replacer”) in order to only select patents related to plant-based beverages. All surveyed patents were somehow related to plant proteins used as ingredient and/or supplement, and/or additives in the beverage industry, or even as a ready-to-consumption product (Fig. 2).

RESULTS AND DISCUSSION

In total, 1036 patent applications were found from January 2015 to June 2020 in the IPC A23J1/14 subgroup. The final sample counted on 113 patents after screening and eligibility criteria application. By comparing the number of plant-based beverage applications in the last 5 years, it was possible seeing an increase in this number back in 2019: 44 patent applications (Fig. 3). Noteworthy, 26 patents were applied up to June 2019, and this finding is indicative of upward tendency estimated to the number of applications in the following years. Such an estimate can be confirmed by both the current plant-based beverage consumption trend1 and populations’ increased interest in protein-rich products9.

Patents were divided into three different groups, namely: “seeds and nuts”, “legumes and pulses”, and “other mixes”, since A23J1/14 subgroup is related to leguminous, vegetable seeds, press-cake, or oil-bearing seeds (Fig. 4). Based on the results, most patents are related to legumes and pulses using (45%), followed by seeds and nuts (36%), other mixes (18%), and patents that did not specify their raw materials (1%).

Most patents (n = 40) mentioned their applicability to protein-rich beverage production. This finding was expected due to the current demand for this category of product9 (Fig. 5). Milk analog (n = 27) and fermented beverage/yogurt analog (n = 25) come right in sequence, and it corroborated consumers’ increased interest in alternatives to dairy products1. Sports drink (n = 25), carbonated beverage (n = 22), juice (n = 17), and acid beverage (n = 11) were also often addressed in patents, and this finding meets the current need of using plant proteins at different pH ranges without compromising the features of final products.

Figure 6 shows the preferable raw materials for patent applicants. It is important to point out that the sum of recorded

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**Fig. 1** Definition of subgroup A23J1/14 based on the International Patent Classification (IPC). Darker blue categories represent broader fields, whereas lighter blue categories concern more specific fields. Data source: World Intellectual Property Organization (WIPO). Elaborated by the authors.
results will be higher than the total number of patents selected for the current study if one takes into consideration that some patents used more than one raw material on its applicability. The most preferable raw materials chosen by patents applicants were pea, rapeseed, and bean.

Seeds and nuts
Seeds are of great economic and biological importance if one takes into account that they have a high oil and protein content, and large starch reserves. Nuts from trees are recommended as part of a healthy diet given their protein, fiber, and phytochemical content. Seeds and nuts can be the raw material for oil production, which is often extracted by cold pressing—this process generates a by-product known as "press-cake"; or it can also be extracted with organic solvents—in this case, the residue is called "meal". The global 2018/2019 oilseed production reached 600.47 million metric tons, hence huge amounts of oil extraction by-products are available. Although press-cakes and meals are often discarded as waste or used as components for feed supplementation, they are good protein, fiber, and bioactive compound sources. Moreover, because of the increasing demand of protein products, such waste types are a potential alternative source for protein extraction. However, the oil extraction procedure often decreases protein solubility and it compromises its use in beverages. Thus, many of the herein-reviewed patents were related to methods applied to increase or preserve the solubility of proteins extracted from cakes and meals. Furthermore, depending on the raw materials, meals and press-cake often possess undesirable amounts of compounds that decrease protein digestibility, such as fibers and antinutritional factors such a matter is constantly discussed in most patents as well. Moreover, the preferable protein extraction methods were related to the protein precipitation using an alkaline, acid, or salted solution, followed by a specific filtration and drying technique (Table 1).

Based on the results, rapeseed was the most used seed, since it was the preferable raw material in 25 patents (Table 1). Rapeseed ranks second position of the major oilseed cultivated worldwide, it just loses its position to soybean. Rapeseed and "canola" are the common names given to species Brassica napus L., Brassica rapa L., and Brassica juncea L.; however, the name "canola" only refers to rapeseed varieties presenting less than 2% erucic acid and meal accounting for less than 30 μmol/g total glucosinolates. The crude protein in rapeseed meals ranges from 35 to 40%. At least 40 different protein fractions can be found in this total, but cruciferin, napin, and oleosin are the most investigated ones. Cruciferin and
napin are the main storage proteins, they account for 60 and 20% of the protein content in rapeseeds, respectively. Oleosin presents structural proteins associated with oil components. Although rapeseed has lower sulfur-amino acid levels, canola meal has better amino acid profile than soybean. Nevertheless, canola proteins present many antinutritional factors, as among them glucosinolates, phenolics, phytates, as well as a large amount of fibers capable of compromising digestibility, color, taste, and physicochemical properties. This finding explains some authors’ interest in patenting inventions that can solve these problem. Patents WO2019110556 (A1) and EP3481220 (A1) explain how to isolate inherently sweet rapeseed proteins presenting low content of antinutritional factors and high solubility, which can be used to reduce the amount of sucrose in beverages, and simultaneously increase protein content in the product. Likewise, BRPI0917295 (A2) provides rapeseed protein isolate that is soluble and stable not only in acid pH but also at higher temperatures. At the moment, Burcon® is the only manufacturer of high-purity canola protein in the world, despite the potential of this raw material.

Hemp (Cannabis sativa L.) was the preferable raw material in 11 patents (Table 1). It is mainly cultivated for the industrial use of its
seeds, fibers, oil, and meal\textsuperscript{34}. At the moment, hemp is at the mainstream, since it is a sustainable crop that does not require fertilizers, herbicides, and pesticides\textsuperscript{35}. Hemp can be legally cultivated for industrial purposes in most countries worldwide, when it has up to 0.3\% of its main psychoactive compound: delta-9-tetrahydrocannabinol (THC)\textsuperscript{26}. Hemp seeds are rich in phytosterols (\(\omega-3\) and \(\omega-6\)) and have \(-25\%\) of proteins in its dry weight\textsuperscript{15}. Approximately 65\% of the total hemp protein comprises a single globular storage protein: edestin; on the other hand, the albumin fraction consists of 25\% of storage proteins\textsuperscript{26}. Although it has low lysine content\textsuperscript{19}, hempseed protein contains all the essential amino acids and accounts for low amounts of antinutritional factors, such as trypsin inhibitor; therefore, it presents high-degree digestibility\textsuperscript{25}. Hempseed protein can be appropriate for athletes and infants, for example, given their quality. Patent BR\ 11\ 2015\ 5001964 (A2) provides a hempseed protein that is completely soluble in acid beverages (lower than 4.4 pH), without the need of stabilizers or additives. Thus, it can be used for protein fortification in soft and sports drinks, as well as in other aqueous systems. Similarly, CN\ 11\ 01530391 (A) disclosed a canned beverage for athletes made with hempseed albumins, which is even better absorbed by the organism than the whole hempseed protein. US2015079235 (A1) proposed hempseed protein using as the main ingredient in an alternative infant formula, which can be either powdered or liquid. Currently, Axiom Foods\textsuperscript{®} and Good Hemp\textsuperscript{®}, which offer products with 58 and 85\% purity, respectively, are among the hempseed protein suppliers in the world\textsuperscript{36,37}. Also, Manitoba Harvest\textsuperscript{®} and LeanHemp\textsuperscript{®} are brands focusing on the hempseed protein supplement segment\textsuperscript{18,39}.

Ten patents used Sunflower (\textit{Helianthus annuus} L) as preferable raw material (Table 1). This species is one of the most cultivated oilseed crops\textsuperscript{40}; its seed meal can reach 40\% protein content when it is mechanically extracted, and 50\% protein content when the oil is extracted with organic solvents\textsuperscript{9}. Approximately 85\% of the total protein content in sunflower seeds is found in the form of storage proteins (11 helianthinin globulin and 25 albumins)\textsuperscript{26}. Globulin content varies from 40 to 90\%, whereas albumin rate ranges from 10 to 30\% of the total protein found in seeds. It is possible observing differences in the ratio of these protein fractions since three different sunflower seed types are majorly cultivated—they are used for oil production, human and pet consumption, and ornamentation\textsuperscript{5}. Despite its low lysine content, sunflower meal remains a good protein source, given its high digestibility and smaller number of antinutritional compounds\textsuperscript{31}. Although sunflower seed proteins have low functionality, such a feature is closely linked to denaturation caused by heating at oil extraction, rather than to native proteins themselves. Moreover, phenolic compounds found in sunflower seeds, such as chlorogenic acid, can crosslink with proteins and change its color, functionality, and bioavailability. However, chlorogenic acid is also beneficial for human health\textsuperscript{30} and can be desirable when it is properly extracted from sunflower seed meal. Patent CN\ 109354574 (A) improved a method by using supercritical carbon dioxide extraction to prepare chlorogenic acid and protein powder from sunflower seeds, in separate. This powder is an interesting raw material for making artificial milk and beverages due to its soft flavor. Similarly, FI\ 128029 (B) addresses a sunflower seed protein with enhanced solubility and low phytate content. Its powder is a suitable ingredient for dairy alternatives. Following functionality improvements, BR\ 11\ 2018070543 (A2) used enzymatic treatment, heating, fermentation, and pressure treatment to increase the techno-functional and organoleptic properties of sunflower seed protein, which is useful as a beverages’ supplement. Presently, Biotechnologies\textsuperscript{®} is the only world sunflower seed protein producer whose product has more than 80\% purity\textsuperscript{42}. However, it is possible finding other suppliers whose products reach about 50\% protein content, among them one finds Austrade Inc\textsuperscript{®} and ETChem\textsuperscript{34,43,44}.

Based on the results, cottonseed was the preferable raw material in seven patents (Table 1). Fiber is the most common

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**Fig. 6 Number of patents by preferable raw materials for use.** Seeds and nuts are represented in blue, whereas legumes and pulses are represented in orange. *The same patent can use more than one raw material as preferable; **In total, 13 patents used other raw material types, such as cereal, seaweed, or fungus, besides using legumes, pulses, seeds, or nuts; ***Three (3) patents did not specify the used raw materials; ****Brazil nut, Camellia seed, Castor bean, Chia seed, Cocoa seed, Fenugreek, Ginkgo biloba seed, Pepper seed, Perilla seed, Physalis seed, Pistachio, Primula seed, Samara seed, Sea buckthorn seed, Snackegourd seed, Tamarind, Thistle seed, Tomato seed, Tung seed, Turnip seed, and Wisteria were cited as preferable raw material by one patent. *****Alfalfa, Broccoli seed, Camellia seed, Grape seed, Hazelnut, Moringa oleifera seed, and Locust bean were cited as preferable raw material by two patents.
| #   | Preferable raw material                      | Publication number         | Origin                          | Beverage type                                           | Presentation form | Protein extraction methods and technologies applied                                                                 | Ref. |
|-----|---------------------------------------------|----------------------------|---------------------------------|--------------------------------------------------------|------------------|----------------------------------------------------------------------------------------------------------------------|------|
| 1   | Camellia seed                               | CN105053506 (A)            | China                           | Protein-rich beverage                                   | Powder           | - Low temperature basic/acid protein precipitation; - Spray drying.                                                   | 79   |
| 2   | Ginkgo biloba seed                          | CN104543328 (A)            | China                           | Beverage (without specification), carbonated beverage, alcoholic beverage | Powder or liquid | - Culture and fermentation; - Vacuum concentration; - Drying and milling.                                           | 80   |
| 3   | Grape seed                                  | US10335446 (B2); US2019000910 (A1) | United States of America        | Juice                                                   | Powder or liquid | - Grinding pomace, centrifuge, and powder.                                                                         | 81   |
| 4   | Hempseed                                    | CN110250276 (A)            | China                           | Protein-rich beverage                                   | Liquid           | - Formula composition.                                                                                                                                                  | 82   |
| 5   | Hempseed                                    | WO2019213757 (A1)          | World Intellectual Property Organization | Sports drink, infant formula                          | Powder or liquid | - Alkalization followed by isoelectric protein precipitation; - Ultrafiltration and microencapsulation.         | 83   |
| 6   | Hempseed                                    | US2015079235 (A1)          | United States of America        | Milk analog, juice, infant formula                      | Powder or liquid | - Formula composition.                                                                                                                                                  | 84   |
| 7   | Hempseed                                    | CN108522780 (A)            | China                           | Beverage (without specification)                       | Powder           | - Low-temperature physical squeezing extraction; - Physical superfine grinding.                                       | 85   |
| 8   | Hempseed                                    | CN110150391 (A)            | China                           | Sport drink                                             | Liquid           | - Basic/acid protein precipitation; - Formula composition.                                                       | 86   |
| 9   | Hempseed                                    | BR112015001964 (A2)        | Brazil                          | Sport drink, protein-rich beverage, carbonated beverage, acid beverage | Powder or liquid | - Calcium salt protein precipitation; - Drying and diafiltration.                                                 | 87   |
| 10  | Moringa oleifera seed                       | CN110856518 (A)            | China                           | Functional beverage                                     | Liquid           | - Ethanol and aqueous extraction; - Vacuum drying.                                                                | 88   |
| 11  | Pepper seed                                 | CN110463818 (A)            | China                           | Protein-rich beverage                                   | Powder           | - Alkaline protein precipitation; - Culture and fermentation; - Enzymolysis; - Spray drying.                  | 89   |
| 12  | Physalis seed                               | CN110432333 (A)            | China                           | Beverage (without specification)                       | Powder           | - Milling and baking the seeds.                                                                                   | 90   |
| 13  | Pumpkin seed                                | RU2590736 (C1)             | Russian Federation              | Milk analog                                             | Powder           | - Natural antibiotic solution maceration; - Drying and milling.                                           | 91   |
| 14  | Pumpkin seed                                | BRPI011075 (B1)            | Brazil                          | Beverage (without specification)                       | Powder or liquid | - Formula composition.                                                                                                                                                  | 92   |
| 15  | Rapeseed                                    | AR097442 (A2)              | Argentina                       | Sports drink, protein-rich beverage                     | Powder           | - Basic/acid protein precipitation.                                                                 | 93   |
| 16  | Rapeseed                                    | BRPI0308380 (B1)           | Brazil                          | Protein-rich beverage, fermented beverage/yogurt analog | Powder           | - Drying the supernatant of a protein micelles dispersion.                                                             | 94   |
| 17  | Rapeseed                                    | BR112012008321 (A2)        | Brazil                          | Sports drink, carbonated beverage, juice, alcoholic beverage | Powder or liquid | - Supernatant heat treatment or isoelectric precipitation extraction.                                               | 95   |
| 18  | Rapeseed                                    | US2020154732 (A1)          | United States of America        | Protein-rich beverage                                   | Powder           | - Basic/acid protein precipitation.                                                                 | 96   |
| 19  | Rapeseed                                    | CN107873944 (A)            | China                           | Functional beverage                                     | Powder           | - Enzymolysis; - Spray drying.                                                                                   | 97   |
| 20  | Rapeseed                                    | WO2019234137 (A1)          | China                           | Protein-rich beverage                                   | Powder           | - Basic/acid protein precipitation.                                                                 | 98   |
| # | Preferable raw material | Publication number | Origin | Beverage type | Presentation form | Protein extraction methods and technologies applied |
|---|------------------------|--------------------|--------|---------------|------------------|--------------------------------------------------|
| 21 | Rapeseed | BRPI0913429 (A2) | Brazil | Carbonated beverage, sports drink, juice, protein-rich beverage | Powder or liquid | - Basic/acid protein precipitation; - Formula composition. |
| 22 | Rapeseed | BRPI0917301 (A2) | Brazil | Protein-rich beverage | Powder | - Basic/acid protein precipitation. |
| 23 | Rapeseed | BRPI0917304 (A2) | Brazil | Protein-rich beverage, carbonated beverage, sport drink | Powder | - Calcium salt protein precipitation; - Acidic protein precipitation; - Diallylation and drying. |
| 24 | Rapeseed | PL2133499 (T3) | Poland | Protein-rich beverage, acid beverage, carbonated beverage, sport drink | Powder | - Calcium salt protein precipitation; - Acidic protein precipitation; - Diallylation and drying. |
| 25 | Rapeseed | BRPI0912171 (A2); BRPI0912171 (B1) | Brazil | Protein-rich beverage, acid beverage, carbonated beverage, sport drink | Powder | - Calcium salt protein precipitation; - Acidic protein precipitation; - Diallylation and drying. |
| 26 | Rapeseed | EP3481220 (A1) | European Patent Office | Beverage (without specification), fermented beverage/yogurt analog | Powder | - Basic/acid protein precipitation; - Drying. |
| 27 | Rapeseed | WO2019110558 (A1) | World Intellectual Property Organization | Protein-rich beverage, fermented beverage/yogurt analog, juice, milk analog | Powder | - Organic solvent or aqueous extraction; - Basic/acid protein precipitation; - Drying. |
| 28 | Rapeseed | HUE033952 (T2) | Hungary | Milk analog, protein-rich beverage, carbonated beverage, sport drink, milk analog | Powder | - Organic solvent or aqueous extraction; - Basic/acid protein precipitation; - Drying. |
| 29 | Rapeseed | PL2498620 (T3) | Poland | Milk analog, protein-rich beverage, carbonated beverage, sport drink, milk analog | Powder | - Organic solvent or aqueous extraction; - Basic/acid protein precipitation; - Drying. |
| 30 | Rapeseed, mustard seed, broccoli seed, linseed, cottonseed, hempseed, safflower seed, sesame seed | CN104543326 (A) | China | Beverage (without specification), fermented beverage, yogurt analog | Powder or liquid | - Supercritical carbon dioxide extraction. |
| 31 | Rapeseed, mustard seed, broccoli seed, linseed, cottonseed, hempseed, safflower seed, sesame seed | CN109354574 (A) | China | Milk analog, protein-rich beverage, carbonated beverage, sport drink, milk analog | Powder | - Supercritical carbon dioxide extraction. |
| 32 | Sesame seed | CN10435326 (A) | China | Milk analog, protein-rich beverage, carbonated beverage, sport drink, milk analog | Powder | - Supercritical carbon dioxide extraction. |
| 33 | Sesame seed | CN10435315 (A) | China | Milk analog, protein-rich beverage, carbonated beverage, sport drink, milk analog | Powder | - Supercritical carbon dioxide extraction. |
| 34 | Sesame seed | CN101810697 (A) | China | Milk analog, protein-rich beverage, carbonated beverage, sport drink, milk analog | Powder | - Supercritical carbon dioxide extraction. |
| 35 | Snake gourd seed | CN103192244 (A) | China | Milk analog, protein-rich beverage, carbonated beverage, sport drink, milk analog | Powder | - Supercritical carbon dioxide extraction. |
| 36 | Sunflower seed | HUE029430 (T2) | Hungary | Milk analog | Powder | - Heated presssed technique. |
| 37 | Sunflower seed | CN109354574 (A) | China | Milk analog | Powder | - Heated presssed technique. |
Legumes and pulses

Legumes are the most consumed staple food after cereals, since they are a low-priced source of nutrients, mainly of proteins; therefore, they are seen as "meat for poor men"\(^4\). In botanical terms, legumes belong to the family *Leguminosae*, which also comprises pulses. All pulses are legumes, although not all legumes are pulses. Based on the Food and Agriculture Organization definition, pulses are only dried edible leguminous presenting low oil content. Consequently, legumes harvested in green forms, such as green beans and green peas, are not included in this group. Furthermore, soybeans and peanuts, which are oil-rich, are also excluded from it. Lastly, crops used for sowing purposes, such as alfalfa and clover, are not pulses\(^5\). Pulses are good energy, fiber, vitamin, mineral, and bioactive compound sources, and besides, ~30% of pulses’ dry bases are proteins\(^6\). In addition to their nutritional importance, pulses have the good nitrogen-fixing capacity and are beneficial to soil fertility and the environment\(^7\). Some native pulses and legumes' proteins are promising to the beverage industry due to their functional features, such as solubility, emulsifying, and foaming proprieties\(^8\). However, depending on the species and on the protein extraction method, beverages made with these proteins also show beany flavor, bitter taste, or sandy mouthfeel\(^9\). —these factors limit their acceptance by consumers.

Another disadvantage of these proteins lies in the fact that different procedures must be followed in order to reduce antinutritional factors and nonprotein compounds from pulses and legumes. Although, isolate proteins extracted from legumes and pulses remain in the mainstream of researchers and patent applicants as they are an economical, ecological, nutritious, and gluten-free raw material used to enrich products\(^10\). Enzymolysis and protein precipitation using an alkaline, acid, or salted solution were the preferable raw material used to enrich products\(^11\). The appropriate extraction of these proteins from the meal is a feasible option to solve this problem. Patents HUE033952 (T2) and PL2498620 (T3) disclosed enhanced methods to produce high-quality protein concentrates and isolates from oilseed meals, including cottonseed, which has incredibly low fiber content and antinutritional factors. These concentrates and isolates are useful as powdered milk analog or to increase protein content of juices, soft drinks, sports drinks, and beverages in general. RU2018129466 (A) disclosed a method to extract cottonseed proteins that can fortify beverages as well. When it is compared to other patents, it also has the advantage of not presenting beany or grassy flavor notes. Nevertheless, so far, cottonseed protein suppliers in the market only provide to animal feeding, they still do not focus on human nutrition.
| #  | Preferable raw material                                                                 | Publication number          | Origin                        | Beverage type                                                                 | Presentation form                                                                 | Protein extraction methods and technologies applied | Ref. |
|----|----------------------------------------------------------------------------------------|-----------------------------|-------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------|------|
| 1  | Alfalfa, lentil, bean, pea, lupine, locust bean, peanut, tamarind, wisteria, chickpea,  | US2019000112 (A1)           | United States of America      | Milk analog, fermented beverage/yogurt analog, protein-rich beverage, sports   | Powder or liquid                                                                  | Basic/acid protein precipitation; Salt protein precipitation; Formula composition. | 120  |
|    | fenugreek, or combinations thereof                                                     |                             |                               | drink, infant formula                                                         |                                                                                  |                                                     |      |
| 2  | Bean and/or pea and/or chickpea and/or lentil                                           | EP3573471 (A1)              | European Patent Office        | Milk analog                                                                  | Powder                                                                          | Enzymolysis; Centrifugation; Spray drying.          | 121  |
| 3  | Black bean or pea                                                                       | US2019133150 (A1)           | United States of America      | Protein-rich beverage                                                        | Powder or liquid                                                                  | Freezing raw material; Grinding.                    | 122  |
| 4  | Black-eyed pea                                                                          | US2019239535 (A1)           | United States of America      | Acid beverage, carbonated beverage, protein-rich beverage, functional         | Powder or liquid                                                                  | Wet grinding; Basic/acid protein precipitation.     | 123  |
|    |                                                                                            |                             |                               | beverage, fermented beverage/yogurt analog                                    |                                                                                  |                                                     |      |
| 5  | Broad bean                                                                              | WO2020051622 (A1)           | World Intellectual Property   | Protein-rich beverage                                                        | Powder                                                                          | Milling; Hydrating; Filtration; Pasteurizing milk-like fluid. | 124  |
|    |                                                                                            |                             | Organization                   |                                                                              |                                                                                  |                                                     |      |
| 6  | Chickpea                                                                                | JP2019520082 (A)            | Japan                         | Milk analog                                                                  | Powder                                                                          | Basic/acid protein precipitation; Ultrafiltration; Evaporation.                                      | 125  |
| 7  | Hyacinth bean                                                                            | CN104774271 (A); CN104774271 (B) | China                         | Beverage (without specification)                                             | Powder                                                                          | Acidic protein precipitation; Enzymolysis; Centrifugation; Drying.                                      | 126  |
| 8  | Kidney bean, red bean, and peanut                                                       | KR102092404 (B1); KR20200013276 (A) | Republic of Korea             | Milk analog                                                                  | Liquid                                                                          | Formula composition.                                 | 127  |
| 9  | Lentil                                                                                  | EP3209141 (A1); EP3209141 (B1) | European Patent Office        | Beverage (without specification)                                             | Powder or liquid                                                                  | Formula composition.                                 | 128  |
| 10 | Lentil, chickpea, pea, or bean                                                          | WO2020061698 (A1)           | World Intellectual Property   | Milk analog                                                                  | Powder or liquid                                                                  | Basic/acid protein precipitation; Heating; Drying.                                             | 129  |
|    |                                                                                            |                             | Organization                   |                                                                              |                                                                                  |                                                     |      |
| 11 | Lentil, chickpea, pea, or bean                                                          | BR112015007140 (A2)         | Brazil                         | Sports drink, protein-rich beverage, acid beverage, carbonated beverage,     | Powder                                                                          | Calcium salt protein precipitation; Diafiltration and drying.                              | 130  |
|    |                                                                                            |                             |                               | milk analog                                                                  |                                                                                  |                                                     |      |
| 12 | Lentil, chickpea, pea, or bean                                                          | KR20190087654 (A)           | Republic of Korea             | Protein-rich beverage                                                        | Powder                                                                          | Calcium salt protein precipitation; Drying.                                                     | 131  |
| 13 | Lentil, chickpea, pea, or bean                                                          | EP3586644 (A1)              | European Patent Office        | Protein-rich beverage, carbonated beverage, milk analog                       | Powder or liquid                                                                  | Calcium salt protein precipitation; Acidic protein precipitation; Diafiltration and drying.   | 132  |
| #  | Preferable raw material                              | Publication number                          | Origin                      | Beverage type                                                                 | Presentation form | Protein extraction methods and technologies applied                                                                 |
|----|-----------------------------------------------------|---------------------------------------------|-----------------------------|-------------------------------------------------------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------|
| 14 | Lentil, chickpea, pea, or bean                     | JP2018110600 (A)                           | Japan                       | Protein-rich beverage, acid beverage, carbonated beverage, sport drink          | Does not specify | Calcium salt protein precipitation; Acidic protein precipitation; Diaffiltration and drying.                            |
| 15 | Lupine                                              | CA2953644 (A1)                             | Canada                      | Milk analog, fermented beverage/yogurt analog                                 | Liquid            | Supercritical carbon dioxide extraction.                                                                               |
| 16 | Lupine                                              | RU2555528 (C1)                             | Russian Federation          | Fermented beverage/yogurt analog                                              | Liquid            | Acidic protein precipitation; Enzymolysis; Pasteurizing.                                                               |
| 17 | Mung bean                                           | US2019191735 (A1)                         | United States of America    | Protein-rich beverage, milk analog, fermented beverage/yogurt analog           | Powder or liquid  | Basic/acid protein precipitation; Ultrafiltration.                                                                      |
| 18 | Mung bean                                           | JP6521257 (B2); JPWO2015105138 (A1)        | Japan                       | Protein-rich beverage                                                        | Powder            | Formula composition.                                                                                                   |
| 19 | Mung bean                                           | JP6332266 (B2); JPWO2014156549 (A1)        | Japan                       | Fermented beverage/yogurt analog                                              | Gel               | Formula composition.                                                                                                   |
| 20 | Mung bean and/or chickpea and/or pea               | CN106261782 (A)                            | China                       | Fermented beverage/yogurt analog                                              | Powder            | Fermentation; Drying.                                                                                                |
| 21 | Mung bean and/or chickpea and/or pea               | CA2962280 (A1)                             | Canada                      | Milk analog                                                                  | Liquid            | Formula composition.                                                                                                   |
| 22 | Pea                                                  | MX2018012893 (A)                           | Mexico                      | Fermented beverage/yogurt analog                                              | Liquid            | Acidic protein precipitation; Fermentation.                                                                            |
| 23 | Pea                                                  | CA3067593 (A1)                             | Canada                      | Sports drink, carbonated beverage, juice, alcoholic beverage                  | Powder or liquid  | Formula composition.                                                                                                   |
| 24 | Pea                                                  | WO2020007940 (A1)                         | World Intellectual Property Organization | Sport drink, protein-rich beverage, infant formula                       | Powder            | Formula composition.                                                                                                   |
| 25 | Pea                                                  | FR3047151 (A1)                             | France                      | Protein-rich beverage, sport drink                                           | Powder or liquid  | Formula composition.                                                                                                   |
| 26 | Pea                                                  | BR1 12019022289 (A2)                       | Brazil                      | Protein-rich beverage, milk analog                                            | Liquid            | Basic/acid protein precipitation; Drying.                                                                              |
| 27 | Pea                                                  | CN107668314 (A)                            | China                       | Functional beverage                                                          | Powder            | Enzymolysis; Centrifugation; Spray drying.                                                                           |
| 28 | Pea                                                  | US2016316785 (A1)                          | United States of America    | Fermented beverage/yogurt analog, juice, alcoholic beverage                  | Powder            | Acidic protein precipitation; Heating.                                                                                |
| 29 | Pea                                                  | FR3070831 (A1)                             | France                      | Sports drink, protein-rich beverage, infant formula                          | Liquid            | Formula composition.                                                                                                   |
| 30 | Pea                                                  | CN109907156 (A)                            | China                       | Functional beverage                                                          | Powder            | Enzymolysis.                                                                                                          |
| 31 | Pea                                                  | MX2018010758 (A)                           | Mexico                      | Fermented beverage/yogurt analog, coffee whitener, protein-rich beverage      | Powder or liquid  | Basic/acid protein precipitation.                                                                                     |

Table 2 continued...
| #  | Preferable raw material | Publication number | Origin | Beverage type | Presentation form | Protein extraction methods and technologies applied | Ref. |
|----|------------------------|--------------------|--------|---------------|------------------|------------------------------------------------------|------|
| 32 | Pea                    | CO2020004049 (A2)  | Colombia | Beverage (without specification) | Powder | - Pasteurizing; - Spay drying; - Isoelectric protein precipitation; - Ultrafiltration. | 151  |
| 33 | Pea                    | CA3079976 (A1)     | Canada  | Protein-rich beverage, juice | Powder or liquid | - Enzymolysis. | 152  |
| 34 | Pea                    | US2019053517 (A1)  | United States of America | Beverage (without specification) | Powder | - Enzymolysis. | 153  |
| 35 | Pea                    | CN109566747 (A)    | China   | Fermented beverage/yogurt analog | Liquid | - Enzymolysis; - Basic/acid protein precipitation; - Fermentation. | 154  |
| 36 | Pea                    | BRI 12019018323 (A2) | Brazil | Acid beverage | Powder | - Acidic protein precipitation. | 155  |
| 37 | Pea                    | ES2676925 (T3)     | Spain   | Sport drink | Powder | - Cetrifugation; - Ultrafiltration. | 156  |
| 38 | Pea                    | CN109907155 (A)    | China   | Functional beverage | Powder | - Basic/acid protein precipitation; - Enzymolysis; - Spray drying. | 157  |
| 39 | Pea                    | EA030803 (B1); EA201691510 (A1) | Eurasian Patent Organisation | Carbonated beverage, juice | Does not specify | - Adsorbent resin extraction. | 158  |
| 40 | Pea                    | WO2020109741 (A1)  | World Intellectual Property Organisation | Acid beverage, carbonated beverage | Powder | - Enzymolysis; - Drying. | 159  |
| 41 | Pea                    | US2020100524 (A1)  | United States of America | Fermented beverage/yogurt analog, milk analog, sports drink, carbonated beverage, acid beverage, protein-rich beverage | Powder | - Basic/acid protein precipitation; - Enzymolysis; - Ultrafiltration. | 160  |
| 42 | Pea                    | CA3008464 (A1)     | Canada  | Milk analog, fermented beverage/ yogurt analog | Powder or liquid | - Acidic protein precipitation. - Enzymolysis; - Ultrafiltration. | 161  |
| 43 | Pea, lentil, chickpea, peanut, pinto bean, Great Northern bean, navy bean, red bean, black bean, kidney bean, broad bean, baby lima bean, pink bean, mayocoba bean, black-eyed pea, cranberry bean, white bean, rice bean, butter bean, or combinations thereof | CN111066944 (A)  | China   | Beverage (without specification) | Does not specify | - Formula composition. | 162  |
| 44 | Pea, lentil, chickpea, peanut, pinto bean, Great Northern bean, navy bean, red bean, black bean, kidney bean, broad bean, baby lima bean, pink bean, mayocoba bean, black-eyed pea, cranberry bean, white bean, rice bean, butter bean, or combinations thereof | US2017087209 (A1) | United States of America | Iron-rich beverage | Powder or liquid | - Salt protein precipitation; - Enzymolysis; - Filtration. | 163  |
| 45 | Peanut                 | CN106260496 (A)    | China   | Beverage (without specification) | Powder | - Basic/acid protein precipitation; - Drying. | 164  |
| 46 | Peanut                 | CN106367196 (A); CN106367196 (B) | China   | Beverage (without specification) | Powder | - Formula composition. | 165  |
Table 2 continued

| Ref. | Publication number | Origin | Beverage Type | Presentation form | Protein extraction methods and technologies applied |
|------|------------------|--------|---------------|-------------------|----------------------------------------------------|
| 47   | CN107927319 (A)  | China  | Juice        | Liquid            | - Enzymolysis.                                      |
| 48   | CN110140801 (A)  | China  | Juice/Powder | Powder/Liquid     | - Spray drying; Enzymolysis; Low temperature basic/acid protein precipitation; Heating; Centrifugation. |
| 49   | US2020170279 (A1)| United States of America | Beverage (without specification) | Powder | - Enzymolysis; Low temperature basic/acid protein precipitation; Heating; Centrifugation. |
| 50   | CN106333057 (A) | China  | Milk analog  | Powder            | - Low temperature basic/acid protein precipitation; Enzymolysis; Spray drying. |
| 51   | FR3072002 (A1); FR3072002 (B1) | France | Fermented beverage/yogurt analog | Gel | - Enzymolysis. |

Based on the results, bean was the preferable raw material in 21 patents (Table 2). Common beans belong to the family **Leguminosae** and to genus **Phaseolus** account for one-third of global pulses production. There are more than 14,000 known different common bean cultivars. Peculiarities of local culture, agriculture, and history influence the mostly consumed beans. Variations on beans’ size, shape, and colors can occur, as well as on their composition and physicochemical features, but these differences tend to be nonsignificant. Overall, dry beans are an important source of proteins—its protein rate ranges from 16 to 33%. Albumins account for up to 10–30% of total protein content on dry weight basis, whereas globulins account for 45–70% of it. Phaseolin and lectin are other important protein fractions found in beans. Although the protein content in beans is significant, it shows some drawbacks, since beans have methionine as limiting amino acid and antinutritional factors are observed in them. These factors can be removed from pulses through a simple fermentation process; consequently, it increases the quality of pulses’ proteins. Patent JPWO2014156549 (A1) disclosed methods to produce a gel by adding alkali metal ions to mung bean protein and by fermenting it. The produced composition can be used as yogurt analog. Similarly, CN106261782 (A) used biological mung bean fermentation to separate protein, starch, fiber, and slurry, and to provide different products, such as instant tablet beverage and fermented drink. Once more, to reduce antinutritional factors, KR20190087654 (A) developed a bean protein presenting low phytic acid content by using calcium salt to precipitate it. At the moment, It is possible finding 80% purity mung bean and fava bean protein suppliers, as among them one finds ETProtein® and Atura®, respectively. The brand Green Boy® also offers powdered proteins extracted from these same bean species. Nancy’s® produces yogurts with different flavors, all made of fava bean protein.

In total, 18 patents were related to peanut’s use as preferable raw material (Table 2). Peanut accounts for 11% of the global protein supply; it has been gaining more popularity due to its resistance to climate changes, as well as because it is a cheap source of high-quality protein. Defatted meal, which is a by-product by the peanut industry, has ~50–55% protein and balanced amino acid profile; therefore, it can be easily used as raw material to produce protein isolates. Peanut proteins are often classified as albumins and globulins. Arachin and conarachin are the main globulins, and both of them are rich in lysine, tryptophan, tyrosine, and phenylalanine. Peanut protein is often nutritionally comparable to animal protein.
| #  | Preferable raw material                                                                 | Publication number       | Origin                                | Beverage type                                      | Presentation form | Protein extraction methods and technologies applied                                                      | Ref. |
|----|----------------------------------------------------------------------------------------|--------------------------|---------------------------------------|--------------------------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------|------|
| 1  | Alfalfa and/or wheat                                                                    | WO2019150144 (A1)       | World Intellectual Property Organization | Sport drink                                      | Powder            | Heating; Microwave extraction; Filtration.                                                                 | 171  |
| 2  | Almond, cashew nut, Brazil nut, coconut, hazelnut, macadamia, peanut, walnut, or pistachio | CN110742128 (A)         | China                                 | Fermented beverage/yogurt analog                 | Liquid            | Enzymolysis; Centrifugation; Fermentation.                                                              | 172  |
| 3  | Cashew nut and/or almond and/or peanut and/or pea and/or oat and/or wheat and/or quinoa | EP3429366 (A1)          | European Patent Office                | Milk analog                                      | Liquid            | Formula composition.                                                                                      | 173  |
| 4  | Chia seed and/or pumpkin seed and/or hempseed and/or almond and/or macadamia and/or lentil and/or pea and/or chickpea and/or mung bean and/or rice | US2019225645 (A1)      | United States of America              | Sports drink, protein-rich beverage, infant formula | Does not specify | Formula composition.                                                                                      | 174  |
| 5  | Does not specify                                                                        | CN110637916 (A)         | China                                 | Fermented beverage/yogurt analog                 | Powder            | Fermentation.                                                                                             | 175  |
| 6  | Does not specify (Legume and/or seed and/or cereal and/or seaweed)                      | JP2017521498 (A)        | Japan                                 | Carbonated beverage, juice, milk analog, sports drink, functional beverage, fermented beverage/yogurt analog, alcoholic beverage | Powder or liquid | Heating; Enzymolysis; Nanofiltration; Spray drying.                                                     | 176  |
| 7  | Does not specify (Legume and/or seed and/or seaweed and/or fungus)                     | EP3634146 (A1)          | European Patent Office                | Protein-rich beverage, milk analog, coffee whitener, fermented beverage/yogurt analog, sport drink, juice | Powder or liquid | Ultrasonication; Filtration.                                                                          | 177  |
| 8  | Pea and coconut                                                                         | US2019307143 (A1)      | United States of America              | Coffee whitener                                  | Liquid            | Isoelectric protein precipitation or enzymolysis.                                                      | 178  |
| 9  | Pea and rice                                                                            | CN111227101 (A)         | China                                 | Beverage (without specification)                | Powder            | Formula composition.                                                                                      | 179  |
| 10 | Pea and/or lupine and/or broad bean and/or rapeseed and/or sunflower seed               | FI128029 (B)            | Finland                               | Milk analog                                      | Does not specify | Formula composition.                                                                                      | 180  |
| 11 | Pea and/or rice and/or oat                                                               | FR3085826 (A3)          | France                                | Beverage (without specification)                | Powder            | Formula composition.                                                                                      | 181  |
| 12 | Pea and/or wheat and/or oat                                                              | WO2019228957 (A1)      | World Intellectual Property Organization | Beverage (without specification), carbonated beverage, juice, alcoholic beverage | Powder or liquid | Formula composition.                                                                                      | 182  |
| 13 | Pea or lupine or bean or chickpea or lentil or peanut or sunflower seed or rapeseed or camelina seed or linseed | BR112018070543 (A2)    | Brazil                                | Milk analog, fermented beverage/yogurt analog | Powder            | Organic solvent extraction; Enzymolysis; Heating; Fermentation.                                          | 183  |
| 14 | Pea or rice                                                                             | BR112019019992 (A2)    | Brazil                                | Infant formula                                   | Powder or liquid  | Enzymolysis; Centrifugation; Nanofiltration; Pasteurizing; Spay drying.                                 | 184  |
| 15 | Pea, walnut, almond, cashew nut, hempseed, or rice                                      | US2020060310 (A1)      | United States of America              | Milk analog, fermented beverage/yogurt analog, protein-rich beverage | Powder            | Formula composition.                                                                                      | 185  |
| #  | Preferable raw material                                                                 | Publication number                          | Origin       | Beverage type                                | Presentation form | Protein extraction methods and technologies applied | Ref. |
|----|--------------------------------------------------------------------------------------------|---------------------------------------------|--------------|---------------------------------------------|-------------------|-----------------------------------------------------|------|
| 16 | Peanut and moringa oleifera seed                                                            | FR3019004 (A1); FR3019004 (B1)             | France       | Juice                                       | Powder            | - Enzymolysis; - Heating; - Acidic protein precipitation; - Drying. | 186  |
| 17 | Peanut, rapeseed, sesame seed, linseed, sunflower seed, cottonseed, safflower seed, perilla seed, castor bean coconut, cocoa seed, almond, tung seed, sesame seed, primula seed, hazelnut, pumpkin seed, walnut, grape seed, sea buckthorn seed, tomato seed pumpkin seed, macadamia, oat, corn, rice, wheat, seaweed, or combinations thereof | CN107125430 (A)                            | China        | Fermented beverage/yogurt analog            | Powder or liquid  | - Enzymolysis.                                      | 187  |
| 18 | Rapeseed, sunflower seed, hempseed, safflower seed, cottonseed, linseed, sesame seed, mustard seed, peanut | RU2018129466 (A)                            | Russian Federation | Protein-rich beverage                        | Powder            | - Acidic protein precipitation; - Dialfiltration; - Drying. | 188  |
| 19 | Sunflower seed, cottonseed, rapeseed, coconut, peanut                                       | WO2020028446 (A1)                           | World Intellectual Property Organization | Protein-rich beverage | Powder            | - Formula composition.                               | 189  |
| 20 | Sunflower seed, cottonseed, rapeseed, coconut, peanut, locust bean, or combinations thereof | US10645950 (B2); US2020060308 (A1)          | United States of America | Beverage (without specification)           | Powder or liquid  | - Formula composition.                               | 190  |
| 21 | Wheat and/or barley and/or corn and/or pea and/or rice                                     | JP6059659 (B2); JPWO2013027813 (A1)        | Japan        | Carbonated beverage, alcoholic beverage     | Does not specify  | - Enzymolysis; - Fermentation.                        | 191  |
ferrmentation, since this process increases its L-lysine, L-methionine, and L-tryptophan contents. However, its allergenicity and poor functional properties hamper peanut protein use by the food industry. Different treatments, such as chemical, physical, or enzymatic methods, have been applied to expand peanut protein functionality. Patent CN106260496 (A) disclosed an improved ultrasonic treatment applicable to peanut protein that provides better solubility, higher yield, and efficiency, as well as environmental protection, when compared to the state of the art. FR3072002 (A1) addresses a stable gel that can be produced by improving peanut protein solubility followed by adding transglutaminase to it. This gel is highly useful to produce yogurts. According to CN106367196 (A), it is possible obtain peanut protein that presents stability in beverages by preventing its denaturation during the extraction process. High-purity peanut protein isolates or concentrates are not in the market yet; however, defatted peanut powder is already provided by ETChem and Peanut Butter & Co, for example.73, 74

Based on the results, chickpea was the preferable raw material in 12 patents (Table 2). It is the second mostly produced legume worldwide and its protein amount ranges from 15 to 30%. Globulins (53 to 60%) and glutelins (19 to 25%) are the main protein fractions in chickpea, but albumins (8 to 12%), and prolamins (3 to 7%) are also relevant in it. Although chickpea lacks sulfured amino acids, it has low content of antinutritional factors and, consequently, high bioavailability of other essential amino acids. Blend chickpea with other pulses that do not lack sulfured amino acids is an interesting solution to its limiting amino acids issue, so the quality of the protein in the final product increases significantly. Patent CA2982280 (A1) provided a method to produce an alternative to milk by using chickpea and/or pea protein as main ingredients. Moreover, the disclosed product has a smooth mouthfeel and does not necessarily need gum, emulsifier, or starch to be added to the formulation. On the other hand, EP3586644 (A1) and WO2020061698 (A1) focused on the production of pulse proteins, including chickpea. These proteins are stable both in hot and acid aqueous environments. Among chickpea proteins available in the market, finds the ones by Innovopro® and Atura®, which sell products with 70 and 80% protein contents, respectively.75, 76 The brand Green Boy® also has chickpea and other different plant-based proteins in its portfolio.

Other mixes

The group “other mixes” regards patents that used either seeds, nuts, legumes, pulses, cereals, seaweeds, fungus, or combinations of these elements. These combinations include blended products to reach a better amino acid score and to optimize the functional and sensorial features of final product. Such an outcome can be obtained through the interaction of proteins from different plant sources (Table 3). FR3085826 (A3) disclosed a powder ready to be reconstituted in water or plant-based milk. This process uses proteins from peas, rice, oats, or from their mixes. Similarly, EP3429366 (A1) divulges a replacement for dairy milk, which is made of peanut protein—but it can also be made of cashew nut, almond, pea, oat, wheat, quinoa, or of combinations of these elements. In regard to functional improvements, CN111227101 (A) provided an instant powdered beverage that can be composed of pea and rice proteins, which shows excellent solubility in hot water (≥85°C). JPWO2013027813 (A1) presented a beer-like product with increased foam stability that was produced with protease, transglutaminase, and with one or more proteins from wheat, barley, corn, pea, or rice. Focusing on sensorial aspects, WO2019228957 (A1) described a method to mask undesirable notes from beverages made of pea, wheat, or oat protein when ethyl cyclohexanoate was used as additive. EP3634146 (A1) suggested the application of ultrasound and membrane filtration processes in proteins from legumes, seeds, seaweeds, or fungus to obtain a clean taste and neutral color product that can be used to enrich a wide range of beverages.

A huge variety of blended products has been introduced in the market. The supplier Burcon® developed a combination of pea and canola proteins, which is nutritionally and functionally better than when these proteins are used separated. The brand Orgain® offers a blend of defatted peanut powder, pea protein, pumpkin seed protein, and almond protein, while Manitoba Harvest® commercializes a mix of pea and hemp proteins, which is ideal to be added to smoothies or non-dairy milks.77, 78

CONCLUSION

Plant proteins extraction to enrich plant-based beverages has recently emerged as solution to lack of this nutrient in these products. However, some other factors, such as poor solubility, off-flavor notes, limiting amino acids, and anti-nutrients remains an issue. Chemical, physical, biological, and enzymatic treatments were reported in patents to solve these problems. Among them, acidification, basification, heating, membrane filtration, centrifugation, ultrasonication, fermentation, or combinations thereof were frequently applied, with the specificity and uniqueness methodology of each patent. Moreover, it has been comprehended that each step of industrial processes, since protein extraction to its incorporation to final products, have huge influence on their nutritional, sensorial, and functional features. Pea, rapeseed, bean, peanut, chickpea, hempseed, sunflower seed, and cottonseed were the most addressed raw materials in the herein assessed patents. Protein blends also emerged as simple alternatives to improve amino acid profile, as well as the functional and sensorial aspects of beverages. Expansion in the use of plant proteins to enrich multiple categories of beverages is another tendency observed. These beverages include sport drinks, carbonated beverages, or even juices, not limited to products that mimic dairy. Briefly, research and development based on plant-based protein have been playing important role in the production of beverages by fulfilling the existing demands from vegetarians, lactose intolerants, and cow milk allergic individuals, but also by turning these products into a suitable option for a wide range of other consumers, such as infants, elderly, athletes, or those who chose a healthier lifestyle. Thus, plant proteins are a promising ingredient to create high-quality beverages, ensuring animal welfare, reducing environmental impact, and guarantying food security if proper technology is applied to them.

DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article.

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## AUTHOR CONTRIBUTIONS

I.A.A., M.R.S., R.S., I.T.P. and J.d.C.d.C. conceived the study. All authors contributed to the study design. M.R.S. collected the data. C.T.A., I.A.A., R.S., I.T.P. and J.d.C.d.C. synthesized the patents applications included in the review. C.T.A. and J.d.C.d.C. created the tables and figures. C.T.A. and J.d.C.d.C. led the writing of this paper. I.A.A., M.R.S., R.S., I.T.P. and J.d.C.d.C. led the revision and editing of this paper.

## COMPETING INTERESTS

The authors declare no competing interests.

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