Title: METHOD FOR REMOVING CONTAMINANTS FROM VEGETABLE OIL AND LECITHIN

Abstract: The invention relates to a method and apparatus for removing chemical contaminants from a crude vegetable oil by prefiltering and filtering through a cationic filter. The prefiltered and filtered vegetable oil can be converted to lecithin with reduced chemical contaminants by conventional and known procedures. The invention also relates to a reduced contaminant vegetable oil and a reduced contaminant vegetable lecithin, which can be made by the method of the invention.
METHOD FOR REMOVING CONTAMINANTS
FROM VEGETABLE OIL AND LECITHIN

Field of the Invention

The invention relates to a method for removing contaminants, such as chemical contaminants, from vegetable oil and lecithin including processing oil by prefitering and filtering through and/or adsorbing on a cationic filter.

Background of the Invention

Edible vegetable oils are generally obtained by processing oil seeds. Crude vegetable oils can be obtained from vegetable seeds by solvent extraction. Hexane is a commonly used extraction solvent. The crude vegetable oils generally contain neutral triglycerides and a host of natural oil seed-derived contaminants including phosphatides, sulphurous compounds, free fatty acids, carbohydrates, peptides, proteins, nucleic acids, oxidized lipids, traces of lower aldehydes and ketones, glycosides of sterols and terpenes, and diverse types of color bodies or dyestuffs. Many of these contaminants are removed from the crude vegetable oils in the course of refining to render the vegetable oils palatable.

The recovery of soybean oil from soybeans is particularly desirable.

Soybean oil is conventionally extracted from dehulled soybeans using hexane. The extractant which includes hexane and crude soybean oil can referred to as miscella and generally requires further processing to provide palatable soybean oil. Several techniques are available for processing the soybean oil. One technique involves evaporating the hexane from the miscella and degumming the resulting crude soybean oil. Degumming, as used in conventional processes, refers to the removal of phosphatides and other gums from the oil by adding water and/or acid thereto and centrifuging. The recovered oil can be further refined with water and alkaline (such as NaOH) and centrifuged to remove the fatty acids and gums. The oil resulting from the alkaline refining step can then be bleached to remove color bodies, hydrogenated to render the oils more stable, and deodorized. The techniques of degumming, alkaline refining, bleaching, hydrogenating, and deodorizing are well known in the art. It should be
appreciated that each separation step, and particularly centrifuging, results in loss of oil. Other techniques for processing miscella are described in U.S. Patent Application Serial Nos. 09/231,692 and 09/483,346 which were filed with the U.S. Patent and Trademark Office on January 14, 1999 and January 14, 2000, respectively. The assignee of these two patent applications is Cargill, Inc., which is the assignee of the present patent application.


Summary of the Invention

A method for removing chemical contaminants from a vegetable oil or lecithin by prefiltering and filtering through a cationic filter is provided by the present invention. The method includes filtering a crude vegetable oil through a prefilter and through a cationic filter. Preferably, the method includes prefiltering a crude vegetable oil through one or more prefilters to produce a clarified vegetable oil and filtering the clarified vegetable oil through one or more cationic
filters. Prefiltering can include any type of filtering suitable for reducing the particulates in the crude vegetable oil to a level that does not unacceptably clog the cationic filter. Prefiltering can employ a plate frame filter with a cake of diatomaceous earth, a bag filter, or a combination thereof. The cationic filter can include a glass filter, a nylon membrane filter, a combination thereof, or any suitable modified polymeric or composite membrane that has a cationic surface charge on the filter. Preferably, the glass filter and/or the nylon membrane filter are coated or chemically treated to increase the amount of cationic charge on the filter. After cationic filtering, the vegetable oil can be processed by any of a variety of conventional or known methods for recovery of lecithin, which has reduced levels of chemical contaminants.

The invention also relates to an apparatus for removing contaminants, preferably chemical contaminants, from vegetable oil. The apparatus of the invention includes a prefilter and a cationic filter. To prefilter is adapted and configured for reducing a particulate in a crude vegetable oil to produce a clarified crude vegetable oil. The cationic filter is adapted and configured for removing a chemical contaminants from a clarified crude vegetable oil. A preferred prefilter includes one or more of a plate frame filter with a cake of diatomaceous earth and/or a bag filter. A preferred cationic filter includes one or more of a glass filter and/or a nylon filter, preferably coated or chemically treated to increase the cationic charge.

In one embodiment, the invention includes a reduced contaminant vegetable oil including a level of DNA of less than about 1μg/mL, about 1 ng/ml, about 1 pg/ml, or about 1 fg/ml. Preferably, the reduced contaminant vegetable oil includes a level of DNA that is undetectable by PCR employing up to about 10-30 cycles with a primer for detecting the 35S promoter from cauliflower mosaic virus. The reduced contaminant vegetable oil can be produced according to the method of the invention. Preferably, the reduced contaminant vegetable oil also includes lecithin.

In another embodiment, the invention includes a reduced contaminant vegetable lecithin including a level of DNA of less than about 1μg/mL, about 1 ng/ml, about 1 pg/ml, or about 1 fg/ml. Preferably, the reduced contaminant
vegetable lecithin includes a level of DNA that is undetectable by PCR employing up to about 10-30 cycles with a primer for detecting the 35S promoter from cauliflower mosaic virus. The reduced contaminant vegetable lecithin can be produced according to the method of the invention, preferably from reduced contaminant vegetable oil that includes lecithin.

**Brief Description of the Drawings**

Figure 1 is a diagrammatic representation of a method for removing chemical contaminants from a vegetable oil or lecithin by prefILTERING and filtering through a cationic filter according to the principles of the present invention.

Figure 2 is a diagrammatic representation of a preferred method for removing chemical contaminants a vegetable oil or lecithin by prefILTERING and filtering through a cationic filter according to the principles of the present invention.

**Detailed Description of the Invention**

The invention relates to a method for removing chemical contaminants from a crude vegetable oil by prefILTERING and filtering through a cationic filter. It should be understood that, as used herein, “crude vegetable oil” refers to any vegetable oil product in need of further processing to provide a desired vegetable oil product.

Certain types of crude vegetable oil can be obtained by expelling oil from vegetable seeds, and other types of crude vegetable oil can be obtained from solvent extraction of vegetable oil seeds, followed by removing the solvent. Techniques for expelling oil from vegetable seeds and for solvent extraction of vegetable seeds are well known and are described, for example, in *Bailey's Industrial Oil and Fat Products, 5th Edition*, edited by Y.H. Hui, New York, Wiley, 1996, and *Handbook of Soy Oil Processing and Utilization*, St. Louis, Mo., American Soybean Association, Champaign, Ill, American Oil Chemists’ Society, the disclosures of which are incorporated herein by reference.

Oil seeds can be prepared for expelling or extracting using techniques well known in the art. This generally includes dehulling and/or grinding, in a dehuller
and/or grinder, to yield ground oil seeds. Expelling can yield crude vegetable oil or another expelled vegetable oil product. In addition, cake from expelling can be extracted for eventual recovery of crude vegetable oil. Extraction produces an extracted vegetable oil product known as miscella, and which includes extraction solvent, vegetable oil, and phospholipid. Solvent can be removed from the miscella by methods known to those of skill in the art, such as evaporation and distillation. Removing the solvent from the miscella produces crude vegetable oil including phospholipid. In certain circumstances, expelled vegetable oil can be combined with miscella before removing solvent to produce crude vegetable oil including phospholipid. Preferably crude vegetable oil is prepared either by expelling or by extraction followed by solvent removal. Preferably, the crude vegetable oil includes less than about 300 ppm to about 1000 ppm remaining extraction solvent.

If desired, the extracted and/or expelled vegetable oil product can be processed further before crude vegetable oil is obtained. For example, the expelled and/or extracted vegetable oil product can be degummed by methods known to those skilled in the art, and, if necessary, solvent removed. The degummed vegetable oil product is then considered crude vegetable oil. It should be noted that, degumming before removing chemical contaminants can result in the chemical contaminants appearing in the lecithin or phospholipid produced by degumming. Alternatively, the extracted and/or expelled vegetable oil product can be further treated by steps of refining, bleaching, hydrogenating, and deodorizing to provide crude vegetable oil. Such techniques are known in the art and are described, for example, in the Handbook of Soy Oil Processing and Utilization, St. Louis, Mo., American Soybean Association, Champaign, Ill, American Oil Chemists’ Society.

Crude vegetable oil that has been processed to remove chemical contaminants according to the invention is referred to herein as "reduced contaminant vegetable oil". Reduced contaminant vegetable oil can be further processed to make a desired, salable vegetable oil product by any of a variety of steps known to those of skill in the art, including degumming, refining, bleaching, hydrogenating, and deodorizing.
For example, reduced contaminant vegetable oil can be further processed by known methods to produce vegetable lecithin referred to herein as "reduced contaminant vegetable lecithin". Reduced contaminant vegetable lecithin can be recovered from reduced contaminant vegetable oil by known methods such as conventional degumming. Reduced contaminant vegetable lecithin can also be recovered from reduced contaminant vegetable oil, after converting this oil to miscella, by known methods for processing miscella, such as those described in U.S. Patent Application Serial Nos. 09/231,692 and 09/483,346 which were filed with the U.S. Patent and Trademark Office on January 14, 1999 and January 14, 2000, respectively.

The preferred vegetable oils which can be processed according to the present invention are the edible vegetable oils which are well-known in the vegetable oil industry. Exemplary vegetable oils include coconut oil, palm oil, palm kernel oil, soya bean oil, corn oil, ground nut oil, olive oil, linseed oil, rapeseed oil, sunflower seed oil, safflower seed oil, cottonseed oil, and grape seed oil. Preferred oils which can be recovered according to the invention include soya bean oil, rapeseed oil, ground nut oil, corn oil, sunflower oil, cottonseed oil, and linseed oil.

Prefiltering

Crude vegetable oil typically includes vegetable oil, residual extraction solvent, solids, phospholipids, and chemical contaminants. The solids can be referred to as fines and can be characterized as particulates. One source of particulates includes meal fines obtained from seed hulls, dirt, sand, and grit. The solids can also include aggregated chemical contaminants or chemical contaminants bound to or trapped in other solids. The solids are generally considered contaminants and it is desirable to remove the solids before separating phospholipids or chemical contaminants from the vegetable oil. In fact, extracting and expelling often include processes for removing solids. Nevertheless, the resulting crude vegetable oil typically includes solids that need to be removed before filtration for the removal of chemical contaminants.

Solids will, if not removed from the crude vegetable oil, relatively quickly
clog a filter suitable for the removal of chemical contaminants. Advantageously, a
prefilter system can remove the solids and/or aggregated chemical contaminants.
The prefilter system can include one or more filters in series to provide reduction
of the solids content of the crude vegetable oil. Preferably, the prefilter can
remove particulates in a targeted size range of greater than about 1 micron. The
resulting crude vegetable oil has a reduced solids content and can be referred to as
clarified crude vegetable oil.

In general, the filters used to remove solids from the crude vegetable oil
have an average pore size in the range of down to less than about 1 micron.

Advantageously, the prefilter system includes a series of prefilters having
decreasing pore size so that the upstream prefilters remove the relatively large
solids and the downstream prefilters remove the smaller solids. The actual pore
size of each filter depends on the solids content of the crude vegetable oil. Of
course, the prefilter system can be provided as a single filter. The finer filters
provided in the prefilter system preferably have an average pore size in the range
of about 0.1 μ to about 1 or 2 μ. Prefiltration can be batch or continuous.
Preferably, the prefilter includes one or more dead end filters. It is desirable for
the prefiltration to remove solids and allow the crude vegetable oil to pass through
the filter.

Figure 1 schematically represents a method for prefiltering vegetable oil at
reference number 10. The solids and aggregate of chemical contaminants can be
removed from the crude vegetable oil 12 by feeding crude vegetable oil 12 through
prefilter system 14. Prefilter system 14 can be provided in any form that can
provide the desired degree of removal of solids and/or aggregated chemical
contaminants. Preferably, prefilter system 14 filters out particles of size greater
than about 1 micron. For example, prefilter 14 can be one or more of a bag filter,
a plate frame filter, a precoat filter, or the like. Prefilter system 14 preferably
includes pore sizes of between about 0.1 μ to about 2 μ.

Figure 2 schematically represents a preferred embodiment 18 of the method
for prefiltering vegetable oil. Preferred embodiment 18 includes a prefilter
system 14 with two prefilters, first prefilter 20 and second prefilter 22. First
prefilter 20 preferably includes pore sizes of between about 20 μ and about 30 μ.
Second prefILTER 22 preferably includes pore sizes of between about 1 μ and about 2 μ. First prefILTER 20 is preferably a precoat filter 24 and second prefILTER 22 is preferably a bag filter 26. Preferably, precoat filter 24 precedes the bag filter 26, and partially clarified crude vegetable oil 28 is fed from precoat filter 24 to bag filter 26.

Precoat filter 24 can be a plate frame filter precoated with a medium suitable for removing the larger solids and contaminant aggregates from the crude vegetable oil 12. A suitable precoat filter 24 can be prepared by providing a depth material on a filter surface. The depth material can be provided by depositing deep bed filtering agents and/or clarifying agents on a filter surface. Exemplary deep bed filtering agents and/or clarifying agents include diatomaceous earth and perlite. Preferably, precoat filter 24 is a plate frame precoated with diatomaceous earth, preferably an about 0.5 inch to about 1 inch cake of diatomaceous earth. Preferably, the diatomaceous earth is flux calcined and filters out particles as small as 0.1 microns, although other diatomaceous earths can also be employed.

Bag filter 26 can be any of a variety of bag filters suitable for removing small solids from a vegetable oil. Suitable types of bag filters include filters made from porous, woven, or fibrous material made of polymers such as polyester, polypropylene, or the like. Preferably, bag filter 26 employs a polyester fiber filter. Bag filter 26 can employ more than one filter bag either in series or parallel. Preferably bag filter 26 employs about 1 to about 7 filter bags, preferably about 3 to about 5 filter bags, preferably about four filter bags. Preferred filter bags are sold by GAF and designated PEXL (polyester extended life)-1-P2E, preferably in a 1 micron size. Additional suitable filter bags are sold by manufacturers such as Filtertech and Parker Hannifin.

The prefiltered crude vegetable oil can be referred to as clarified crude vegetable oil 14, because it has been treated for the removal of solids and aggregated chemical contaminants. Preferably, prefilter 14 provides a clarified crude vegetable oil 16 having a solids content of less than about 15 to about 30 ppm. Preferably, the clarified crude vegetable oil 16 has an almost negligible solids content. Of course, the clarified crude vegetable oil 16 can include a solids content of greater than about 50 to about 100 ppm, but it is expected that the
solids will cause premature clogging of the downstream cationic filter, which, in turn, would require more frequent cleaning or replacement of the filter.

Typically, the crude vegetable oil 12 will include a solids content which, if directed to the cationic filter according to the invention, would fairly quickly clog the cationic filter. In general, crude vegetable oil 12 typically contains a solids content of up to about 1000 ppm, although this amount can certainly be higher depending on the extraction operation. It should be understood that the steps of crude vegetable oil 12 preparation can yield a variety of solids contents, and the prefilter system is provided for reducing the solids content to avoid fouling of the cationic filter. In many oil processing operations, the solids content of the crude vegetable oil 12 is between about 500 ppm and about 2000 ppm. The size of the solids which should be removed from the crude vegetable oil 12 are typically provided in a distribution between about 10 μ and about 1000 μ.

Chemical Contaminant Filtration and/or Adsorption

Clarified crude vegetable oil typically includes chemical contaminants such as extraction solvent, phospholipids, and vegetable derived contaminants. The vegetable derived contaminants can include macromolecules, such as polysaccharides, proteins, and polynucleotides, and small molecules, such as lipids, sugars, and other metabolites. Such chemical contaminants can provide undesirable characteristics to the vegetable oil that render the oil unpalatable, unsalable, or that otherwise reduce the value of the vegetable oil. These contaminants can also provide undesirable characteristics to the phospholipids or lecithins derived from the crude vegetable oil. Thus, it is desirable to remove one or more chemical contaminants before separating the phospholipids from the oil and further processing and selling the oil.

Many consumers and governments will not accept vegetable oil or lecithin from genetically modified crops. Unfortunately, when a genetically modified crop is grown near a conventional (naturally bred or non-modified) crop, cross pollination can result in protein or nucleic acid from the genetically modified crop appearing in products made from the conventional crop. For example, when conventional soybeans are grown near genetically modified soybeans, protein
and/or nucleic acid from the genetically modified soybean can be transferred by cross pollination and found in oil made from the conventional soybean. The character of the conventional soybean crop has not been modified, yet contaminating protein and/or nucleic acid may be found in the oil. Such contamination can result in rejection of this conventional product. In this circumstance, it is desirable to make the oil from the conventional soybean acceptable by removing any protein and/or nucleic acid contaminant that may have been acquired by cross-pollination or in other ways.

Advantageously, chemical contaminants can be removed from vegetable oil by filtration. Filtration to remove one or more chemical contaminants from vegetable oil can rely on properties of the chemical contaminants, such as size, charge, or hydrophobicity, that differentiate the contaminants from the vegetable oil. For example, a cationic filtration medium can retain anionic chemical contaminants, an anionic filtration medium can retain cationic chemical contaminants, a size exclusion filtration medium can retain contaminants larger than the molecular constituents of soybean oil, and a hydrophobic filtration medium can retain contaminants more hydrophobic than soybean oil. The contaminant removal filtration system can include one or more filters in series to provide for reduction in the amount of one or more chemical contaminants in the vegetable oil. A series of different cationic filters can be employed to remove one or more anionic contaminants from the vegetable oil. Alternatively, the series of filters can include anionic, cationic, size exclusion, or hydrophobic filters in any number or order suitable for removing a particular chemical contaminant.

A preferred filtration system for removing chemical contaminants from vegetable oil is a cationic filtration system. This preferred cationic filtration system can include one or more cationic filters in series. Such a cationic filtration system can be employed to remove chemical contaminants including species having a negative charge, e.g. a net negative charge or regions of negative charge, such as proteins and polynucleotides, from a vegetable oil, such as soybean oil. Polynucleotides or nucleic acids have a negative charge due to their sugar-phosphate backbone. Proteins can have a negative charge due, for example, to charged side chains of amino acids. The present inventors have determined that
protein contaminants in soybean oil are retained by a cationic membrane, indicating, for the purposes of the present invention, that these contaminant proteins are negatively charged species. A preferred cationic filtration system employs a cationic glass filter with a pore size of about 0.45 micron followed by a nylon membrane filter with a pore size of the range of about 0.1 to about 0.2 micron. Such a filter system not only removes many chemical contaminants but can also remove fine solids, such as fine meal particulate, with sizes that can be less than 1 micron.

Figure 1 schematically represents a method for removing chemical contaminants from vegetable oil at reference number 30. Chemical contaminants can be removed from the clarified crude vegetable oil 16 by feeding clarified crude vegetable oil 16 through chemical contaminant removal system 30. Chemical contaminant removal system 30 can be provided in any form suitable for the desired degree of removal of a particular chemical contaminant or contaminants. For example, chemical contaminant removal system 30 can include one or more filters such as a cationic filter, an anionic filter, a size exclusion filter, a hydrophobic filter, or the like. Chemical contaminant removal system 30 provides reduced contaminant vegetable oil 32.

Chemical contaminant removal system 30 preferably includes one or more cationic filters. The cationic filter can be constructed in any of a variety of configurations suitable for filtering a vegetable oil and can be made from any of a variety of materials for binding a negatively charged substance. The filter material itself can be suitable for binding a negatively charged substance, or the filter material can be coated or otherwise treated to impart such binding. Suitable materials include glass, glass treated fiber, nylon, nylon treated with a coating, polyester, polyester treated with a coating, Teflon, polycarbonate, or any chemically modified polymeric membrane containing a positive charge. Preferred cationic filters have a capacity to bind about 0.01 to about 1.5 μmol of a negatively charged species per square centimeter of filter area (μmol/cm²), preferably about .03 to about 0.5 μmol/cm², preferably about 0.06 to about 0.3 μmol/cm², preferably about 0.15 μmol/cm². The cationic filters typically have a pore size of about 0.1 micron to about 0.45 micron.
The capacity of a cationic filter can be measured by determining the volume of a solution containing a known concentration of a charged solute that can pass through a cationic filter having a particular surface area before the charged solute begins to appear in the filtrate. For example, a charged dye such as Metanil Yellow (which has a single negative charge) can be dissolved in water, and aliquots of the dye solution can be filtered through a selected filter material, such as treated nylon 66. After each aliquot has been filtered, the filtrate can be examined for discoloration by the dye. The volume of filtrate recovered up to and including the first colored aliquot represents the breakthrough volume, which is the volume of solution from which the dye has been bound by the cationic membrane. The breakthrough volume, the concentration of the dye solution, and the surface area of the membrane yield the capacity of an area of membrane to bind a quantity of charged dye. This can be expressed in units of moles of charge bound per unit of membrane area, such as µmol/cm².

Figure 2 schematically represents a preferred embodiment 32 of chemical contaminant removal system 30. Preferred embodiment 32 includes a cationic filter system 36 with two cationic filters, the first cationic filter 38 and second cationic filter 40.

First cationic filter 38 preferably includes a pore sizes of between about 0.45 micron and about 0.8 micron and preferably has a capacity to bind about 0.01 to about 1.5 µmol of a negatively charged species per square centimeter of filter area (µmol/cm²). First cationic filter 38 can be any cationic filter suitable for filtering or adsorbing any particles or molecules having a negative charge, e.g. a net negative charge or regions of negative charge. Suitable materials for first cationic filter 38 include glass, glass treated fiber, nylon, nylon treated with a coating, polyester, polyester treated with a coating, teflon, or polycarbonate. The material can have a variety of configurations, such as a membrane or pleated membrane. First cationic filter 40 can include pore sizes of between about 0.45 micron and about 0.8 micron and can have a capacity of about 0.03 to about 0.5 µmol/cm².

Second cationic filter 40 can be any cationic filter suitable for filtering or adsorbing residual amounts of a chemical contaminant, such as DNA or DNA
fragments. Suitable materials for second cationic filter 40 include nylon, nylon treated with a coating, polyester, polyester treated with a coating, Teflon, or polycarbonate. The material can have a variety of configurations, such as a membrane or pleated membrane. Second cationic filter 40 can include pore sizes of between about 0.1 micron and about 0.2 micron and can have a capacity to bind about 0.01 to about 1.5 \( \mu \text{mol/cm}^2 \) of a negatively charged species per square centimeter of filter area (\( \mu \text{mol/cm}^2 \)), preferably about .03 to about 0.5 \( \mu \text{mol/cm}^2 \), preferably about 0.06 to about 0.3 \( \mu \text{mol/cm}^2 \), preferably about 0.15 \( \mu \text{mol/cm}^2 \).

First cationic filter 38 preferably includes a glass filter 42, which is cationic due to the surface charge of the glass material, or a coating on the glass material that imparts a surface charge, and has a pore size of about 0.45 micron. Preferred glass filters 42 also include also include an absolute filter or an electronic grade particle rejection (e.g. 99.99\%) filter. A preferred glass filter 42 is generally cylindrical, pleated, and has a size of about 4 feet by about 2.5 inches in diameter and a surface area of about 22 square feet. Suppliers of preferred glass filters and filter materials include Parker Hannifin, Osmonics, and MSI, who sell glass filters under designations such as Calyx CG glass microfiber cartridges (MSI), Inphorn process filters (Parker Hannifin), and Fulflo® Glass-Mate cartridges (Parker Hannifin).

Second cationic filter 40 preferably includes a nylon filter 44, which is cationic due to a surface coating and a pore size of about 0.1 to about 0.2 microns. The second cationic filter is preferably generally cylindrical, pleated, and has a length of about 4 feet and diameter of about 2.5 inches. Suitable nylon filters 44 also include an O-ring seal assembly, preferable a 222 or 226 assembly. A preferred nylon filter 44 has a size of about 4 feet by about 2.5 inches in diameter. Suppliers of preferred nylon filters and filter materials include Osmonics, MSI, Parker Hannifin, and U.S. Filter, under designations such as Calyx PH Nylon cartridges (MSI), Calyx CN Nylon cartridges (MSI), Advantage™ TM filter cartridges (Parker Hannifin), and Ultra Pure membranes (Parker Hannifin).

The crude vegetable oil processed through the chemical contaminant removal system 30 can be referred to as reduced contaminant vegetable oil 32, because it has been treated for the removal of chemical contaminants. Preferably,
chemical contaminant removal system 30 provides a reduced contaminant vegetable oil 32 with levels of chemical contaminants reduced below a level of about 10, 3, 1, 0.3, 0.1, 0.03, or 0.01 μg/mL or below about 3, 1, 0.3, or 0.1 ng/mL. Preferably, the reduced contaminant vegetable oil includes levels of protein and polynucleotides that cannot be detected by typically sensitive PCR or commercial dye or stain based protein assays.

Preferably, chemical contaminant removal system 30 provides a reduced contaminant vegetable oil 32 with levels of DNA reduced below a level of about 10, 3, 1, 0.3, 0.1, 0.03, or 0.01 μg/mL, below about 3, 1, 0.3, 0.1, 0.03, 0.01 ng/mL, below about 3, 1, 0.3, 0.1, 0.03, 0.01 pg/mL, or below about 3, 1, 0.3, 0.1, 0.03, 0.01 pg/mL, or below about 3, 1, 0.3, 0.1, 0.03, 0.01 pg/mL; more preferably less than about 1μg/mL, about 0.1μg/mL, about 0.01μg/mL, about 0.001μg/mL; or about 1 ng/ml. Preferably, these levels of DNA refer to levels of DNA having about 88 or more bases, with unspecified amounts of smaller DNA fragments. Preferably, the reduced contaminant vegetable oil includes a level of DNA that is undetectable by PCR employing typically sensitive conditions and primers for finding DNA in a food product. For example, PCR can run for about 10 to about 30 cycles with primers for DNA typically found in a genetically modified organism, e.g. the 35S promoter from cauliflower mosaic virus. Suitable methods for such PCR are known to those of skill in the art and are described in references such as:


Reduced contaminant vegetable oil can be processed by conventional degumming, or by converting to miscella and using known methods for processing miscella, to produce lecithin that has been treated for the removal of chemical contaminants, which can be referred to as reduced contaminant vegetable lecithin 46. Preferably, chemical contaminant removal system 30 and subsequent processing of reduced contaminant vegetable oil provide a reduced contaminant vegetable lecithin 46 with levels of chemical contaminants reduced below a level of about 10, 3, 1, 0.3, 0.1, 0.03, or 0.01 μg/mL or below about 3, 1, 0.3, or 0.1
ng/mL. Preferably, the reduced contaminant vegetable lecithin 46 includes levels of protein and polynucleotides that cannot be detected by typically sensitive PCR or commercial dye or stain based protein assays.

Preferably, chemical contaminant removal system 30 and subsequent processing provides a reduced contaminant vegetable lecithin 46 with levels of DNA reduced below a level of about 10, 3, 1, 0.3, 0.1, 0.03, or 0.01 µg/mL, below about 3, 1, 0.3, 0.1, 0.03, 0.01 ng/mL, below about 3, 1, 0.3, 0.1, 0.03, 0.01 pg/mL, or below about 3, 1, 0.3, 0.1, 0.03, 0.01, 0.003, 0.001, 0.0003, or 0.0001 fg/mL; more preferably less than about 1µg/mL, about 0.1µg/mL, about 0.01µg/mL, or about 1 ng/ml. Preferably, these levels of DNA refer to levels of DNA having about 88 or more bases, with unspecified amounts of smaller DNA fragments. Preferably, the reduced contaminant vegetable lecithin 46 includes a level of DNA that is undetectable by PCR employing typically sensitive conditions and primers for finding DNA in a food product. For example, PCR can run for about 10 to about 30 cycles with primers for DNA typically found in a genetically modified organism, e.g. the 35S promoter from cauliflower mosaic virus. Suitable methods for such PCR are described hereinabove.

**EXAMPLES**

The present method has been successfully employed both in a laboratory and at a pilot plant scale. The pilot plant scale runs were conducted on soybean while including natural soybean and added DNA. In each case, method of the invention removed the DNA to produce reduced contaminant vegetable lecithin. The results are reported in the table below.
<table>
<thead>
<tr>
<th>Run</th>
<th>Sample</th>
<th>Soy-DNA</th>
<th>35S and NOS promoter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feed</td>
<td>pos.</td>
<td>pos.</td>
</tr>
<tr>
<td>1</td>
<td>Oil from 0.45 um</td>
<td>neg.</td>
<td>neg.</td>
</tr>
<tr>
<td>1</td>
<td>Oil from 0.2 um</td>
<td>neg.</td>
<td>neg.</td>
</tr>
<tr>
<td>2</td>
<td>Feed</td>
<td>pos.</td>
<td>pos.</td>
</tr>
<tr>
<td>2</td>
<td>Oil from 0.45 um</td>
<td>neg.</td>
<td>neg.</td>
</tr>
<tr>
<td>2</td>
<td>Oil from 0.2 um</td>
<td>neg.</td>
<td>neg.</td>
</tr>
<tr>
<td>3</td>
<td>Feed</td>
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<td>pos.</td>
</tr>
<tr>
<td>3</td>
<td>Oil from 0.45 um</td>
<td>neg.</td>
<td>neg.</td>
</tr>
<tr>
<td>3</td>
<td>Oil from 0.2 um</td>
<td>neg.</td>
<td>neg.</td>
</tr>
</tbody>
</table>

The method was employed with a feed rate of 8 liters per minute through a filter with a surface area of 90 square feet. The level of DNA was reduced below a level detectable by PCR employing primers specific for soybean DNA or for cauliflower mosaic virus 35S promoter and NOS terminator. PCR was conducted by the testing organization Genescan, Germany employing proprietary, but commercially available, methods.

The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.
WE CLAIM:

1. A method for removing chemical contaminants from vegetable oil comprising the steps of:
   (a) prefILTERING crude vegetable oil to provide removal of particulates having a targeted size range of greater than about 1 micron to provide clarified crude vegetable oil; and
   (b) filtering the clarified vegetable oil by cationic filtration for selective removal from the clarified vegetable oil of negatively charged species.

2. The method of claim 1, wherein prefiltering comprises filtering through diatomaceous earth.

3. The method of claim 2, wherein prefiltering through diatomaceous earth comprises filtering through flux calcined diatomaceous earth defining a pore size of about 0.7 micron.

4. The method of claim 1, wherein prefiltering comprises filtering through a bag filter.

5. The method of claim 4, wherein prefiltering through a bag filter comprises filtering through a polyester bag defining a pore size of about 1 micron.

6. The method of claim 1, wherein prefiltering comprises filtering through diatomaceous earth followed by filtering through a bag filter.

7. The method of claim 1, wherein cationic filtering comprises filtering through a glass filter.

8. The method of claim 7, wherein cationic filtering through a glass filter comprises filtering through an about 0.45 micron glass filter.
9. The method of claim 1, wherein cationic filtering comprises filtering through a nylon filter.

10. The method of claim 9, wherein cationic filtering through a nylon filter comprises filtering through an about 0.1 to about 0.2 micron nylon filter.

11. The method of claim 1, wherein filtering comprises filtering through a glass filter followed by filtering through a nylon filter.

12. The method of claim 1, further comprising the step of: recovering reduced contaminant vegetable lecithin from the reduced contaminant vegetable oil.

13. The method of claim 12, wherein recovering comprises degumming the reduced contaminant vegetable oil to produce reduced contaminant vegetable lecithin.

14. The method of claim 12, wherein recovering comprises converting the reduced contaminant vegetable oil to miscella and producing reduced contaminant vegetable lecithin from the miscella.

15. An apparatus for removing contaminants from vegetable oil comprising:
   (a) a prefilter, the prefilter being adapted and configured to provide removal of particulates having a targeted size range of greater than about 1 micron to provide clarified crude vegetable oil;
   (b) a cationic filter, the cationic filter being adapted and configured for selective removal from the clarified vegetable oil of negatively charged species.

16. The apparatus of claim 15, wherein the prefilter comprises a plate frame filter with a cake of diatomaceous earth.
17. The apparatus of claim 15, wherein the prefilter comprises a bag filter.

18. The apparatus of claim 17, wherein the bag filter comprises a polyester bag defining a pore size of about 1 micron.

19. The apparatus of claim 17, wherein the bag filter comprises a plurality of filter bags.

20. The apparatus of claim 19, wherein the bag filter comprises four filter bags.

21. The apparatus of claim 15, wherein the prefilter comprises a plate frame filter with a cake of diatomaceous earth and a bag filter.

22. The apparatus of claim 15, wherein the cationic filter comprises a glass filter.

23. The apparatus of claim 22, wherein the glass filter comprises an about 0.45 micron glass filter.

24. The apparatus of claim 15, wherein the cationic filter comprises a nylon filter.

25. The apparatus of claim 24, wherein the nylon filter comprises an about 0.1 to about 0.2 micron nylon filter.

26. The apparatus of claim 15, wherein the cationic filter comprises a glass filter and a nylon filter.

27. A reduced contaminant vegetable oil comprising a level of DNA of less than about 1 ng/mL.
28. The reduced contaminant vegetable oil of claim 27, comprising a level of DNA undetectable by PCR employing a primer adapted and configured for detecting a cauliflower mosaic virus S35 promoter and less than about 8 cycles.

29. The reduced contaminant vegetable oil of claim 27, produced by subjecting a crude vegetable oil to prefiltering followed by cationic filtering.

30. The reduced contaminant vegetable oil of claim 27, further comprising lecithin.

31. A reduced contaminant vegetable lecithin comprising a level of DNA of less than about 1 ng/mL.

32. The reduced contaminant vegetable lecithin of claim 31, comprising a level of DNA undetectable by PCR employing a primer adapted and configured for detecting a cauliflower mosaic virus S35 promoter and less than about 8 cycles.

33. The reduced contaminant vegetable oil of claim 31, produced by subjecting a crude vegetable oil to prefiltering followed by cationic filtering and degumming.
Crude Vegetable Oil

Prefilter

Chemical Contaminant Removal

Oil for Degumming

Degumming

Lecithin PCR-

Degummed Oil PCR-

Fig. 1
Crude Vegetable Oil

Precoat Filter

Bag Filter

1st Cationic Filter glass filter

2nd Cationic Filter nylon filter

Oil for Degumming

Degumming

Lecithin PCR-

Degummed Oil PCR-

Fig. 2
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C11B3/00 C11B3/10 A23D9/013 A23D9/00 A23D9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C11B A23D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base searched during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, FSTA, COMPENDEX, CHEM ABS Data, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents:
  *A* document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search: 12 December 2001

Date of mailing of the international search report: 14/01/2002

Name and mailing address of the ISA:
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Fax: (+31-70) 340-3015

Authorized officer: Rooney, K
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