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(54) PROTEIN CONCENTRATES AND ISOLATES, AND PROCESSES FOR THE PRODUCTION THEREOF FROM TOASTED OILSEED MEAL

PROTEINKONZENTRATE UND -ISOLATE SOWIE VERFAHREN ZU IHRER HERSTELLUNG AUS EINEM GERÖSTETEM ÖLSAMEN-NAHRUNGSMITTEL

CONCENTRÉS ET ISOLATS DE PROTÉINE, ET PROCÉDÉS POUR LA PRODUCTION DE CEUX-CI À PARTIR DE TOURTEAU D'OLÉAGINEUX GRILLÉ

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Description

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to a process for the production of protein concentrates and protein isolates from a toasted oilseed meal.

BACKGROUND

[0002] Oilseeds typically contain from about 20 percent oil to about 50 percent oil by weight, with the percentages varying with the type of oilseed. Generally, the seed is pressed, with or without a prior heat treatment step, to obtain a pressed oil and a pressed seedcake. Generally, the pressed seedcake is then solvent extracted to remove or reduce the remaining oil. Removing the residual solvent from the meal is generally performed by heating the meal to evaporate the residual solvent, and in the process, the meal is toasted. As a result of the heating/toasting of the meal, a significant portion of the protein is denatured, rendering much of the protein less soluble in many solvents. After removal of the solvent from the pressed seedcake and drying of the seedcake, there generally remains a toasted, toasted defatted meal, which contains from about 25% to about 55% of protein on a dry weight basis.

[0003] Some toasted defatted meals, depending upon the oilseed, contain a high amount of fiber, as well as other anti-nutritional factors and undesirable compounds, such as glucosinolates, phytic acid or phytates, sinapine and sinigrin. The fiber and anti-nutritional factors present in the protein render the toasted defatted meal unattractive for commercial uses. In addition, toasted meal is not generally used as a source of protein, because of its high percentage of insoluble protein, which is difficult to remove from the fiber.

[0004] In the case of toasted canola defatted meal, one method of separating the protein from the fiber, anti-nutritional factors and other undesirable compounds has been to dissolve the canola protein in a high ionic strength (i.e. high salt content) aqueous solution. This results in the canola protein dissolving in the aqueous solution, while the fiber is insoluble. However, the salt is difficult and uneconomical to remove and recover from the resultant canola protein solution. US 6 335 043 B1 discloses a method of extracting proteins from soybean.

SUMMARY OF THE DISCLOSURE

[0005] Herein, a process for the production of protein concentrates and protein isolates is disclosed. In addition, protein concentrates and protein isolates produced in accordance with the processes of the disclosure are also disclosed. In particular, the disclosure relates to a process for the facile removal of fiber, antinutritional factors and other constituents from a toasted oilseed meal containing such, to produce protein concentrates and protein isolates of high quality.

[0006] In an embodiment of processes of the present disclosure, an oilseed is heat treated to a temperature of about 60°C to about 120°C, optionally about 70°C to about 100°C, or about 80°C to about 90°C, or about 80°C.

[0007] In another embodiment of the present disclosure, a process for the production of a protein concentrate possessing a protein content of about 70% to about 75% is disclosed.

[0008] The invention refers to

1. a process for the production of a protein concentrate from a toasted oilseed meal comprising:

    i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
    ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
    iii) optionally adjusting the pH of the mixture to solubilize proteins in the mixture;
    iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

        a) a fiber fraction, and
        b) a protein fraction comprising

            (i) an insoluble protein fraction, and
            (ii) a soluble protein fraction;

    v) separating the fiber fraction from the protein fraction and mixing the fiber fraction with a second blending solvent to form a fiber mixture;
    vi) treating the fiber mixture with a protease at a temperature and a pH suitable for protease activity;
    vii) subjecting the fiber mixture to a g-force sufficient to separate the fiber mixture to form:

a) a second fiber fraction, and
b) a hydrolyzed protein fraction, comprising

(i) an insoluble protein fraction comprising partially hydrolyzed and un-hydrolyzed protein, and
(ii) a soluble hydrolyzed protein fraction;

viii) optionally adjusting the pH of the protein fraction from step iv(b) to a pH suitable to precipitate proteins;
ix) separating the precipitated proteins from the protein fraction;
x) optionally combining the precipitated proteins and the hydrolyzed protein fraction to form the protein concentrate.

2. The process according to 1, wherein the first and second blending solvents comprise water.

3. The process according to 1 or 2, wherein the temperature suitable for phytase activity is between 20° and 60°C and the pH suitable for phytase activity is between 2.0 and 7.0.

4. The process according to any one of 1 to 3, wherein the mixture and/or the fiber mixture is subjected to a g-force of between 100g and 500g.

5. The process according to any one of 1 to 4, wherein separating the mixture and/or the fiber mixture comprises using a centrifuge or a hydrocyclone.

6. The process according to any one of 1 to 5, wherein the pH suitable to precipitate the proteins in the protein fraction is between 4.0 and 6.0.

7. The process according to any one of 1 to 6, further comprising the step of drying the protein concentrate to a moisture of between 4% and 8% (w/w).

8. The process according to any one of 1 to 7, wherein the protein concentrate also comprises peptides and free amino acids.

9. The process according to any one of 1 to 8, wherein the toasted oilseed meal comprises canola meal.
The invention also refers to a

10. process for the production of a protein isolate from a toasted oilseed meal comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to solubilize proteins in the mixture;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) a protein fraction comprising

(i) an insoluble protein fraction, and
(ii) a soluble protein fraction;

v) separating the insoluble protein fraction from the soluble protein fraction to recover therefrom an insoluble protein concentrate and a soluble protein extract; and
vi) subjecting the soluble protein extract to membrane filtration to recover therefrom the protein isolate.

11. The process according to 10, wherein the first blending solvent comprises water, a saline solution or a polysaccharide solution.

12. The process according to 11, wherein the first blending solvent comprises water.

13. The process according to any one of 10 to 12, wherein the temperature suitable for phytase activity is between 20° and 60°C and the pH suitable for phytase activity is between 2.0 and 7.0.

14. The process according to any one of 10 to 13, wherein the mixture is subjected to a g-force of between 100g and 500g.

15. The process according to any one of 10 to 14, wherein the toasted oilseed meal comprises canola meal.

[0009] In another embodiment, the toasted defatted or toasted protein-enriched meal comprises a canola, rapeseed, mustard seed, broccoli seed, flax seed, cotton seed, hemp seed, safflower seed, sesame seed or soybean meal. In a further embodiment, the toasted protein-enriched meal comprises a canola meal. In an embodiment, the toasted protein-enriched meal comprises a soybean meal. In another embodiment, the toasted protein-enriched meal comprises mustard seed meal. In a further embodiment, the toasted protein-enriched meal comprises flax seed meal.

[0010] In another embodiment, the mixing solvent comprises water, methanol, ethanol or isopropanol, and mixtures thereof. In a further embodiment, the solvent is water or ethanol, and mixtures thereof. In an embodiment of the disclosure, the toasted defatted or toasted protein-enriched meal is mixed with a mixing solvent in a ratio of 3 to 10 parts solvent to 1 part of the toasted defatted or toasted protein-enriched meal, optionally 4 to 8, or 4 to 6, on a weight-to-weight basis.

[0011] In another embodiment of the disclosure, the mixture is screened through a mesh screen of typically 10 to about 2 US mesh size, optionally a mesh screen of 20 to 200 US mesh size. In another embodiment, the mesh size is 40 US mesh size.

[0012] In an embodiment of the present disclosure, the toasted defatted or toasted protein-enriched meal is mixed thoroughly with water to form the second mixture. In an embodiment, the mixing of water and the toasted defatted or toasted protein-enriched meal comprises using a wet mill or an inline mixer.

[0013] In another embodiment of the present disclosure, the cellulase complex is added to the second mixture in an amount of 1 gram to 10 grams for about every 1 kg of dry solids of the toasted defatted or toasted protein-enriched meal (0.1% to 1%). In a further embodiment, the cellulase complex is mixed with the second mixture for about 0.5 hours to about 5 hours. In another embodiment, the cellulase complex is mixed with the second mixture for 1 to 3 hours.

[0014] In another embodiment of the disclosure, the second mixture with the added cellulase complex is heated to a temperature of 30°C to 60°C, suitably 40°C to 60°C.

[0015] In an embodiment, the cellulase complex comprises at least one of endocellulase, exocellulase, cellobiohydrolase, cellobiase, endohemicellulase and exohemicellulase.

[0016] In an embodiment of the disclosure, the extraction solvent comprises methanol, ethanol or isopropanol, and mixtures thereof. In a further embodiment, the extraction solvent comprises ethanol or water, and mixtures thereof.

[0017] In an embodiment of the present disclosure, the first or second mixture is washed at least once with about 5% to about 100%, optionally about 25% to about 85%, or about 50% to about 85%, or about 60% to about 85%, of the extraction solvent (v/v) in water.

[0018] In an embodiment of the present disclosure, the ratio of the extraction solvent to the first or second mixture is about 5% to about 95%, optionally about 10% to about 90%, about 20% to about 70%, or about 40% to about 80%(v/v) (extraction solvent to first or second mixture).

[0019] In an embodiment of the present disclosure, the first or second mixture is washed with the extraction solvent at a temperature of about 10°C to about 90°C. In another embodiment, the first or second mixture is washed with the extraction solvent at a temperature of about 20°C to about 60°C. In a further embodiment, the first or second mixture is washed with the extraction solvent at a temperature of about 20°C to about 25°C.

[0020] In another embodiment of the present disclosure, the extract is separated from the washed toasted defatted or toasted protein-enriched meal by centrifugation, vacuum filtration, pressure filtration, decantation or gravity draining in an extractor.

[0021] In another embodiment of the present disclosure, steps 2) and 3) are repeated at least twice.

[0022] In another embodiment of the present disclosure, the process further comprises the step of drying the washed toasted defatted or toasted protein-enriched meal to form the protein concentrate. In a further embodiment, the washed toasted defatted or toasted protein-enriched meal is dried in a vacuum dryer, fluidized bed dryer, ring dryer or spray dryer. In another embodiment, the washed toasted defatted or toasted protein-enriched meal is dried to a moisture content of about 0.5% to about 12%, optionally about 1% to about 10%, about 4% to about 8%. In a further embodiment, the washed toasted defatted or toasted protein-enriched meal is dried to a moisture content of about 6%.

[0023] In another embodiment of the present disclosure, the extract is desolventized and dried to form a high sugar fraction. In an embodiment, the extract is desolventized by spray drying, drum drying or vacuum drying.

[0024] In an embodiment of the present disclosure, a process for the production of a protein concentrate possessing a protein content of about 75% to about 90% is disclosed. In another embodiment, the protein concentrate is hydrolyzed to produce peptides and free amino acids. In another embodiment, the hydrolyzed protein concentrate comprises peptides and/or free amino acids.

[0025] In another embodiment, the first and second blending solvents comprise water, a saline solution or a polysaccharide solution. In a further embodiment, the first and second blending solvents comprise water.

[0026] In an embodiment of the disclosure, the ratio of the toasted oilseed meal to the first blending solvent is 1:3 to 1:30 (w/w) of meal to water, optionally 1:8 to 1:10 (w/w).

[0027] In an embodiment of the disclosure, the phytase is added in an amount between 0.01% to 0.1% (w/w) based on the weight of the toasted oilseed meal. In a further embodiment, the temperature suitable for phytase activity is between 20° and 60°C. In a further embodiment, the pH suitable for phytase activity is between 2.0 and 7.0.

[0028] In another embodiment of the disclosure, the mixture is subjected to a g-force of between 100g and 500g, suitably between 150g and 400g, optionally between 180g and 350g.

[0029] In another embodiment, separating the mixture comprises using a centrifuge or a hydrocyclone. In an embodiment, the centrifuge comprises a decanter centrifuge or a disc stack centrifuge.

[0030] In another embodiment, separating the insoluble protein fraction from the soluble protein fraction comprises using a centrifuge or a hydrocyclone. In a further embodiment separating the insoluble protein fraction from the soluble protein fraction comprises using a centrifuge. In another embodiment, centrifuging to separate the insoluble protein fraction from the soluble protein fraction comprises a g-force between 2,500g and 9,500g.

[0031] In another embodiment, the process further comprises the step of drying the protein isolate to a moisture content of between 4% and 8% (w/w).

[0032] In a further embodiment, the protein isolate comprises a hydrolyzed protein concentrate. In another embodiment, the hydrolyzed protein concentrate comprises peptides and/or free amino acids.

[0033] Other features and advantages of the present disclosure will become apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] The following embodiments will be described in relation to the drawings in which:

FIG. 1 is a schematic representation showing a preparation of toasted defatted meal of an oilseed;
FIG. 2 is a schematic representation showing a preparation of a toasted protein-enriched meal from the toasted defatted meal of an oilseed;
FIG. 3 is a schematic representation of a first embodiment for crushing of *Juncea* Seed and preparation of toasted defatted *Juncea* meal;
FIG. 4 is a schematic representation of a second embodiment showing the crushing of Juncea seed and preparation of toasted defatted Juncea meal;
FIG. 5 is a schematic representation of a first embodiment showing the milling and screening of toasted defatted Juncea meal;
FIG. 6 is a schematic representation of a second embodiment illustrating a milling and screening process of toasted defatted Juncea meal;
FIG. 7 is schematic representation showing a preparation of a protein concentrate from a toasted protein-enriched meal;
FIG. 8 is a schematic representation of a first embodiment showing the removal of fiber during a preparation of a protein concentrate from a toasted protein-enriched meal;
FIG. 9 is a schematic representation of a second embodiment showing the removal of fiber during a preparation of a protein concentrate from a toasted protein-enriched meal;
FIG. 10 is a schematic representation of a third embodiment showing the removal of fiber during a preparation of a protein concentrate from a toasted protein-enriched meal;
FIG. 11 is a schematic representation of a fourth embodiment showing the removal of fiber during the preparation of a protein concentrate from a toasted protein-enriched meal;
FIG. 12 is a schematic representation of a first embodiment showing a preparation of a protein concentrate and a protein isolate from a toasted protein-enriched meal;
FIG. 13 is a schematic representation of a second embodiment showing a preparation of a protein concentrate and a protein isolate from a toasted protein-enriched meal;
FIG. 14 is a schematic representation of a first embodiment showing a preparation of a protein isolate from a toasted protein-enriched meal;
FIG. 15 is a schematic representation of a second embodiment showing a preparation of a protein isolate from a toasted protein-enriched meal;
FIG. 16 is a schematic representation of a first embodiment showing a preparation of a protein concentrate from a protein enriched meal;
FIG. 17 is a schematic representation of a second embodiment showing a preparation of a protein concentrate from a protein enriched meal;
FIG. 18 is a schematic representation of a third embodiment showing a preparation of a protein concentrate from

a protein enriched meal;
FIG. 19 is a schematic representation illustrating a preparation of a protein concentrate from a protein slurry with fiber removed;
FIG. 20 is a schematic representation illustrating a wet fiber removal process; FIG. 21 is a schematic representation illustrating a preparation of a protein concentrate from a protein slurry after the removal of fiber;
FIG. 22 is schematic representation illustrating a preparation of a protein concentrate produced by recycling a protein fraction;
FIG. 23 is a schematic representation illustrating a wet fiber removal process; FIG. 24 is a schematic representation illustrating a first recycling of a protein fraction and a wet fiber removal process;
FIG. 25 is a schematic representation illustrating a second recycling of a protein fraction and a wet fiber removal process;
FIG. 26 is a schematic representation illustrating a third recycling of a protein fraction and a wet fiber removal process;
FIG. 27 is a schematic representation illustrating a fourth recycling of a protein fraction and a wet fiber removal process;
FIG. 28 is a schematic representation illustrating a preparation of a protein isolate and a hydrolyzed protein extract;
FIG. 29 is a schematic representation illustrating a preparation of a hydrolyzed protein extract;
FIG. 30 is a schematic representation illustrating a fifth recycling of a protein fraction and a wet fiber removal process;
FIG. 31 is a schematic representation of a first embodiment illustrating a preparation of a protein concentrate;
FIG. 32 is a schematic representation of a second embodiment illustrating a preparation of a protein concentrate;
FIG. 33 is a schematic representation illustrating a separation and removal of fiber from a protein slurry containing insoluble and soluble proteins;
FIG. 34 is a schematic representation illustrating a separation and removal of fiber from a protein slurry containing insoluble and soluble proteins;
FIG. 35 is a schematic representation of a first embodiment showing the removal of fiber during the preparation of a protein concentrate from a toasted defatted meal;
FIG. 36 is a schematic representation of a second embodiment showing the removal of fiber during the preparation of a protein concentrate from a toasted defatted meal;
FIG. 37 is a schematic representation showing the removal of fiber during the preparation of a protein concentrate and a protein isolate from a toasted defatted meal;
FIG. 38 is a schematic representation illustrating a preparation of a hydrolyzed protein concentrate;
FIGs. 39. and 40 are schematic representations illustrating a preparation of a protein concentrate from a toasted defatted meal using a protease;
FIG. 41 is a schematic representation illustrating a preparation of a protein concentrate using a concurrent process; and
FIG. 42 is a schematic representation illustrating a preparation of a protein concentrate using a counter-current process.

DETAILED DESCRIPTION OF THE DISCLOSURE

(I) DEFINITIONS

[0035] The term "peptide" as used herein refers to various natural compounds containing two or more amino acids linked by the carboxylic acid group of one amino acid to the amino group of another amino acid. Peptides generally have 4-100 amino acids (US Patent Office Classification Index Glossary) and a molecular weight of less than 10,000 Daltons.

[0036] The term "protein" as used herein refers to peptides with more than 50-100 amino acids and a molecular weight in excess of about 10,000 Daltons. The US Patent Office Classification Index Glossary defines protein as peptides with more then 100 amino acids.

[0037] The term "partially defatted meal" (alternatively called "seedcake" or "presscake") as used herein refers to a oilseed meal in which the oilseed has been pressed to remove the oil contained within. The pressing of the oilseed results in pressed oil and a partially defatted meal, which contains from 15% to 50% of protein on a dry weight basis and from 10% to 20% oil, optionally 14% to 16%, on a dry weight basis. Heating of the partially defatted meal results in the toasting of the meal.

[0038] The term "toasted defatted meal" (alternatively called "toasted fully defatted meal") as used herein refers to an oilseed which has been i) pressed to remove oil, which forms a seedcake and pressed oil, and ii) subjected to solvent extraction, using, for example, hydrophobic solvents such as butane, pentane, hexane and/or other refrigerants such as iodotrifluoromethane (ITFM) and R134a (1,1,1,2-tetrafluoroethane), to remove or reduce residual oil from the seedcake and form a defatted meal. Heating the meal to remove the solvent results in the toasting of the meal. Accordingly, the defatted meal is heated to a temperature of at least 90°C, preferably at least 100°C which removes or reduces residual

oil in the defatted meal. Heating the defatted meal to at least 90°C, preferably at least 100°C also toasts the defatted meal, and denatures much of the protein in the meal. Additionally, heating the defatted meal to a temperature of at least 90°C, preferably at least 100°C, and denaturing much of the protein, results in the toasted defatted meal possessing a Protein Dispersibility Index (PDI) of less than or equal to 20, optionally less than or equal to 10. A toasted defatted meal will typically have a protein content of 25 % to 55%, optionally 30% to 50%, suitably 35% to 50%, on a dry weight basis, and from 0% to 4% oil, optionally 0.5% to 4%, optionally 1% to 3%, on a dry weight basis.

[0039] The term "toasted protein-enriched meal" as used herein refers to a toasted defatted meal as described above, which has subsequently been treated to remove fiber from the toasted defatted meal. Accordingly, the toasted defatted meal is typically subjected to a milling step and a screening step to remove fiber and obtain a toasted protein-enriched meal having a protein content of 30% to 60%, optionally 40% to 55%, suitably 50% to 55% on a dry weight basis, and 5% to 6.5% fiber, optionally less than about 6%. Collectively, a toasted partially defatted meal, a toasted fully defatted meal and a toasted protein-enriched meal may be referred to as "toasted meal".

[0040] The term "toasted" as used herein refers to the heating of an oilseed meal (partially defatted, fully defatted or protein-enriched meal), generally to remove solvents from the meal, which results in a toasting the oilseed meal. The toasting of the meal denatures many of the proteins in the meal, rendering them less soluble in many solvents, such as the blending solvents, mixing solvents, extraction solvents, etc.

[0041] The term "protein concentrate" as used herein refers to a toasted defatted or toasted protein-enriched meal that has been treated using the processes of the present disclosure to increase the protein content, where the protein concentrate has greater than 60% protein content but less than 90% protein content on a dry weight basis. The balance may comprise carbohydrate, ash, fiber and oil. In an embodiment, the protein concentrate is generally produced from the insoluble protein fraction or soluble/insoluble protein fractions of a protein mixture. In one embodiment, the protein concentrate also includes hydrolyzed protein concentrate. In one embodiment, the protein concentrate also contains between 0-9%(w/w), 2-8%(w/w) or 3-7%(w/w) of fiber.

[0042] The term "hydrolyzed protein concentrate" as used herein refers to a protein concentrate that has been treated to hydrolyze the proteins within the protein concentrate into amino acids and smaller peptides. Proteins can be hydrolyzed using various chemicals, such as strong acids and bases, and enzymes, preferably proteases.

[0043] The term "protease" as used herein refers to any enzyme that hydrolyzes proteins by hydrolysis of the peptide bonds that link amino acids together in the polypeptide chain forming the protein. Examples of proteases include Alcalase®, Flavourzyme® and Protamex®. The proteases solubilize and partially hydrolyse proteins trapped within the fiber fraction and to release insoluble proteins from the fiber fraction using a dosage of a single protease.

[0044] The term "protein isolate" as used herein refers to a toasted defatted or toasted protein-enriched meal that has been treated using the processes of the present disclosure to increase the protein content, where the protein isolate has 90% or greater than 90% protein on a dry weight basis. The balance may comprise carbohydrate, ash, and oil. In an embodiment, the protein isolate is generally produced from the soluble protein fraction of a protein mixture.

[0045] The term "hydrolyzed protein isolate" as used herein refers to a protein isolate that has been treated with proteases to hydrolyze the proteins within the protein isolate into amino acids and smaller peptides.

[0046] The term "mixing solvent" as used herein refers to a solvent that forms a protein slurry or mixture when mixed with a toasted partially defatted, toasted fully defatted or toasted protein-enriched meal. In addition, the fiber present in the meal possesses minimal solubility in the mixing solvent (eg. typically less than 1% (w/w) solubility, or about 0% solubility), and suitably, is not soluble in the mixing solvent. Examples of mixing solvents include water, alcohols, such as methanol, ethanol or isopropanol, polysaccharide solutions such as guar gum solution, saline solutions, or mixtures of any of the above.

[0047] The term "blending solvent" as used herein refers to any aqueous solvent (typically at least: 80%, 85%, 90%, 95%, 98% or 99% water by weight) that forms a slurry or mixture when mixed with a toasted partially defatted, toasted fully defatted or toasted protein-enriched meal. Typically the blending solvent is free from organic solvents, such as methanol, ethanol, propanol, iso-propanol, tetrahydrofuran since these solvents are not desirable as residues in a protein isolate, concentrate or hydrosylate for human consumption, however, if organic solvents are present, they are in the blending solvent in small amount (eg. typically equal to or less than: 20%, 10%, 10%, 5% or 1%) so that their presence in the final product is negligible. Examples of blending solvents include water, acidic water, alkaline water, saline salt solutions (such as sodium chloride, potassium chloride, calcium chloride), polysaccharide solutions (such as guar gum), and aqueous protein solutions.

[0048] The invention contemplates using a variety of solvents, which could include blending solvents, mixing solvents or other combinations or alcohols (eg. 80% ethanol), water and/or aqueous solvents. The use of the term blending solvents should not be construed as precluding the use of organic solvents in processes as disclosed herein.

[0049] The term "extraction solvent" as used herein refers to a solvent which is capable of solubilizing antinutritional compounds, or other constituents, that are present in the oilseed and which are desirably removed. Examples of antinutritionals include glucosinolates, phytic acid, phytates and other compounds that reduce the nutritional or commercial value of the protein concentrate or protein isolate. Antinutritional compounds are compounds that are, for example, not

digestible by mammals (e.g humans), have adverse effects, such as toxicity or are bitter tasting, and are desirably removed from the protein product. Accordingly, the concentration of antinutritionals in a protein product produced in accordance with a process of the present disclosure is less than 1% (w/w), optionally less than about 0.5% (w/w), optionally less than 0.1% (w/w), and optionally less than 0.05% (w/w). Examples of other compounds include materials that undesirably effect the quality, color, taste, odor, appearance or characteristics of the end product. Examples include compounds that cause a darkening or variation in the color, cause a bitter taste or a pungent odor, such as sinapine or sinigrin, or affect the handling or agglomeration of the end product. While the antinutritionals or other components are not desirable in the protein concentrates or isolates they may constitute commercially valuable side products which can have utility as medicinal or industrial ingredients or end products once separated from the protein concentrate or isolate. Examples of extraction solvents include water, alcohols, such as methanol, ethanol, isopropanol, or mixtures of any of the above. Other extractions solvents which are useful include tetrahydrofuran (THF), dimethylformamide (DMF), and ethers, such as methyl t-butyl ether. However, it will be known to those skilled in the art that solvents such as THF, DMF or ethers, as a result of their higher toxicity as compared to, for example, ethanol, require lower limits in the protein product.

[0050] The term "homogeneous agitation" as used herein refers to the mixing of a protein meal, such as a toasted partially defatted meal, a toasted fully defatted meal or a toasted protein-enriched meal with a solvent to form a homogenous mixture or suspension. Such agitation is accomplished, for example, by mixing the slurry or mixture at a speed of 30 rpm to 300 rpm in a standard mixer.

[0051] The term "washed" used herein refers to a protein fraction that has been mixed with an extraction solvent, such as ethanol, to remove antinutritional compounds, or other constituents, from the protein fraction.

[0052] The term "protein slurry" as used herein refers to protein, for example, the protein in a toasted defatted or toasted protein-enriched meal, that has been mixed with a mixing solvent to form a suspension of protein, and optionally fiber and other antinutritional compounds, in the mixing solvent.

[0053] The terms "soluble protein fraction" and "insoluble protein fraction" as used herein refer to specific protein fractions which are either soluble or insoluble, respectively, in a particular solvent, such as a blending solvent, mixing solvent or an extraction solvent. In an embodiment, the insoluble protein fraction is generally composed of insoluble globulin and denatured proteins. The insoluble protein fraction is generally composed of insoluble globulin proteins. In another embodiment, the soluble protein fraction is generally composed of albumin, soluble globulin and undenatured proteins. The soluble protein fraction is generally composed of soluble albumin and soluble globulin proteins.

[0054] The term "water" as used herein refers to any source of water, for example, tap water, distilled water or reverse osmosis water.

[0055] The term "alkaline water" as used herein refers to water which has a basic pH of greater than about 7.0, optionally 7.0 to 12.0. The alkalinity of the water results from the addition of a base to water, for example, an alkali hydroxide such as sodium hydroxide. For example, a solution of sodium hydroxide at a concentration of 5% to 15% (w/w), optionally 11%.

[0056] The term "suitable for phytase activity" as used herein refers to the conditions, such as the temperature and pH, and optionally includes the length of time, in which the phytase enzyme is able to hydrolyze the phosphate groups on phytate or phytic acid, and accordingly, reduce the amount of phytates or phytic acid in the mixture. In an embodiment, the temperature suitable for phytase activity is between 20°C and 60°C, optionally between 40°C and 55°C, suitably between 50°C and 55°C. In another embodiment, the pH suitable for phytase activity is between 2.0 and 7.0. optionally between 4.0 and 6.0, suitably between 4.5 and 5.5, optionally 5.0 to 5.5. In another embodiment, the concentration of the phytase enzyme is between 0.01% to 1.0% (w/w) based on the weight of the toasted oilseed meal, optionally 0.01% and 0.5% optionally 0.01% and 0.1%. It will be understood that the conditions suitable for phytase activity apply to all of the processes of the present disclosure.

[0057] The term "suitable for protease activity" as used herein refers to the conditions, such as the temperature and pH, and optionally includes the length of time, in which a protease enzyme is able to hydrolyze proteins. In an embodiment, the temperature suitable for protease activity is between 30°C and 70°C, optionally between 35°C and 70°C. In another embodiment, the pH suitable for protease activity is between 5.0 and 9.0, optionally between 5.5 and 8.5. In another embodiment, the concentration of the protease enzyme is between 0.01% to 1.0% (w/w) based on the weight of the toasted oilseed meal, optionally 0.01% and 0.5% optionally 0.01% and 0.1%. It will be understood that the conditions suitable for protease activity apply to all of the processes of the present disclosure.

[0058] The term "g-force sufficient to separate the mixture" as used herein refers to the force necessary to separate the insoluble fiber fraction in the mixture from the protein fractions. In an embodiment, the g-force is between 100g and 500g, suitably between 150g and 400g, optionally between 170g and 350g. It will be understood that when the mixture is subjected to a sufficient g-force, the insoluble fiber, due to its relative higher density and/or greater particle size, will separate from the protein fractions. It should also be recognized that forces greater than the ranges necessary to separate the phases are not desirable as they can result in the high concentrations of the insoluble protein being deposited in the fiber phase. In addition, as a result of the insoluble protein fraction having a higher relative density and/or particle size compared to the soluble protein, the insoluble protein fraction will separate from the soluble protein fraction. It will be

understood though that not all of the protein will separate from the insoluble fiber fraction, and likewise, not all of the insoluble fiber will separate from the protein fraction. Moreover, not all of the insoluble protein fraction will separate from the soluble protein fraction. Accordingly, when the mixture has been subjected to a g-force sufficient to separate the mixture, the insoluble fiber fraction will comprise at least 10% crude fiber, optionally 15%, 20%, 25, 30% crude fiber on a dry weight basis. Likewise, the protein fraction will comprise less than 10% crude fiber, optionally less than 5%, 4%, 3%, 2%, 1% and less than 1% crude fiber with the majority of other material comprising soluble and insoluble proteins, carbohydrate, ash and oil. In an embodiment, the g-force sufficient to separate the mixture is obtained by rotating a centrifuge at a speed of 500 RPM to 2,500 RPM. It will be understood that a centrifuge will have a rotational radius which will vary depending on the size of the centrifuge. In another embodiment, the g-force sufficient to separate the mixture is obtained by using a hydrocyclone with a g-force of between 50g and 250g.

(II) PROTEIN CONCENTRATES AND ISOLATES

[0059] The present disclosure relates to processes for the production of a protein concentrate or a protein isolate from toasted oilseed. A protein concentrate is an isolated protein extract of pressed oilseed, wherein the extract has greater than 60% protein content but less than 90% protein content on a dry weight basis. A protein concentrate has been treated to separate protein in the oilseed from the fiber and other unwanted antinutritional factors. A protein isolate is an isolated protein extract of pressed oilseed, wherein the extract has greater than or equal to 90% protein content on a dry weight basis. Typically, the protein isolate has up to 98%, 99%, 99.5% or 100% protein content on a dry weight basis. Examples of pressed oilseed include seedcake, toasted defatted meal or toasted protein-enriched meal, as explained below. Typically, the non-protein content includes non-protein compounds such as antinutritional substances, fiber, and other components or impurities such as coloring agents.

[0060] In an embodiment, the disclosure provides a process for the removal of fiber, antinutritionals and other constituents, that are present within the oilseed. A person skilled in the art would recognize that antinutritionals include glucosinolates, phytic acid, phytates and other compounds that reduce the nutritional or commercial value of the protein concentrate or protein isolate. For example, antinutritional compounds may not be digestible by mammals (e.g humans), have adverse effects, such as toxicity, and are desirably removed from the protein product. Certain antinutritionals have other undesirable properties, such as undesirable organoleptic properties. Examples of such compounds are sinapine, which has a bitter taste, and sinigrin which has a pungent and very bitter flavor. Further, other antinutritional constituent of oilseeds that are typically removed include coloring agents and/or other inert compounds. In an embodiment, the constituents which are removed or are reduced to safe or acceptable levels, are undesirable constituents or impurities using the processes of the present disclosure. A person skilled the art would recognize the safe and/or acceptable levels of particular antinutritionals in the final protein product.

[0061] The term toasted protein-enriched meal refers to a meal that possesses a protein content of 30% to 60%, optionally 30% to 55%, suitably 50% to 55%, on a dry weight basis. Such toasted protein-enriched meals are useful to prepare the concentrates and isolates of the disclosure, which may be further processed.

In another embodiment of the disclosure, there is also included protein concentrates and protein isolates, produced in accordance with the processes of the disclosure.

[0062] In an embodiment, the protein concentrate possessing a protein content of 60% to 70% produced in accordance with the processes of the present disclosure are utilized as a protein ingredient in aquafeeds for fish, swine and pet foods.

[0063] In another embodiment, the protein concentrate possessing a protein content of 70% to 75% produced in accordance with the processes of the present disclosure are useful as a protein ingredient for baked food products such as bread, rolls, cake and pastry products (including mixtures for preparing baked food products), cookies, biscuits, crackers, pancakes, pastries, doughnuts, and other pasta products. In addition, this protein concentrate is useful as a protein ingredient in meat products such as baked meat, hot dogs, bologna, analogs, ham and sausages. Further, this protein concentrate is also useful as a protein ingredient in vegetarian foods. It will be understood by a person skilled in the art that this protein concentrate is also useful for other applications where a lower grade of protein concentrate is sufficient, such as in aquafeeds and pet foods as described above.

[0064] In another embodiment, the protein concentrate possessing a protein content of 75% to less than 90% produced in accordance with the processes of the present disclosure is useful as a protein ingredient in breakfast cereals, and baked goods, as well as meat products such as bologna, frankfurters, luncheon loaves and ham. Further, this protein concentrate is useful in candies, confections, desserts, dietary items, Asian foods, soup mixes, gravies and other similar food items. Again, it will be understood by a person skilled in the art that this protein concentrate is also useful for other applications where a lower grade of protein concentrate is sufficient, such as in aquafeeds, pet foods, bakery products and meat products, as described above.

[0065] In another embodiment, the protein isolate possessing a protein content of greater than 90% produced in accordance with the processes of the present disclosure is useful as a protein ingredient in nutritional beverages such as protein fortified soft drinks, sports drinks, fruit juices and other high protein drinks. In addition, this protein isolate is

useful as a protein ingredient for nutritional supplements, special diet products, and high protein nutritional tablets. In addition, the protein isolate is useful as a protein ingredient in infant formulas, as well as an ingredient in comminuted and emulsified meats, simulated meats, combination meat products and cured or uncured meat products. Further, the protein isolate is useful as a protein ingredient in pasta (eg. macaroni), bread and other bakery products, pancakes, waffles, crackers, donuts, pie crusts, soups, egg replacements, dried milk replacements and dairy analogs. Again, it will be understood by a person skilled in the art that this protein isolate is also useful for other applications where a lower grade of protein is sufficient, such as in aquafeeds, pet foods, and meat products, as described above.

[0066] In another embodiment, the hydrolyzed protein isolate possessing a protein content of greater than 90% produced in accordance with the processes of the present disclosure is useful as a protein ingredient in nutritional beverages such as protein fortified soft drinks, sports drinks, fruit juices and other high protein drinks. In addition, the hydrolyzed protein isolate is useful as a cosmetic ingredient. Further, the hydrolyzed protein isolate is useful as a protein ingredient for healthy food applications to improve absorption and digestibility. Again, it will be understood by a person skilled in the art that this hydrolyzed protein isolate is also useful for other applications where a lower grade of protein is sufficient, such as in aquafeeds, pet foods, bakery products and meat products, as described above.

(III) PROCESSES OF THE DISCLOSURE

[0067] A person skilled in the art would be able to produce a toasted protein-enriched meal using methods that are well known in the art. A general method for obtaining a toasted protein-enriched meal is shown in Figures 1 - 6. For example, when beginning with an oilseed, such as canola, rapeseed, mustard seed, broccoli seed, flax seed, cotton seed, hemp seed, safflower seed, sesame seed or soybean meal, in particular canola, the moisture content of the oilseed is adjusted. The moisture adjusted oilseed is optionally exposed to a heat treatment. In an embodiment of the processes of the present disclosure, the oilseed is heat treated to a temperature of 60°C to 120°C, optionally 70°C to 100°C, or 80°C to 90°C, or about 80°C. In another embodiment, the heat treatment is carried out at a temperature of 100°C. The heat treatment of the oilseed results in the inactivation of the enzymes present in the oilseed, for example, myrosinase, lipase, phospolipase. If the oilseed is not heat treated, the enzymes (such as myrosinase, lipase, phospolipase), as a result of their enzymatic action, can degrade the oil and breakdown glucosinolates releasing sulphur into oil. At a temperature of 75-100°C, the enzymes are deactivated, and are therefore not able to degrade the oil and breakdown glucosinolates releasing sulphur into oil. Accordingly, in an embodiment, a heat treatment temperature of 75-100°C results in a reasonably high protein dispersibility index (PDI), lower sulphur, FFA and phosphorus in pressed and butane/R134a extracted oils.

[0068] Alternatively, in an embodiment, the oilseed is not exposed to a heat treatment and its moisture content is not adjusted. It will be understood by a person skilled in the art that the moisture content of the seed is typically in the range of 7% to 10% for a pressing operation. If the moisture content of the seed is not in this range, the moisture of the seed is optionally adjusted to 7% to 10% by adding water or drying, which is followed by blending and tempering.

[0069] The oilseed is then pressed to remove the oil from within the oilseed. Generally, an oilseed such as canola, rapeseed, mustard seed, broccoli seed, flax seed, cotton seed, hemp seed, safflower seed, sesame seed or soybean, contains 15% to 50% oil (w/w), depending on the particular oilseed. Typically, oil is removed from an oilseed by pressing the oil from the oilseed to form a pressed oilseed. Examples of pressed oilseeds are a seedcake (or a presscake), while a toasted defatted meal or a toasted protein-enriched meal begin from a seedcake (or presscake), as explained below. It will be understood that a seedcake and a presscake define the same pressed seed meal. Methods of pressing oil from an oilseed are well known in the art. A typical pressing will remove 30% to 70% of the oil in the oilseed, and results in pressed oil and a pressed seedcake (or presscake).

[0070] In an embodiment, the removal of much of the remaining oil from the seedcake is accomplished by solvent extraction of the seedcake. Solvent extraction is a well known process in the art and utilizes solvents, such as hexane, methyl pentane or other refrigerants such as ITFM and R134a (1,1,1,2-tetrafluoroethane), to remove residual oil from the seedcake.

[0071] In another embodiment, the remaining oil in the seedcake is removed using solvent extraction, wherein the solvent is ethanol, which has been heated close to its boiling point.

[0072] The solvent extraction process results in a toasted defatted seedcake meal and a solution of solvent and oil. The oil is separated from the solvent and utilized for other purposes. Generally, depending on the extraction process, the seedcake will contain residual amounts of solvent that are removed from the seedcake. The removal of the residual solvent from seedcake is accomplished by heating the seedcake in a desolventizer toaster (DT), flash desolventizer (such as a ring dryer) or vacuum oven, which causes the residual solvent to evaporate. The seedcake is subsequently dried. The above process removes much of the oil from the pressed oilseed and leaves material known as toasted defatted meal. In an embodiment, the toasted defatted meal will contain less than about 6% of oil, optionally 0.5% to 3% (w/w).

[0073] The toasted defatted meal is then subjected to a milling step and a screening step to obtain a pressed oilseed

known as a toasted protein-enriched meal.

[0074] The toasted defatted meal is typically milled, for example with a disc mill or a hammer mill, to reduce the particle size of the toasted defatted meal. When using a disc mill, the toasted defatted meal is forced through two rotating discs which crush the toasted defatted meal. When a hammer mill is used to reduce the particle size of the toasted defatted meal, the meal is loaded into the hammer mill, wherein the hammers reduce the particle size of the toasted defatted meal.

[0075] After the particle size of the toasted defatted meal has been sufficiently reduced, the milled toasted defatted meal is screened through mesh screens, which results in an initial separation of a fiber fraction from the toasted defatted meal, resulting in a toasted protein-enriched meal. Fiber tends to have a larger particle size which is not able to pass through the screen. However, a portion of the fiber will be able to pass through the screen, and as such, only a portion of the fiber is removed by screening. Typically, about a 45 US mesh screen is used for the initial fiber separation. This is a dry screening process which results in a fiber enriched meal, which does not pass through the screen, and the toasted protein-enriched meal, which does pass through the screen. The toasted protein-enriched meal, however, still contains a significant amount of fiber and other antinutritional factors. From the milled toasted defatted material, a 30% to 60% by weight toasted protein-enriched meal is typically obtained, while the fiber fraction constitutes 40% to 70% of the original weight of the toasted defatted material. The toasted protein-enriched meal possesses a protein content of 40% to 60%, optionally 50% to 55%, while the fiber fraction possesses 35% to 48% protein content. In an embodiment of the disclosure, it is this toasted protein-enriched meal that is utilized to produce the protein concentrates and protein isolates of the present disclosure. However, in another embodiment, it will be apparent to those skilled in the art that a seedcake, toasted defatted meal or toasted protein-enriched meal is utilized with the processes of the present disclosure. The use of such a toasted defatted or toasted protein-enriched meal, and processing with a minimum amount of heat during conditioning, pressing, solvent extraction, desolventization and drying, leads to better protein concentrates and protein isolates.

[0076] In an embodiment of the present disclosure, there is a process for removing fiber from a toasted partially defatted, toasted fully defatted or toasted protein-enriched meal or "meal"). In particular, the process relates to separating and removing fiber from a meal based on the density and particle size differences between the fiber particles and the protein particles. The separation and removal of fiber is accomplished by using separation methods, at specific speeds, which can separate particles based on their density or particle size such as centrifugation or hydrocyclone to separate the fiber from the mixture and form the protein slurry. In an embodiment, the separation is accomplished using centrifugation. In another embodiment, the separation is accomplished using a decanter centrifuge. In another embodiment, the separation is accomplished using a decanter centrifuge at a speed of 1,000 rpm to 2,000 rpm. In another embodiment, the separation is accomplished using a decanter centrifuge at a speed of about 1,500 rpm. In an embodiment, the centrifugation of a meal mixture results in three layers: i) an insoluble fiber layer and a protein slurry on top of the fiber, which is comprised of ii) an insoluble protein fraction and iii) a soluble protein fraction. Separation of the top and middle layers (the soluble protein extract and the insoluble fine protein fraction) from the bottom layer (coarse fiber solids), results in a protein slurry with fiber removed.

[0077] In an embodiment of the present disclosure, a process for the production of a protein concentrate possessing a protein content of 60% to 70% is obtained from a toasted defatted or toasted protein-enriched meal. An optional general process for the production of a protein concentrate is illustrated in Figure 7.

[0078] In an embodiment, a toasted defatted or toasted protein-enriched meal is produced by the process above, and is then washed at least once with 5% to 100%, optionally 20% to 90%, or 40% to 80% (v/v) ethanol in water, resulting in an ethanol extract and an ethanol washed toasted defatted or toasted protein-enriched meal. Other alcohols, such as methanol or isopropanol, can be utilized for washing the toasted defatted or toasted protein-enriched meal. In an embodiment, ethanol is used for washing the toasted defatted or toasted protein-enriched meal because it is less toxic than other alcohols, and a higher percentage of ethanol residue is allowed in the final product.

[0079] In another embodiment, the toasted defatted or toasted protein-enriched meal is washed once with ethanol, wherein the ratio of ethanol to the toasted protein-enriched meal is 1:3 to 1:15, typically 1:4 to 1:8, optionally 1:6, on a weight-to-weight basis of toasted protein-enriched meal to ethanol.

[0080] In another embodiment, the toasted defatted or toasted protein-enriched meal is washed twice with ethanol, wherein the amount of ethanol added to the toasted protein-enriched meal results in a ratio of 1:2 to 1:15, typically 1:5 to 1:8, optionally 1:6, on a weight-to-weight basis of toasted protein-enriched meal to ethanol. Typically, washing the toasted defatted or toasted protein-enriched meal at least twice results in the removal of more impurities from the toasted defatted or toasted protein-enriched meal and therefore increases the protein content in the protein concentrate.

[0081] In a further embodiment, the toasted defatted or toasted protein-enriched meal is washed in a counter-current extractor. In this embodiment, the toasted defatted or toasted protein-enriched meal is washed 2 times to 10 times, wherein the ratio of solvent to the toasted defatted or toasted protein-enriched meal is 1 to 10 of meal to 1 of meal.

[0082] In another embodiment, the toasted defatted or toasted protein-enriched meal is washed with ethanol at a temperature of 10°C to 90°C, optionally 20°C to 60°C, suitably at a temperature of 40°C to 60°C.

[0083] The ethanol extract is optionally separated from the ethanol washed toasted defatted or toasted protein-enriched

meal by centrifugation, filtration, vacuum filtration, pressure filtration, sedimentation, decantation or gravity draining. With respect to centrifugation, the ethanol mixture is typically fed to a decanter centrifuge or a basket centrifuge. The ethanol extract is then separated from the ethanol washed toasted defatted or toasted protein-enriched meal by centrifugal force. For the decanter centrifuge, a screw conveyer is contained within a solid bowl and both rotate at high speeds. Solids settling on the bowl are conveyed by the screw conveyer out of the centrifuge. For a basket centrifuge, which consists of a perforated basket rotating inside a stationary housing, the ethanol mixture is fed into the basket and centrifugal force pushes it against the filter liner. The solids are retained by the liner while the liquid passes through. For filtration, the ethanol extract is typically separated from the ethanol washed toasted defatted or toasted protein-enriched meal by draining through a perforated belt or basket in a reactor. For vacuum filtering or pressure filtering, the separation is aided by vacuum or pressure. In an embodiment, the ethanol extract is concentrated by evaporation of the ethanol to form a high sugar fraction, optionally containing antinutritional factors that can be further purified. The antinutritional compounds may be purified into valuable pharmaceutical, medicinal or chemical compounds, such as glucosinolates, phytic acid or phytates, sinapine and sinigrin. In an embodiment, the ethanol extract is heated under vacuum at 30°C to 90°C, which results in the evaporation of ethanol and water, and soluble solids are left behind. Ethanol is further separated from water by distillation and re-used in the process. The concentrated high-sugar fraction is dried by spray drying, rotary drum drying, vacuum drying, flash drying, ring drying, microwave drying, freeze drying or using a fluidized bed dryer.

[0084] In another embodiment, the washed toasted defatted or toasted protein-enriched meal is dried to form the protein concentrate, possessing a protein content of 60% to 70%. In a further embodiment, the washed toasted protein-enriched meal is dried in a spray dryer, drum dryer, vacuum dryer, fluidized bed dryer or ring dryer to form the protein concentrate possessing a protein content of 60% to 70%. These dryers remove the solvent by drying the protein concentrate under a vacuum or at atmospheric pressure at elevated temperatures of 30°C to 100°C.

[0085] In an embodiment, the protein concentrate is dried to a moisture content of 1% to 10%, optionally 4% to 8%.

[0086] In another embodiment, the ethanol that is removed through drying is recovered and recycled so it can be used again in further ethanol extractions. The ethanol is recovered through evaporation and distillation.

[0087] In another embodiment, the dried protein concentrate possessing a protein content of 60% to 70% is further milled into powder form without coarse particles.

[0088] In another embodiment of the present disclosure, there is provided a process for producing a protein concentrate possessing a protein content of 70% to 75% on a dry weight basis. In an embodiment, a general process for the production of a protein concentrate possessing a protein content of 70% to 75% is illustrated in Figures 8 - 11, where the removal of fiber is also detailed. In an embodiment, the use of an extraction solvent, such as ethanol, leads to a protein concentrate or protein isolate having superior organoleptic properties, as well as superior water solubility properties, which therefore possesses better functional properties.

[0089] In another embodiment of the present disclosure, the extract is separated from the washed toasted defatted or toasted protein-enriched meal by centrifugation, vacuum filtration, pressure filtration, decantation or gravity draining. In an embodiment, the extract is concentrated by evaporation of the extraction solvent dried to form a high sugar fraction, as is performed above.

[0090] In another embodiment of the disclosure, steps 2) and 3) are optionally repeated at least once. In an embodiment, steps 2) and 3) are repeated at least twice. Repeating steps 2) and 3) results in a protein product containing less impurities, such as fiber and other antinutritional factors.

[0091] In an embodiment, the soluble protein fraction is purified by ultrafiltration and diafiltration using a membrane filtration apparatus. In an embodiment, when ultrafiltration is utilized, the soluble protein fraction is heated to a temperature of 1°C to 60°C, optionally 40°C to 55°C, before being passed through an ultrafiltration apparatus fitted with membranes to filter proteins larger than about 10,000 daltons, optionally 30,000, or 100,000 daltons. The filtered protein is recycled back to the feed tank while the liquid is discarded. The ultrafiltration process is continued until the amount of protein that has been filtered in the feed tank is equal to 30% to 40% of its initial weight of the soluble protein fraction.

[0092] In a further embodiment, when diafiltration is utilized, it is conducted at 1°C to 60°C, optionally 40°C to 55°C, using the diafiltration unit, which is fitted with the membranes to filter proteins larger than about 10,000 daltons, optionally about 30,000, or about 100,000 daltons. The original volume of soluble protein fraction in the feed tank is held constant by adding water to make up for the removed liquid. The filtered protein is recycled back to the feed tank. The amount of water added to maintain the original volume of protein solution is about 2 times the original volume of soluble protein fraction. For example, if 100 L of soluble protein fraction is used, 200 L of water is added to the soluble protein fraction in the feed tank during the cycle of diafiltration. The volume of the feed tank is kept constant at 100 L with the continued addition of water to the feed tank while the liquid is removed from the system through diafiltration.

[0093] In an embodiment, after the soluble protein fraction has been filtered, the filtered soluble protein is spray dried to form a high functional protein isolate comprising a protein content of greater than about 90% on a dry weight basis. It will be understood by a person skilled in the art that spray drying is the transformation of a feed from a fluid state into a dried form by spraying the feed into a circulating hot air medium. Generally, spray drying transforms the filtered protein

into many droplets which are then exposed to a fast current of hot air. As a result of the very large surface area of the droplets the water in the protein evaporates almost instantaneously and the droplets are transformed into powdery dry protein particles. In an embodiment, the inlet temperature is 180°C to 220°C which is the temperature of the hot air entering the spray dryer chamber, the outlet temperature is 75°C to 90°C, which is the temperature of the exhaust, and the feed temperature is 40°C to 50°C. It will be understood by a person skilled in the art that the washed protein precipitate can be used as a protein isolate without drying. However, the dried protein

[0094] In another embodiment of the disclosure, the process further comprises the step of filtering the clarified soluble protein fraction using a diafiltration apparatus.

[0095] In another embodiment, the clarified soluble protein fraction is dried in a vacuum dryer, fluidized bed dryer, freeze dryer, ring dryer or spray dryer to form the protein isolate.

[0096] The present disclosure relates to processes for the production of protein concentrates and protein isolates, in which the toasted oilseed meal is subjected to low g-forces to separate the fiber from the insoluble and soluble protein fractions. Removing the fiber from a protein mixture using low g-forces, separates the insoluble fiber from the protein fraction, and in particular the insoluble protein fraction, which consequently increases the amount of recoverable protein from a toasted oilseed meal.

skilled in the art that phytates and phytic acid may constitute undesirable anti-nutritional compounds in a protein meal, and accordingly, are desirably removed from the toasted oilseed meal and the final protein products. Accordingly, the addition of phytase enzyme results in the hydrolysis of the phytates and/or phytic acid which are subsequently removed from the mixture. In addition, it has also been determined that phytates and/or phytic acid complex with proteins to form an insoluble gel complex. Accordingly, in an embodiment, when filtration, such as diafiltration or ultrafiltration, is utilized to purify and separate protein concentrates and/or protein isolates, the insoluble protein/phytate (or phytic acid) gel complexes block the filtration apparatus, reducing the flow through the filtration apparatus, and accordingly, reducing the amount of recoverable protein and filtration efficiency. It will be understood that the addition of phytase to the mixture and the conditions recited for reduction or removal of phytates and/or phytic acid apply to all of the processes and embodiments of the present disclosure.

[0097] In another embodiment of the disclosure, the mixture is subjected to a g-force sufficient to separate the mixture to form a fiber fraction and protein fractions comprising an insoluble protein fraction and a soluble protein fraction. The separation of the mixture using a sufficient g-force is described herein with reference to a centrifuge, such as a decanter centrifuge or a disc stack centrifuge, but a person skilled in the art would understand that other methods of separation that create a separation force, including a hydrocyclone, are also included. Accordingly, in an embodiment, when the mixture is subjected to a sufficient g-force using a centrifuge, the mixture separates into three-phases as a result of the sedimentation principle: (i) an insoluble fiber fraction, and (ii) protein fractions comprising (ii.a) an insoluble protein fraction, and (ii.b) a soluble protein fraction. The centripetal acceleration acting on the mixture results in the insoluble fiber fraction, which has a relatively higher density and/or greater particle size compared to the other fractions, moving further along the radial direction in which the centripetal force is acting (perpendicular to the axis of rotation). When a centrifuge is utilized, the insoluble fiber fraction (or phase) moves towards the bottom of the centrifuge tube, as a result of its relatively higher density and/or greater particle size, resulting in one of the phases of separation. As a result of the proteins in the insoluble protein fraction having a lower relative density and/or smaller particle size as compared to the insoluble fiber fraction, the insoluble protein fraction forms another phase of separation (the middle phase). Finally, the proteins in the soluble protein fraction, being soluble in the blending solvent and/or having a lower relative density compared to the fiber fraction and insoluble protein fraction, remain near the top of the centrifuge tube. If toasted oilseed meal is toasted partially defatted meal, a fourth phase may also form on top of the soluble protein phase comprising residual oil. It will be understood that subjecting the mixture to a sufficient g-force will not result in a total separation of the three fractions, and accordingly, a minor amount of fiber will be present in the protein fraction, while protein will be present in the insoluble fiber fraction. There will be a certain amount of protein trapped within the structure of the insoluble fiber fraction that is not separable using mechanical means (i.e. using a centrifuge). In an embodiment, the amount of protein trapped within the fiber fraction will be 30%, optionally 20%, 10%, 5%, 1%. In another embodiment, proteases are used to hydrolyze the protein trapped within the fiber fraction, which releases the protein from the fiber, and can be recovered therefrom, and such a process is also included in the present disclosure. In another embodiment, proteases (such as Protames, Alcalase 2.4L FG and/or Flavourzyme 1000L) are used to hydrolyze the protein trapped within the fiber fraction, which releases the protein from the fiber, and can be recovered therefrom, and such a process is also included in the present disclosure. In this embodiment, the hydrolyzed protein is separated from the fiber using any of the means disclosed herein (e.g. centrifugation, hydrocyclone). It will be understood that the disclosure concerning the g-force sufficient to separate the mixture as described above applies to all of the processes and embodiments of the present disclosure.

[0098] In an embodiment, the mixture is subjected to a g-force of between 100g and 500g, suitably between 150g and 400g, optionally between 180g and 350g. Calculation of g-force (or relative centrifugal force) optionally involves the RPMs (revolutions per minute) of the device, as well as the rotational radius (in centimeters):

$$\text{g-force} = (\text{RPM})^2 * (\text{rotational radius}) * (0.00001118)$$

A person skilled in the art will readily be able to calculate the g-force from the RPMs of a given separation device, such as a centrifuge or a hydrocyclone.

[0099] In another embodiment, separating the mixture comprises using a centrifuge or a hydrocyclone. In another embodiment, the centrifuge comprises a decanter centrifuge or a disc stack centrifuge.

[0100] In another embodiment, as there will be a residual amount of protein in the separated fiber fraction, the separated fiber fraction is washed with a second blending solvent, optionally at least once, optionally twice or more than twice, and the mixture is then again subjected to a g-force to separate the mixture to form a fiber fraction and a protein fraction comprising an insoluble protein fraction and a soluble protein fraction.

[0101] In another embodiment, the separation of the insoluble fiber fraction from the protein fractions, results in fiber solids which are dried and consequently constitute a high fiber canola meal containing a low concentration of anti-nutritional factors, such as phytates and/or phytic acid.

[0102] In another embodiment, the pH of the protein fraction comprising the insoluble protein fraction and soluble protein fraction is adjusted using an acid, such as phosphoric acid, nitric acid, citric acid, sulfuric acid, and the pH is adjusted to between 4.0 and 6.0, optionally 4.0 and 5.0, suitably 4.0 and 4.5. In an embodiment, adjusting the pH of the protein fraction using an acid results in undesirable ash becoming soluble in the protein fraction, and therefore, separable from the final protein concentrate.

[0103] In another embodiment, the protein fraction comprising the insoluble protein fraction and the soluble protein fraction is heated to a temperature between 80°C and 100°C, optionally 90°C and 100°C, suitably 95°C and 100°C, for a time period of between 5 minutes and 60 minutes, optionally 5 minutes and 45 minutes, suitably between 10 minutes and 30 minutes. Increasing the temperature of the protein fractions denatures some of the undenatured proteins in the soluble protein fraction, rendering them insoluble, and therefore increasing the yield of the insoluble protein concentrate.

[0104] In a further embodiment, separating the precipitated proteins comprises using a centrifuge or a hydrocyclone. In another embodiment, separating the precipitated proteins comprises using a centrifuge, such as decanter centrifuge or a disc stack centrifuge. In another embodiment, centrifuging the precipitated proteins comprises a g-force between 2,500g and 9,500g. When the centrifuge is operated at such a g-force, the precipitated proteins move along the radial axis to the bottom of the centrifuge tube and are easily separated from the supernatant.

[0105] In another embodiment of the disclosure, the process further comprising the step of drying the protein concentrate to a moisture content of between 4% and 8%, optionally 6% (w/w). In another embodiment, the drying is performed using a fluidized bed dryer, conveyor dryer, rotary dryer, drum dryer, spray drier or a ring drier.

[0106] In another embodiment, the protein concentrate comprises a hydrolyzed protein concentrate. In another embodiment, the hydrolyzed protein concentrate comprises peptides and/or free amino acids.

[0107] The present disclosure also includes a process for the production of a protein concentrate from a toasted oilseed meal as shown in Figure 36, comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to a pH between 6.0 and 10.0;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) protein fractions comprising an insoluble protein fraction and a soluble protein fraction;

v) optionally mixing the fiber fraction with a second blending solvent and repeating step iv);
vi) optionally adjusting the pH of the protein fraction to a pH between 4.0 and 6.0;
vii) mixing the protein fraction with a mixing solvent to form a protein slurry and precipitate the proteins;
viii) separating the precipitated proteins from the protein slurry to form the protein concentrate; and
ix) optionally repeating steps vii) and viii) with the precipitated proteins.

[0108] In another embodiment, the first and second blending solvents comprise water, a saline solution or a polysaccharide solution. In a further embodiment, the first and second blending solvents comprise water.

[0109] In an embodiment of the disclosure, the ratio of the toasted oilseed meal to the first blending solvent is 1:3 to 1:30 (w/w) of meal to water, optionally about 1:8 to about 1:10 (w/w).

[0110] In an embodiment, the temperature suitable for phytase activity is between 20°C and 60°C, optionally between 40°C and 55°C, suitably between 50°C and 55°C. In another embodiment, the pH suitable for phytase activity is between

2.0 and 7.0, optionally between 4.0 and 6.0, suitably between 4.5 and 5.5, optionally 5.0 to 5.5. In another embodiment, the concentration of the phytase enzyme is between 0.01% to 1.0% (w/w) based on the weight of the toasted oilseed meal, optionally 0.01% and 0.5% optionally 0.01% and 0.1%. In another embodiment, the mixture is incubated with the phytase enzyme under good agitation.

[0111] In another embodiment of the disclosure, after treating the mixture with the phytase enzyme, the pH of the mixture is optionally adjusted to a pH of about 6.0 to about 10.0, optionally 6.5 to about 9.5, suitably 7.0 to 8.0, using a base, such as sodium hydroxide, potassium hydroxide, etc. In an embodiment, adjusting the pH of the mixture results in the protein becoming more soluble in the blending solvent, such as water, which consequently increases the yield of the protein concentrate.

[0112] In another embodiment of the disclosure, the mixture is subjected to a g-force of between 100g and 500g, suitably between 150g and 400g, optionally between 180g and 350g.

[0113] In another embodiment, separating the mixture comprises using a centrifuge or a hydrocyclone. In another embodiment, the centrifuge comprises a decanter centrifuge or disc stack centrifuge.

[0114] In another embodiment, as there will be a residual amount of protein in the separated fiber fraction, the separated fiber fraction is washed with a second blending solvent, optionally at least once, optionally twice or more than twice, and the mixture is then again subjected to a g-force to separate the mixture to form a fiber fraction and a protein fraction comprising an insoluble protein fraction and a soluble protein fraction.

[0115] In another embodiment, the separation of the insoluble fiber fraction from the protein fraction, results in fiber solids which are dried and consequently constitute a high fiber canola meal containing a low concentration of anti-nutritional factors, such as phytates and/or phytic acid.

[0116] In another embodiment, the pH of the protein fraction comprising the insoluble protein fraction and soluble protein fraction is adjusted using an acid, such as phosphoric acid, nitric acid, citric acid, sulfuric acid, hydrochloric acid, and the pH is adjusted to between 4.0 and 6.0, optionally 4.0 and 5.0, suitably 4.0 and 4.5. In an embodiment, adjusting the pH of the protein fraction using an acid results in undesirable ash becoming soluble in the protein fraction, and therefore, separable from the final protein concentrate.

[0117] In another embodiment of the disclosure, the protein fraction is mixed with a mixing solvent comprising an ethanol:water mixture, wherein the ethanol is present in an amount between 90% and 100%, optionally 95% and 100% (v/v). It will be understood that 100% ethanol may contain a small percentage of impurities such as water, etc., which cannot be removed from the ethanol. In an embodiment, mixing solvent is added to the protein fraction at a ratio of between 2:1 and 1:2 (v/v of mixing solvent:protein fraction), optionally 1:1. In an embodiment, when the mixing solvent comprises an alcohol, such as ethanol (80%, 90%, 95% ethanol in water or 100% ethanol), proteins in the protein slurry precipitate from solution, as a result the proteins being less soluble in the mixing solvent (such as ethanol) than in the blending solvent (such as water), and therefore increases the yield of the protein concentrate.

[0118] In another embodiment, separating the precipitated proteins comprises using a centrifuge or a hydrocyclone. In another embodiment, separating the precipitated proteins comprises using a centrifuge, such as decanter centrifuge or disc stack centrifuge. In another embodiment, centrifuging the precipitated proteins comprises a g-force between 2,500g and 9,500g. When the centrifuge is operated at such a g-force, the precipitated proteins move along the radial axis to the bottom of the centrifuge tube and are easily separated from the supernatant.

[0119] In another embodiment of the disclosure, steps viii) and viii) are repeated at least twice, such that the precipitated proteins are washed with mixing solvent to remove impurities.

[0120] In another embodiment, the process further comprises the step of drying the protein concentrate to a moisture content of between 4% and 8% (w/w), optionally 6% (w/w). In another embodiment, the drying is performed using a fluidized bed dryer, spray dryer or a ring drier.

[0121] In another embodiment, the protein concentrate comprises a hydrolyzed protein concentrate. In a further embodiment, the hydrolyzed protein concentrate comprises peptides and/or free amino acids.

[0122] The present disclosure also includes a process for the production of a protein isolate from a toasted oilseed meal as shown in Figure 37, comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to a pH between 6.0 and 10.0;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) protein fractions comprising an insoluble protein fraction and a soluble protein fraction;

v) optionally mixing the fiber fraction with a second blending solvent and repeating step iv);
vi) separating the insoluble protein fraction from the soluble protein fraction to recover therefrom an insoluble protein

concentrate and a soluble protein extract; and
vii) subjecting the soluble protein extract to filtration to recover therefrom the protein isolate.

[0123] In another embodiment, the first and second blending solvents comprise water, a saline solution or a polysaccharide solution. In a further embodiment, the first and second blending solvents comprise water.

[0124] In an embodiment of the disclosure, the ratio of the toasted oilseed meal to the first blending solvent is 1:3 to 1:30 (w/w) of meal to water, optionally 1:8 to 1:10 (w/w).

[0125] In an embodiment, the temperature suitable for phytase activity is between 20°C and 60°C, optionally between 40°C and 55°C, suitably between 50°C and 55°C. In another embodiment, the pH suitable for phytase activity is between 2.0 and 7.0, optionally between 4.0 and 6.0, suitably between 4.5 and 5.5, optionally 5.0 and 5.5. In another embodiment, the concentration of the phytase enzyme is between 0.01% and 1.0% (w/w) based on the weight of the toasted oilseed meal, optionally 0.01% and 0.5% optionally 0.01% and 0.1%. In another embodiment, the mixture is incubated with the phytase enzyme under good agitation.

[0126] In another embodiment of the disclosure, after treating the mixture with the phytase enzyme, the pH of the mixture is optionally adjusted to a pH of between 6.0 and 10.0, optionally 7.0 and 9.0, suitably 7.0 and 8.0, using a base, such as sodium hydroxide, potassium hydroxide, etc. In an embodiment, adjusting the pH of the mixture results in the protein becoming more soluble in the blending solvent, such as water, which consequently increases the yield of the protein isolate.

[0127] In another embodiment of the disclosure, the mixture is subjected to a g-force of between 100g and 500g, suitably between 150g and 400g, optionally between 180g and 350g.

[0128] In another embodiment, separating the mixture comprises using a centrifuge or a hydrocyclone. In an embodiment, the centrifuge comprises a decanter centrifuge or disc stack centrifuge.

[0129] In another embodiment, as there will be a residual amount of protein in the separated fiber fraction, the separated fiber fraction is washed with a second blending solvent, optionally at least once, optionally twice or more than twice, and the mixture is then again subjected to a g-force to separate the mixture to form a fiber fraction and a protein fraction comprising an insoluble protein fraction and a soluble protein fraction.

[0130] In another embodiment, the separation of the insoluble fiber fraction from the protein fraction, results in fiber solids which are dried and consequently constitute a high fiber canola meal containing a low concentration of anti-nutritional factors, such as phytates and/or phytic acid.

[0131] In another embodiment, separating the insoluble protein fraction from the soluble fiber fraction comprises using a centrifuge or a hydrocyclone. In a further embodiment separating the insoluble protein fraction from the soluble protein fraction comprises using a centrifuge, such as a decanter centrifuge or disc stack centrifuge.

[0132] In another embodiment, centrifuging to separate the insoluble protein fraction from the soluble protein fraction comprises a g-force between 2,500g and 9,500g. In another embodiment, the separation of the insoluble protein fraction from the soluble protein fraction results in a wet protein concentrate that can be subsequently dried. The extract from the separation of the insoluble protein fraction from the soluble protein fraction comprises the soluble protein, which is subsequently filtered through a filtration apparatus, such as ultrafiltration and/or diafiltration, resulting in the protein isolate. As described above, phytates and/or phytic acid can complex and bind to the proteins, and consequently block the filtration apparatus. The removal of the phytates and/or phytic acid from the toasted oilseed meal mixture (oilseed meal and blending solvent) using phytase as described above, such that the filtration apparatus is not blocked with such complexes, resulting the filtration apparatus performing efficiently to produce the protein isolate.

[0133] In another embodiment, the process further comprises the step of drying the protein isolate to a moisture content of between 4% and 8% (w/w), optionally 6% (w/w). In another embodiment, the drying is performed using a spray drier or a ring drier.

[0134] In a further embodiment, the protein isolate comprises a hydrolyzed protein isolate. In another embodiment, the hydrolyzed protein concentrate comprises peptides and/or free amino acids.

[0135] In another embodiment of the disclosure, the protein in a toasted oilseed meal is significantly denatured, and therefore, much of the protein is insoluble in aqueous solutions. Only about 10% of the protein in a toasted oilseed meal is soluble in an aqueous solution. In one embodiment, the processes of the disclosure increase the yield of recoverable protein from a toasted oilseed meal, and in one embodiment, contain between 0-9%(w/w), 2-8%(w/w) or 3-7%(w/w) of fiber in the protein concentrate. Accordingly, the present disclosure includes a process for obtaining a protein concentrate from a toasted oilseed meal comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to a pH suitable to solubilize proteins in the mixture;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) a protein fraction comprising

(i) an insoluble protein fraction, and
(ii) a soluble protein fraction;

v) separating the fiber fraction from the protein fraction and mixing the fiber fraction with a second blending solvent to form a fiber mixture;
vi) treating the fiber mixture with a protease at a temperature and a pH suitable for protease activity;
vii) subjecting the fiber mixture to a g-force sufficient to separate the fiber mixture to form:

a) a second fiber fraction, and
b) a hydrolyzed protein fraction, comprising

(i) an insoluble protein fraction comprising partially hydrolyzed and un-hydrolyzed protein, and
(ii) a soluble hydrolyzed protein fraction;

viii) optionally adjusting the pH of the protein fraction from step iv(b) to a pH suitable to precipitate the proteins;
x) separating the precipitated proteins from the protein fraction;
xi) optionally combining the precipitated proteins and the hydrolyzed protein fraction to form the protein concentrate.

[0136] In one embodiment, the pH of the mixture (toasted oilseed meal and first blending solvent) is optionally adjusted to solubilize proteins (undenatured proteins) into the first blending solvent. In an embodiment, the pH of the mixture is adjusted to a pH between 6 and 8, optionally between 6.5 and 7.5, optionally about 7.0, using a base such as sodium hydroxide, which solubilizes some of the proteins present in the toasted oilseed meal, and upon low g-force separation, increases the amount of protein in the protein fraction. In addition, adjusting the pH to about 7.0 results in the fiber fraction (after low g-force separation of the mixture) having a neutral pH as a by-product.

[0137] In another embodiment, the process further comprises mixing the fiber fraction with the first blending solvent and repeating step iv) once, twice or three times and/or mixing the second fiber fraction with the second blending solvent and repeating step vii) once, twice or three times. The repeated washing of the fiber fractions with the blending solvent increases the amount of protein that is recovered for the protein concentrate as the repeated washings separates additional protein that is trapped within the fiber structure.

[0138] In another embodiment, the first and second blending solvents comprise water, a saline solution or a polysaccharide solution, optionally water, and wherein the ratio of the toasted oilseed meal to the first blending solvent is 1:3 to 1:30 (w/w) of meal to water, optionally 1:8.

[0139] In another embodiment, the temperature suitable for phytase activity is between 20° and 60°C and the pH suitable for phytase activity is between 2.0 and 7.0 and the temperature suitable for protease activity is between 30° and 70°C and the pH suitable for protease activity is between 5.0 and 9.0.

[0140] In another embodiment, the mixture and/or the fiber mixture is subjected to a g-force of between 100g and 500g, optionally between 150g and 400g, or between 170g and 350g. In an embodiment, separating the mixture and/or the fiber mixture comprises using a centrifuge or a hydrocyclone, optionally a decanter centrifuge.

[0141] In a further embodiment, the pH of the protein fraction from step iv(b) is adjusted to precipitate proteins in the protein fraction. The protein fraction comprises (i) an insoluble protein fraction, and (ii) a soluble protein fraction, and the adjustment of the pH precipitates proteins from the soluble protein fraction, and therefore increases the yield of the protein concentrate. In one embodiment, the pH of the protein fraction is adjusted to the isoelectric point of the soluble protein, at which point the soluble protein precipitates from solution. In one embodiment, the pH suitable to precipitate the proteins in the protein fraction is between 4.0 and 6.0, optionally 4.0 and 5.0, suitably 4.0 and 4.5 using an acid such as phosphoric acid, nitric acid, sulfuric acid, hydrochloric acid, optionally phosphoric acid having a concentration of 40% to 60% (w/w), optionally about 50%. In another embodiment, adjusting the pH of the protein fraction using an acid results in undesirable ash becoming soluble in the protein fraction, and therefore, separable from the final protein concentrate.

[0142] In another embodiment, separating the precipitated proteins comprises using a centrifuge or a hydrocyclone. In another embodiment, separating the precipitated proteins comprises using a centrifuge, such as decanter centrifuge or disc stack centrifuge. In another embodiment, centrifuging the precipitated proteins comprises a g-force between 2,500g and 9,500g. When the centrifuge is operated at such a g-force, the precipitated proteins move along the radial axis to the bottom of the centrifuge tube and are easily separated from the supernatant.

[0143] In another embodiment, the process further comprises the step of drying the protein concentrate to a moisture of between 4% and 8% (w/w). In another embodiment, the protein concentrate also comprises peptides and free amino acids.

[0144] In another embodiment, the toasted oilseed meal comprises a canola, rapeseed, mustard seed, broccoli seed, flax seed, cotton seed, hemp seed, safflower seed, sesame seed or soybean meal, optionally canola meal.

[0145] The present disclosure also includes a process for the production of a protein concentrate from a toasted oilseed meal comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to a pH suitable to solubilize proteins in the mixture;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) a protein fraction comprising

(i) an insoluble protein fraction, and
(ii) a soluble protein fraction;

v) separating the fiber fraction from the protein fraction and mixing the fiber fraction with a second blending solvent to form a fiber mixture;
vi) treating the fiber mixture with a protease at a temperature and a pH suitable for protease activity;
vii) subjecting the fiber mixture to a g-force sufficient to separate the fiber mixture to form:

a) a second fiber fraction, and
b) a hydrolyzed protein fraction, comprising

(i) an insoluble protein fraction, and
(ii) a soluble hydrolyzed protein fraction;

ix) mixing the protein fraction with a mixing solvent to precipitate proteins;
x) separating the precipitated proteins from the protein fraction; and
xi) optionally combining the precipitated proteins and the hydrolyzed protein fraction to form the protein concentrate.

[0146] In one embodiment, the pH of the mixture (toasted oilseed meal and first blending solvent) is optionally adjusted to solubilize proteins (undenatured proteins) into the first blending solvent. In an embodiment, the pH of the mixture is adjusted to a pH between 6 and 8, optionally between 6.5 and 7.5, optionally about 7.0, using a base such as sodium hydroxide, which solubilizes some of the proteins present in the toasted oilseed meal, and upon low g-force separation, increases the amount of protein in the protein fraction. In addition, adjusting the pH to about 7.0 results in the fiber fraction (after low g-force separation of the mixture) having a neutral pH as a by-product.

[0147] In another embodiment, the process further comprises mixing the fiber fraction with the first blending solvent and repeating step iv) once, twice or three times and/or mixing the second fiber fraction with the second blending solvent and repeating step vii) once, twice or three times. The repeated washing of the fiber fractions with the blending solvent increases the amount of protein that is recovered for the protein concentrate as the repeated washings separates additional protein that is trapped within the fiber structure.

[0148] In another embodiment, the first and second blending solvents comprise water, a saline solution or a polysaccharide solution, optionally water, and wherein the ratio of the toasted oilseed meal to the first blending solvent is 1:3 to 1:30 (w/w) of meal to water, optionally 1:8.

[0149] In another embodiment, the temperature suitable for phytase activity is between 20° and 60°C and the pH suitable for phytase activity is between 2.0 and 7.0 and the temperature suitable for protease activity is between 30° and 70°C and the pH suitable for protease activity is between 5.0 and 9.0.

[0150] In another embodiment, the mixture and/or the fiber mixture is subjected to a g-force of between 100g and 500g, optionally between 150g and 400g, or between 170g and 350g. In an embodiment, separating the mixture and/or the fiber mixture comprises using a centrifuge or a hydrocyclone, optionally a decanter centrifuge.

[0151] In another embodiment, the pH of the protein fraction from step iv(b) is adjusted using an acid, such as phosphoric acid, nitric acid, citric acid, sulfuric acid, hydrochloric acid, and the pH is adjusted to between 4.0 and 6.0, optionally 4.0 and 5.0, suitably 4.0 and 4.5. In an embodiment, adjusting the pH of the protein fraction using an acid results in undesirable ash becoming soluble in the protein fraction, and therefore, separable from the final protein concentrate.

[0152] In another embodiment of the disclosure, the protein fraction is mixed with a mixing solvent comprising an ethanol:water mixture, wherein the ethanol is present in an amount between 80% and 100%, optionally 90% and 100%, optionally 95% and 100% (v/v). It will be understood that 100% ethanol may contain a small percentage of impurities

such as water, etc., which cannot be removed from the ethanol. In an embodiment, mixing solvent is added to the protein fraction at a ratio of between 2:1 and 1:2 (v/v of mixing solvent-protein fraction), optionally 1:1. In an embodiment, when the mixing solvent comprises an alcohol, such as ethanol (80%, 90%, 95% ethanol in water or 100% ethanol), soluble proteins in the protein fraction precipitate from solution, as a result the proteins being less soluble in the mixing solvent (such as ethanol) than in the blending solvent (such as water), and therefore increases the yield of the protein concentrate.

[0153] In another embodiment, the mixing solvent comprises an ethanol:water mixture, wherein the ethanol is present in an amount between 80% and 100% (v/v). The addition of the mixing solvent to the protein fraction from step iv(b) causes proteins in the protein fraction to precipitate as a result of the proteins having a lower solubility in such a solvent (such as ethanol/water mixture). Accordingly, the amount of protein recovered is increased upon separation.

[0154] In another embodiment, separating the precipitated proteins comprises using a centrifuge or a hydrocyclone. In another embodiment, separating the precipitated proteins comprises using a centrifuge, such as decanter centrifuge or disc stack centrifuge. In another embodiment, centrifuging the precipitated proteins comprises a g-force between 2,500g and 9,500g. When the centrifuge is operated at such a g-force, the precipitated proteins move along the radial axis to the bottom of the centrifuge tube and are easily separated from the supernatant.

[0155] In another embodiment, the process further comprises the step of drying the protein concentrate to a moisture of between 4% and 8% (w/w). In another embodiment, the protein concentrate also comprises peptides and free amino acids.

[0156] In another embodiment, the toasted oilseed meal comprises a canola, rapeseed, mustard seed, broccoli seed, flax seed, cotton seed, hemp seed, safflower seed, sesame seed or soybean meal, optionally canola meal.

[0157] In another embodiment, the present disclosure also includes a process for the production of a protein isolate from a toasted oilseed meal comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to a pH suitable to solubilize proteins;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) a protein fraction comprising

(i) an insoluble protein fraction, and
(ii) a soluble protein fraction;

vi) separating the insoluble protein fraction from the soluble protein fraction to recover therefrom an insoluble protein concentrate and a soluble protein extract; and
vii) subjecting the soluble protein extract to filtration to recover therefrom the protein isolate.

[0158] In one embodiment, the pH of the mixture (toasted oilseed meal and first blending solvent) is optionally adjusted to solubilize proteins (undenatured proteins) into the first blending solvent. In an embodiment, the pH of the mixture is adjusted to a pH between 6 and 8, optionally between 6.5 and 7.5, optionally about 7.0, which solubilizes some of the proteins present in the toasted oilseed meal, and upon low g-force separation, increases the amount of protein in the protein fraction. In addition, adjusting the pH to about 7.0 results in the fiber fraction (after low g-force separation of the mixture) having a neutral pH as a by-product.

[0159] In another embodiment, the process further comprises mixing the fiber fraction with the first blending solvent and repeating step iv) once, twice or three times. The repeated washing of the fiber fraction with the blending solvent increases the amount of protein that is recovered for the protein concentrate as the repeated washings separates additional protein that is trapped within the fiber structure.

[0160] In another embodiment, the first and second blending solvents comprise water, a saline solution or a polysaccharide solution, optionally water, and wherein the ratio of the toasted oilseed meal to the first blending solvent is 1:3 to 1:30 (w/w) of meal to water.

[0161] In another embodiment, the temperature suitable for phytase activity is between 20° and 60°C and the pH suitable for phytase activity is between 2.0 and 7.0 and the temperature suitable for protease activity is between 30° and 70°C and the pH suitable for protease activity is between 5.0 and 9.0.

[0162] In another embodiment, the mixture and/or the fiber mixture is subjected to a g-force of between 100g and 500g, optionally between 150g and 400g, or between 170g and 350g. In an embodiment, separating the mixture and/or the fiber mixture comprises using a centrifuge or a hydrocyclone, optionally in a decanter centrifuge.

[0163] In another embodiment, centrifuging to separate the insoluble protein fraction from the soluble protein fraction comprises a g-force between 2,500g and 9,500g. In another embodiment, the separation of the insoluble protein fraction

from the soluble protein fraction results in a wet protein concentrate that can be subsequently dried. The extract from the separation of the insoluble protein fraction from the soluble protein fraction comprises the soluble protein, which is subsequently filtered through a filtration apparatus, such as ultrafiltration and/or diafiltration, resulting in the protein isolate. As described above, phytates and/or phytic acid can complex and bind to the proteins, and consequently block the filtration apparatus. The removal of the phytates and/or phytic acid from the toasted oilseed meal mixture (oilseed meal and blending solvent) using phytase as described above, such that the filtration apparatus is not blocked with such complexes, resulting the filtration apparatus performing efficiently to produce the protein isolate.

[0164] In another embodiment, the process further comprises the step of drying the protein concentrate to a moisture of between 4% and 8% (w/w). In another embodiment, the protein concentrate also comprises peptides and free amino acids.

[0165] In another embodiment, the toasted oilseed meal comprises a canola, rapeseed, mustard seed, broccoli seed, flax seed, cotton seed, hemp seed, safflower seed, sesame seed or soybean meal, optionally canola meal.

[0166] In another embodiment, any of the above processes is conducted using a counter-current process.

[0167] In another embodiment, there is also included a process for treating a toasted oilseed meal comprising a fiber fraction and a protein fraction,

[0168] The following examples are illustrative of embodiments of the present disclosure:

EXAMPLES

Reagents and Materials

[0169] Canola seeds (*Brassica juncea and Brassica napus*) were obtained from Viterra, North Battleford, Saskatchewan, Canada. Commercial methyl pentane was purchased from Univar Canada Ltd., Saskatoon, Saskatchewan, Canada. Enzyme samples of Cellulase (Celluclast®) 1.5L), Cellulase **Complex, Alcalase® 2.4L FG, Flavourzyme® and Protamex® were obtained from Novozymes North America, Inc., Franklinton, N.C. USA.** Toasted canola meal (*B. napus*) was produced from canola seed (*B.napus*) using the simulated industrial procedure and processing conditions of flaking, cooking, pressing, oil extraction with methyl pentane, and desolventization and toasting at 95-100°C. The dried toasted meal was milled to break big chunks using a pilot plant disc mill. The milled and toasted canola meal was collected in a bulk sack.

Analysis

[0170] Mixing of the materials was performed using a Ribbon Blender (Torco Model R-12, Toronto Coppersmithing International Ltd., Scarborough, Ontario, Canada). Heat treatments of seed samples were conducted using an Infra Red Cereal Processing System (Micronizing Company Limited, Framlingham, Sulfolk, England) or a two-tray Simon-Rosedown cooker (Laboratory cooker-press, Simon-Rosedowns Limited, Hull, England). Pressing of the oil seeds is performed using a Gusta Laboratory Screw Press. Ultrafiltration was carried out using a Millipore® Ultrafiltration Unit (Model A60, Millipore® Corporation, Bedford, MA, USA). Protein content of the samples was determined by the Leco® Protein Analyzer (Model FP-428, Leco® Corporation, ST. Joseph, MI. U.S.A.) based on AOCS Official Method Ba 4e-93. Moisture content of the samples was determined by drying samples in a 105 $\pm$ 2°C convection oven for 16 hours or to a constant weight based on AOCS Official Method Ba 2a-38. Oil content of the samples was determined based on AOCS Official Method Ba 3-38 with the following changes: (a) 2 g of sample was used instead of 5 g in the analysis; (b) extraction continued for 4 hours, and (c) extraction flask was heated to remove residual petroleum ethers. Ash content of the samples was determined based on AOCS Official Method Ba 5a-49 with the following changes: (a) samples were pre-ashed on a hot plate prior to being placed into the muffle furnace; (b) samples were incinerated for 18 hours in muffle furnace; and (c) nitric acid was added if sample remained black. Crude fiber content of the samples was determined based on AOCS Official Method Ba 6-84 with the following changes: (a) samples with oil contents below 3% were not toasted defatted and (b) digest was dried for 2 hours at 130°C. Protein dispersibility index (PDI) of the samples was determined based on A.O.C.S. Official Method Ba 10-65. Free fatty acid (FFA) of the oil samples was determined based on AOCS Official Method Ca 5a-40. Phosphorus and sulphur of the samples were determined based on the modified methods of AOCS Ca20-99 and AOCS Ca 17-01 (modified), respectively. Crude fiber content of the samples was determined based on AOCS Official Method Ba 6-84 with the following changes: (a) samples with oil contents below 3% were not toasted defatted and (b) digest was dried for 2 hours at 130°C. Protein dispersibility index (PDI) of the samples was determined based on A.O.C.S. Official Method Ba 10-65. Glucosinolate content of the samples was determined based on the Method of the Canadian Grain Commission, Grain Research Laboratory (Daun, J.K. and McGregor, D.I., Glucosinolate Analysis of Rapeseed (Canola), December 15, 1981). Solvent residues were determined using GC/MS techniques based on a modified method of A.O.C.S. Official Method, Ba 13-87.

Example 1-Preparation of a Protein Concentrate from Toasted Meal

[0171] Approximately 0.4 kg of toasted defatted and toasted canola meal *(B.napus)* was mixed with 4 kg of water for 1 hour at ambient temperature. The canola meal slurry was centrifuged at 2,100 RPM (1,215 g force) for 10 minutes using a laboratory centrifuge. Three layers were formed in the centrifuge bottles, the top liquid layer, the middle insoluble protein layer and the bottom fiber layer. The fiber layer was manually separated from the insoluble protein layer. The recovered fiber solids were mixed with 2 kg of water ambient temperature for 10 minutes, which was followed by centrifugation at 1,000 RPM (172 g force) for 10 minutes. Similarly, the fiber layer was manually separated from the insoluble protein layer. The insoluble protein solids and all the liquid extracts were combined together to form a protein slurry. The protein slurry was mixed with 2.4 kg of 100% denatured ethanol (SDAG13) for 1 hour. This was followed by centrifugation at 4000 RPM (4,400 g force) for 10 minutes to recover the precipitated proteins. The precipitated proteins were mixed with 2.4 kg of 100% denatured ethanol (SDAG13). This was followed by centrifugation at 4,000 RPM (4,400 g force) for 10 minutes to recover the precipitated proteins. The washed protein precipitates were desolventized in a fume hood before drying at 50°C to 4% moisture in a laboratory vacuum oven. Approximately 136.63 g of protein concentrate was produced containing 70% protein and 5.97% crude fiber on a dry weight basis (as seen in Table 1). As shown in Table 1, the fiber separation process increased the crude fiber content to 22.4% in the fiber solids while reduced it to 5.97% in the canola protein concentrate.

Example 2-Preparation of a Protein Concentrate from Toasted Meal

[0172] Approximately 0.25 kg of toasted defatted and toasted canola meal was mixed with 2.5 kg of water for 1 hour at ambient temperature. This was followed by centrifugation at 2,000 RPM (1,100 g force) for 10 minutes using the lab centrifuge to obtain three layers in the centrifuge bottles, the top liquid layer, the middle insoluble protein layer and the bottom fiber layer. The bottom fiber layer was manually separated from the middle insoluble protein layer. The wet fiber solids were dried in a force-air oven at 60°C overnight. Approximately 107.9 g of dried fiber solids was produced.

[0173] Canola protein slurry containing the top liquid layer and the middle insoluble protein layer was adjusted to pH4.5 by addition of 20% phosphoric acid. This was followed by centrifugation at 4,000 RPM (4,400 g force) for 10 minutes to separate the precipitated protein from the liquid extract. The precipitated proteins were mixed with water at a ratio of 1 to 3 by weight for 0.5 hour. This was followed by centrifugation at 4,000 RPM (4,400 g force) for 10 minutes to separate the washed protein precipitates from the liquid extract. Finally the washed protein solids were mixed with water at a ratio of 1 to 3 by weight for 0.5 hour. This was again followed by centrifugation at 4,000 RPM (4,400 g force) for 10 minutes to separate the final washed protein solids from the liquid extract. The final washed protein solids were dried in a force-air oven at 60°C overnight. Approximately 61.34 g of dried protein solids or protein concentrate was produced. As shown in Table 2, the fiber separation process increased the crude fiber content to 21.7% in the fiber solids while reduced it to 8.15% in the canola protein concentrate from the original 12.7% crude fiber in the toasted defatted and toasted canola meal. The ash content was reduced to 2.54% in the protein concentrate.

Example 3-Preparation of a Protein Concentrate from Toasted Meal

[0174] Approximately 15 kg of toasted defatted and toasted canola meal *(B.napus)* was mixed with 120 kg of tab water at ambient temperature under agitation for 1 hour. Canola meal slurry was centrifuged at 180 g force (1500 RPM bowl speed) to separate fiber solids from canola protein slurry (slurry 1) containing soluble and insoluble proteins using a Bird Decanter (Bird 6" Continuous Bowl Decanter, Saskatoon, Canada). Fiber solids was mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which was followed by centrifugation at 180 g force (1500 RPM bowl speed) to separate the 1st washed fiber solids from canola protein slurry (slurry 2) containing soluble and insoluble proteins using the Bird Decanter. The 1st washed fiber solids were mixed with water at a ratio of 1 to 1 by weight at ambient temperature. This was followed by centrifugation at 180 g force (1500 RPM bowl speed) to separate the second washed fiber solids from canola protein slurry (slurry 3) containing soluble and insoluble proteins using the Bird Decanter.

[0175] The canola protein slurries containing soluble and insoluble proteins are combined together and approximately 227.5 kg of protein slurry containing soluble and insoluble proteins was obtained. 227.5 kg of protein slurry was mixed 180 kg of 100% denatured ethanol (SDAG 13) at a volume ratio of 1 to 1 at ambient temperature under agitation. This was followed by centrifugation at 6,550 g force (8500 RPM) to recover precipitated proteins using a Westfalia® Disc Stack Centrifuge (SA-7, Oelde, Germany). The precipitated proteins were washed with 90 kg of 85% ethanol (v/v) twice and centrifuged to recover the washed protein solids using a Basket Centrifuge (Tolhurst® - 26" Center-Slung, Ametek Inc., East Moline, Illinois, USA). The recovered protein solids were desolventized in a fume hood before the final drying in a vacuum tray dryer to 5.59% moisture. The produced protein concentrate contained 76.8% protein and 0.99% fiber on a dry weight basis (as seen in Table 3).

[0176] As shown in Table 3, toasted defatted and toasted canola meal contained 12.7% crude fiber (dwb). After

centrifugation at 180 g force to separate the fiber solids from the canola protein slurry containing soluble and insoluble proteins, the crude fiber content was reduced to 1.34% in the protein slurry while it was increased to 15% in the fiber solids. The washing of the fiber solids with water and separation of washed fiber solids from canola protein slurry containing soluble and insoluble proteins by centrifugation at 180 g force further increased the crude fiber content to 17.9% in the first washed fiber solids and 20.2% in the second washed fiber solids. The canola protein slurry contained 0.97% crude fiber and 0.99% crude fiber from the first and second wash and separation processes, respectively.

[0177] Precipitation of proteins by ethanol and recovery of precipitated proteins increased the protein content to 71.5% (as seen in Table 3). The washing of the precipitated proteins with 85% (v/v) ethanol further increased the protein content to 75.3% in the first wash and 76.8% in the second wash, respectively. Ethanol precipitation and wash mainly removed carbohydrates. One step ethanol precipitation was sufficient to produce protein concentrate containing higher than 70% protein on a dry weight basis.

Example 4-Preparation of a Protein Concentrate from Toasted Meal

[0178] Approximately 40 kg of toasted defatted and toasted canola meal (*B.napus*) was mixed with 320 kg of tab water at ambient temperature under agitation for 1 hour. Canola meal slurry was centrifuged at 180 g force (1500 RPM bowl speed) to separate fiber solids from canola protein slurry (slurry 1) containing soluble and insoluble proteins using the Bird® Decanter (Bird 6" Continuous Bowl Decanter, Saskatoon, Canada). Fiber solids were mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which was followed by centrifugation at 180 g force (1500 RPM bowl speed) to separate the washed fiber solids from canola protein slurry (slurry 2) containing soluble and insoluble proteins using the Bird® Decanter.

[0179] Canola protein slurries containing soluble and insoluble proteins are combined together and approximately 369.5 kg of protein slurry containing soluble and insoluble proteins was obtained. The pH of combined protein slurry was adjusted to 4.5 $\pm$ 0.1 by addition of 85% phosphoric acid. This was followed by centrifugation at 3,300 g force (5200 RPM bowl speed) to recover the majority of the precipitated proteins using a Westfalia® Decanter Centrifuge (CA 225-010, Germany). The supernatant still contained a small amount of fine precipitated proteins that were recovered by centrifugation at 6,715 g force (7560 RPM) using a Westfalia® Disc Stack Centrifuge (SA-14, Germany). The precipitated proteins were combined together, which was followed by mixing with water at a ratio of 1 to 3 by weight, pH 4.5 and ambient temperature. The washed protein precipitates were recovered by centrifugation at 3,300 g using the decanter at first, which was followed by centrifugation at 6,715 g using the Disc Stack Centrifuge to recover to remaining final precipitated proteins. Finally, the washed protein precipitates were mixed with water at a ratio of 1 to 3 by weight, pH 4.5 and ambient temperature. The final washed protein precipitates were recovered by centrifugation using both the Decanter at 3,300 g and the Disc Stack Centrifuge at 6,715 g.

[0180] The final washed protein precipitates were mixed with water at a ratio of 1 to 1 by weight, which was followed by spray drying at an inlet air temperature of 185 $\pm$ 5°C and an outlet air temperature of 85 $\pm$ 5°C. The produced protein concentrate contained 74.7% protein and 0.31% crude fiber on a dry weight basis (as seen in Table 4).

[0181] As shown in Table 4, toasted defatted and toasted canola meal contained 12.7% crude fiber (dwb). After centrifugation at 180 g force to separate the fiber solids from the canola protein slurry containing soluble and insoluble proteins, the crude fiber content was reduced to 0.8% in the protein slurry while it was increased to 17.0% in the fiber solids. Wash of fiber solids with water and separation of washed fiber solids from canola protein slurry containing soluble and insoluble proteins by centrifugation at 180 g force further increased the crude fiber content to 19.1% in the washed fiber solids. The canola protein slurry contained only 0.2% crude fiber from the wash and separation process.

[0182] Precipitation of proteins at pH 4.5 and recovery of precipitated proteins increased the protein content to 75.4% (Table 4). Wash of precipitated proteins with water further increased the protein content slightly (Table 4). The purification process by precipitation and washing mainly removed carbohydrate. One step precipitation was sufficient to produce protein concentrate containing above 70% protein on a dry weight basis.

Example 5-Preparation of Hydrolyzed Protein Concentrate from Recovered Fiber Solids

[0183] Approximately 126.3 kg of insoluble fiber solids from a toasted meal were mixed with 100 kg of water in a tank as shown in Figure 38. This was followed by pH adjustment to 8.3 $\pm$ 0.1 using 0.9 kg of 11.06% NaOH solution. Approximately 0.5 kg of a 1st protease (Alcalase® 2.4L FG) was added to the slurry. The slurry was then heated to 60 $\pm$ 2°C and held at this temperature for 4 hours. The slurry was cooled down to 50 $\pm$ 2°C and pH adjusted to 6.5. Approximately 0.5 kg of the 2nd protease (Flavouzyme®) was added to the slurry, which was followed by holding at 50 $\pm$ 2°C for 4 hours. The slurry was centrifuged using a Westfalia® Decanter at 3300 x g to separate the hydrolyzed protein extract from the insoluble fiber fraction. The insoluble fiber was washed further with 120 kg of filtered tap water, which was again followed by centrifugation at 3300 x g to separate the wash protein extract from the washed fiber solids using the Westfalia® Decanter. The hydrolyzed protein extract and the wash hydrolyzed protein extract were combined.

The combined hydrolyzed protein extract was fed to a Millipore® Ultrafiltration Unit (Model A60, Millipore Corporation, Bedford, MA, USA) at ambient temperature. The Ultrafiltration Unit (UF) was fitted with three hollow fiber cartridges having a molecular weight cutoff of 10,000 daltons. Each cartridge contained 5 m^2 of membrane surface area. The hydrolyzed protein extract was pumped through the hollow fiber cartridges at a rate of 800 - 1000 kg /hr. The retentate was recycled back to the feed tank and the permeate was collected in another tank. The UF unit was operated at an inlet pressure of 25 psi maximum and a retentate back pressure of 15 psi maximum. The flux rate or permeate rate was about 190 - 300 kg/hr throughout the ultrafiltration process. The ultrafiltration process continued until about 40 kg of retentate remained in the feed tank. Approximately 260 kg of water was added continuously into the feed tank and ultrafiltration was conducted at ambient temperature using the same UF unit fitted with the same three hollow fiber cartridges. The original volume of retentate in the feed tank was held constant by adding water to make up for the removed permeate. The retentate was recycled back to the feed tank. The ultrafiltration process continued until all 260 kg of water was added to the retentate.

[0184] Approximately 540 kg of permeate and 47.7 kg of retentate were obtained from the ultrafiltration process. The permeate was spray dried to produce hydrolyzed protein concentrate using a Komline® Sanderson pilot plant spray dryer equipped with a centrifugal atomizer with a wheel speed up to 10,000 rpm (Komline® Sanderson Ltd., Brampton, Ontario, Canada). The spray drying operation was conducted at an inlet air temperature of 185 ± 5°C and an outlet air temperature of 85 ± 5°C. Approximately 3.36 kg of spray dried hydrolyzed protein concentrate containing 82% protein (dwb) was produced.

Example 6-Hypothetical Preparation of Protein Concentrate from Toasted Meal using Phytase

[0185] Approximately 15 kg of toasted defatted and toasted canola meal *(B.napus)* is mixed with 120 kg of tab water at ambient temperature. Approximately 12 g of phytase (Natuphos® 10,000 L Phytase) at 0.08% dosage based on the starting weight of toasted defatted and toasted canola meal is added to the canola meal slurry. The pH of canola meal slurry is adjusted to 5.5 and temperature to 50°C. After holding for 1.5 hours under agitation, canola meal slurry is centrifuged at 180 g force (1500 RPM bowl speed) to separate fiber solids from canola protein slurry (slurry 1) containing soluble and insoluble proteins using a Bird Decanter (Bird 6" Continuous Bowl Decanter, Saskatoon, Canada). Fiber solids is mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which is followed by centrifugation at 180 g force (1500 RPM bowl speed) to separate the 1^{st} washed fiber solids from canola protein slurry (slurry 2) containing soluble and insoluble proteins using the Bird Decanter. The 1^{st} washed fiber solids are mixed with water at a ratio of 1 to 1 by weight at ambient temperature. This is followed by centrifugation at 180 g force (1500 RPM bowl speed) to separate the second washed fiber solids from canola protein slurry (slurry 3) containing soluble and insoluble proteins using the Bird Decanter.

[0186] Canola protein slurries containing soluble and insoluble proteins are combined together. The protein slurry is mixed with 100% denatured ethanol (SDAG 13) at a volume ratio of 1 to 1 at ambient temperature under agitation. This is followed by centrifugation at 6,550 g force (8500 RPM) to recover precipitated proteins using a Westfalia Disc Stack Centrifuge (SA-7, Oelde, Germany). The precipitated proteins are washed with 85% ethanol (v/v) twice and centrifuged to recover the washed protein solids using a Basket Centrifuge (Tolhurst - 26" Center-Slung, Ametek Inc., East Moline, Illinois, USA). The recovered protein solids are desolventized in a fume hood before the final drying in a vacuum tray dryer to 5.59% moisture. The canola protein concentrate would contain over 70% protein, low fiber, low ash and low anti-nutritional factors

Example 7-Hypothetical Preparation of Protein Concentrate from Toasted Meal using Phytase

[0187] Approximately 40 kg of toasted defatted and toasted canola meal *(B.napus)* is mixed with 320 kg of tab water at ambient temperature. Approximately 32 g of phytase (Natuphos® 10,000 L Phytase) at 0.08% dosage based on the starting weight of toasted defatted and toasted canola meal is added to the canola meal slurry. The pH of canola meal slurry is adjusted to 5.5 and temperature to 50°C. After holding for 1.5 hours under agitation, canola meal slurry is centrifuged at 180 g force (1500 RPM bowl speed) to separate fiber solids from canola protein slurry (slurry 1) containing soluble and insoluble proteins using the Bird Decanter (Bird 6" Continuous Bowl Decanter, Saskatoon, Canada). Fiber solids are mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which is followed by centrifugation at 180 g force (1500 RPM bowl speed) to separate the washed fiber solids from canola protein slurry (slurry 2) containing soluble and insoluble proteins using the Bird Decanter.

[0188] Canola protein slurries containing soluble and insoluble proteins are combined together. The pH of combined protein slurry is adjusted to 4.5 ± 0.1 by addition of 85% phosphoric acid. The protein slurry is heated to 95-100°C for 10 to 60 minutes. The protein slurry is cooled down to 65°C. This is followed by centrifugation at 3,300 g force (5200 RPM bowl speed) to recover the majority of the precipitated proteins using a Westfalia Decanter Centrifuge (CA 225-010, Germany). The supernatant would still contain a small amount of fine precipitated proteins that would be recovered by

centrifugation at 6,715 g force (7560 RPM) using a Westfalia Disc Stack Centrifuge (SA-14, Germany). The precipitated proteins are combined together, which is followed by mixing with water at a ratio of 1 to 3 by weight, at pH4.5 and at ambient temperature. The washed protein precipitates are recovered by centrifugation at 3,300 g using the Decanter at first, which is followed by centrifugation at 6,715 g using the Disc Stack Centrifuge to recover the remaining precipitated proteins. Finally, the washed protein precipitates are mixed with water at a ratio of 1 to 3 by weight, pH 4.5 and ambient temperature. The final washed protein precipitates are recovered by centrifugation using both the Decanter at 3,300 g and the Disc Stack Centrifuge at 6,715 g. The final washed protein precipitates are dried to about 6% moisture. The canola protein concentrate would contain over 70% protein, low fiber, low ash and low anti-nutritional factors.

Example 8-Preparation of Protein Concentrate From Toasted Meal Without Protease

[0189] A trial is carried out as a control to prepare a protein concentrate without the use of protease for protein hydrolysis. Approximately 100 g of defatted and toasted canola meal (*B.napus*) was mixed with 800 g of water at ambient temperature. The canola meal slurry had a pH 5.70, which was in the acceptable pH range for phytate hydrolysis. The canola meal slurry was heated to 52 ± 2°C and 0.3% phytase was added to the slurry (Natuphos powder form, 10,000 FTU/g) based on the weight of canola meal. Hydrolysis of phytates was carried out at 52 ± 2°C for 1 hour. After hydrolysis of phytates, the pH of canola meal slurry was adjusted to 7.0 by slow addition of 10% NaOH solution.

[0190] After pH adjustment to 7.0, the canola meal slurry was centrifuged at 4,000 rpm for 10 minutes using a lab centrifuge. Three layers defined as the top layer of liquid extract, the middle layer of insoluble protein solids and the bottom layer of insoluble fiber solids were obtained in the centrifuge bottles. The larger fiber particles with higher density settled faster than the smaller insoluble protein particles with lower density. Therefore, the larger fiber particles settled to the bottom of the bottles at first. The smaller insoluble protein particles with lower density settled on the top of the fiber solids. The liquid extract containing soluble proteins was the top supernatant layer. The bottom fiber solids were manually separated from the middle layer of insoluble protein solids and the top layer of soluble protein extract. The fiber solids were mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which was followed by centrifugation at 4000 rpm for 10 minutes. The bottom fiber layer was again manually separated from the middle insoluble protein and the top protein extract layers. This water washing and fiber separation process was repeated three times. All of the middle layers of insoluble protein solids and the top layers of soluble protein extract were combined together. The protein slurry was adjusted to pH 4.5 by addition of 50% phosphoric acid. This was followed by centrifugation at 4,000 rpm to separate the precipitated protein solids from the supernatant. Approximately 193 g of precipitated protein solids was produced. The precipitated protein solids were mixed with 212 g of water. pH of the protein slurry was adjusted to 7.0 by addition of 10% NaOH solution. This was followed by freeze drying into 25 g of protein concentrate.

Example 9

(i) Preparation of Protein Concentrate From Toasted Meal using 0.1% Alcalase

[0191] Figures 39 and 40 illustrate the preparation of a protein concentrate from a toasted meal using a protease. Approximately 100 g of defatted and toasted canola meal *(B.napus)* was mixed with 800 g of water at ambient temperature. The canola meal slurry had a pH 5.75, which was in the acceptable pH range for phytate hydrolysis. The canola meal slurry was heated to 52 ± 2°C and 0.3% phytase was added into the slurry (Natuphos. powder form, 10,000 FTU/g) based on the weight of canola meal. Hydrolysis of phytates was carried out at 52 ± 2°C for 1 hour. After hydrolysis of phytates, the pH of canola meal slurry was adjusted to 7.0 ± 0.1 by slow addition of 10% NaOH solution.

[0192] After pH adjustment to 7.0 ± 0.1, the canola meal slurry was centrifuged at 4,000 rpm for 10 minutes using a centrifuge. Three layers defined as the top liquid layer, the middle insoluble protein layer and the bottom insoluble fiber layer were obtained in the centrifuge bottles. The larger fiber particles with higher density settled faster than the smaller insoluble protein particles with lower density. Therefore, the larger fiber particles settled to the bottom of the bottles at first. The smaller insoluble protein particles with lower density settled on the top of the fiber layer. The liquid extract containing soluble proteins was at the top layer. The bottom fiber layer was separated manually from the middle insoluble protein layer and the top liquid extract layer. The fiber fraction was mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which was followed by centrifugation at 4,000 rpm for 10 minutes. The bottom layer of fiber solids was again manually separated from the middle layer of insoluble protein solids and the top layer of soluble protein extract. This water washing and fiber separation process was repeated three times. Approximately 252 g of the final washed fiber solids was obtained. All the middle insoluble protein and the top soluble protein extract layers were combined together and approximately 1,459 g of protein slurry was obtained. The protein slurry was adjusted to pH 4.5 by addition of 50% phosphoric acid. This was followed by centrifugation at 4,000 rpm to separate 155 g of precipitated protein solids from 1,304 g of supernatant. The precipitated protein solids were mixed with water at a ratio of 1 to 2 by weight, which was followed by centrifugation at 4,000 rpm for 10 minutes to separate the washed protein solids from the washing extract.

[0193] The 252 g of the washed fiber solids was mixed with water at a ratio of 1 to 1.5 by weight. pH of the slurry was adjusted 8.3 ± 0.1 by addition of 10% NaOH solution. The fiber slurry was heated to 60 ± 2°C. 0.1 g of Alcalase (0.1% dosage based on the weight of toasted meal) was added to the slurry and protein hydrolysis was carried out at 60 ± 2°C for 2 hours. After protein hydrolysis, the slurry was centrifuged at 4,000 rpm for 10 minutes using the lab centrifuge. Three layers defined as the top layer of soluble hydrolyzed protein extract, the middle layer of insoluble protein solids and the bottom layer of insoluble fiber solids were obtained in the centrifuge bottles. The fiber solids were manually separated from the hydrolyzed protein extract and the insoluble protein solids. The insoluble fiber solids were mixed with water at a ratio of 1 to 1 by weight. This was followed by centrifugation at 4,000 rpm for 10 minutes using the lab centrifuge. The washed fiber solids were again separated from the top layer of hydrolyzed protein extract and the middle layer of insoluble protein solids. Approximately 262 g of washed fiber solids was obtained. All the soluble hydrolyzed protein extracts and insoluble protein solids were combined together. Approximately 906 g of hydrolyzed protein slurry containing soluble hydrolyzed protein extract and insoluble protein solids was obtained.

[0194] The hydrolyzed protein slurry (906 g) was mixed with the washed and unhydrolyzed protein precipitates (155 g) and pH of the mixture was adjusted pH7.0 before freeze drying into 33 g of dried protein concentrate. The protein concentrate was a mix a mixture of unhydrolyzed, hydrolyzed and partially hydrolyzed proteins and did not have a bitter taste.

(ii) Preparation of Protein Concentrate From Toasted Meal using 0.5% Alcalase

[0195] Approximately 100 g of defatted and toasted canola meal (*B.napus*) was mixed with 800 g of water at ambient temperature. The canola meal slurry had a pH 5.77, which was in the acceptable pH range for phytate hydrolysis. The canola meal slurry was heated to 52 ± 2°C and 0.3% phytase (Natuphos. powder form, 10,000 FTU/g) was added to the slurry (based on the weight of canola meal). Hydrolysis of phytates was carried out at 52 ± 2°C for 1 hour. After hydrolysis of phytates, the pH of canola meal slurry was adjusted to 7.0 ± 0.1 by the slow addition of 10% NaOH solution.

[0196] After pH adjustment to 7.0 ± 0.1, the canola meal slurry was centrifuged at 4,000 rpm for 10 minutes using a lab centrifuge. Three layers defined as the top layer of liquid extract, the middle layer of insoluble protein solids and the bottom layer of insoluble fiber solids were obtained in the centrifuge bottles. The larger fiber particles with higher density settled faster than the smaller insoluble protein particles with lower density. Therefore, the larger fiber particles settled to the bottom of the bottles at first. The smaller insoluble protein particles with lower density settled on the top of the fiber solids. The liquid extract containing soluble proteins was the top supernatant layer. The bottom fiber solids were manually separated from the middle layer of insoluble protein solids and the top layer of soluble protein extract. The fiber solids were mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which was followed by centrifugation at 4000 rpm for 10 minutes. The bottom fiber layer was again manually separated from the middle insoluble protein and the top protein extract layers. This water washing and fiber separation process was repeated three times. Approximately 229 g of the final washed fiber solids was obtained. All the middle layers of insoluble protein solids and the top layers of soluble protein extract were combined together and approximately 1,341 g of protein slurry was obtained. The protein slurry was adjusted to pH 4.5 by addition of 50% phosphoric acid. This was followed by centrifugation at 4,000 rpm to separate the precipitated protein solids from the supernatant. The precipitated protein solids were mixed with water at a ratio of 1 to 2 by weight, which was followed by centrifugation at 4,000 rpm for 10 minutes to separate the washed protein solids from the washing extract.

[0197] The 229 g of the washed fiber solids was mixed with water at a ratio of 1 to 1.5 by weight and the pH of the fiber slurry was adjusted to 8.3 ± 0.1 by addition of 10% NaOH solution. The fiber slurry was heated to 60 ± 2°C and 0.5 g of Alcalase (0.5% dosage based on the weight of toasted meal) was added to the slurry and protein hydrolysis was carried out at 60 ± 2°C for 2 hours. After protein hydrolysis, the slurry was centrifuged at 4,000 rpm for 10 minutes using the lab centrifuge. Three layers defined as the top layer of soluble hydrolyzed protein extract, the middle layer of insoluble protein solids and the bottom layer of insoluble fiber solids were obtained in the centrifuge bottles. The fiber solids were manually separated from the hydrolyzed protein extract and the insoluble protein solids. The insoluble fiber solids were mixed with water at a ratio of 1 to 1 by weight. This was followed by centrifugation at 4,000 rpm for 10 minutes using the lab centrifuge. The washed fiber solids were again separated from the top layer of hydrolyzed protein extract and the middle layer of insoluble protein solids. Approximately 251 g of washed fiber solids was obtained. All the top layers of hydrolyzed protein extract and the middle layers of insoluble protein solids were combined together. Approximately 779 g of hydrolyzed protein slurry containing soluble hydrolyzed protein extract and insoluble protein solids were obtained.

[0198] The hydrolyzed protein slurry (779 g) was mixed with the washed and unhydrolyzed protein precipitates and pH of the mixture was adjusted to 7.0 before freeze drying into 31 g of dried protein concentrate. The protein concentrate was a mix a mixture of unhydrolyzed, hydrolyzed and partially hydrolyzed proteins and did not have a bitter taste.

(iii) Preparation of Protein Concentrate From Toasted Meal using 0.5% Protamex

[0199] Approximately 100 g of defatted and toasted canola meal (*B.napus*) was mixed with 800 g of water at ambient temperature. The canola meal slurry had a pH 5.72, which was in the acceptable pH range for phytate hydrolysis. The canola meal slurry was heated to 52 ± 2°C and 0.3% phytase (Natuphos. powder form, 10,000 FTU/g) based on the weight of canola meal was added to the slurry. Hydrolysis of phytates was carried out at 52 ± 2°C for 1 hour. After hydrolysis of phytates, the pH of canola meal slurry was adjusted to 7.0 ± 0.2 by slow addition of 10% NaOH solution.

[0200] After pH adjustment to 7.0 ± 0.1, the canola meal slurry was centrifuged at 4,000 rpm for 10 minutes using a lab centrifuge. Three layers defined as the top layer of liquid extract, the middle layer of insoluble protein solids and the bottom layer of insoluble fiber solids were obtained in the centrifuge bottles. The larger fiber particles with higher density settled faster than the smaller insoluble protein particles with lower density. Therefore, the larger fiber particles settled to the bottom of the bottles at first. The smaller insoluble protein particles with lower density settled on the top of the fiber solids. The liquid extract containing soluble proteins was the top supernatant layer. The bottom fiber solids were manually separated from the middle layer of insoluble protein solids and the top layer of soluble protein extract. The fiber solids were mixed with water at a ratio of 1 to 1 by weight at ambient temperature, which was followed by centrifugation at 4000 rpm for 10 minutes. The bottom fiber layer was again manually separated from the middle insoluble protein and the top protein extract layers. This water washing and fiber separation process was repeated three times. All the middle layers of insoluble protein solids and the top layers of soluble protein extract were combined together and approximately 1,763 g of protein slurry was obtained. The protein slurry was adjusted to pH 4.5 by addition of 50% phosphoric acid. This was followed by centrifugation at 4,000 rpm to separate the precipitated protein solids from the supernatant. The precipitated protein solids were mixed with water at a ratio of 1 to 2 by weight, which was followed by centrifugation at 4,000 rpm for 10 minutes to separate the washed protein solids (158 g) from the washing extract. Approximately 2,100 g of soluble sugar extract was generated.

[0201] The washed fiber solids were mixed with water at a ratio of 1 to 1.5 by weight. pH of the slurry was adjusted to 6.0 ± 0.1 by addition of 10% NaOH solution. The fiber slurry was heated to 42 ± 2°C. 0.5 g of Protamex (0.5% dosage based on the weight of toasted meal) was added to the slurry and protein hydrolysis was carried out at 42 ± 2°C for 2 hours. After protein hydrolysis, the slurry was centrifuged at 4,000 rpm for 10 minutes using the lab centrifuge. Three layers defined as the top layer of soluble hydrolyzed protein extract, the middle layer of insoluble protein solids and the bottom layer of insoluble fiber solids were obtained in the centrifuge bottles. The fiber solids were manually separated from the hydrolyzed protein extract and the insoluble protein solids. The insoluble fiber solids were mixed with water at a ratio of 1 to 1 by weight. This was followed by centrifugation at 4,000 rpm for 10 minutes using the lab centrifuge. The washed fiber solids were again separated from the top layer of hydrolyzed protein extract and the middle layer of insoluble protein solids. Approximately 201 g of washed fiber solids was obtained. All the top layers of hydrolyzed protein extract and the middle layers of insoluble protein solids were combined together. Approximately 788 g of hydrolyzed protein slurry containing soluble hydrolyzed protein extract and insoluble protein solids were obtained.

[0202] The hydrolyzed protein slurry (788 g) was mixed with the washed and unhydrolyzed protein precipitates (158 g) and pH of the mixture was adjusted pH7.0 before freeze drying into 34 g of dried protein concentrate. The protein concentrate was a mix a mixture of unhydrolyzed, hydrolyzed and partially hydrolyzed proteins and did not have a bitter taste.

[0203] As shown in Table 5, protein concentrates containing 67.1% protein (dwb) and 59.3% protein (dwb) were produced from toasted canola meal (*B.napus*) using 0.5% Alcalase and 0.1% Alcalase, respectively. Protein concentrate containing 56.5% protein was produced without the use of protease. Protein concentrate containing 57.3% protein was produced with the use of 0.5% Protamex. Protein concentrates have fiber content of 6.53 - 9.82% (dwb). Protein hydrolysis with the use of protease helps to reduce the protein content and to increase the fiber content in the fiber solids and thus helps to increase the protein recovery yield.

[0204] The yield of protein concentrates based on the starting weight of the toasted canola meal (*B.napus*) is shown in Table 6. The use of protease improves the yield of protein concentrate from 25% to 31-34% for toasted canola meal *(B.napus).* The improvement of protein concentrate yield by protein hydrolysis with the use of protease resulted from two factors: (1) solubiliztion of insoluble proteins in the fiber solids by protease and (2) help to release of insoluble protein particles through the enzymatic hydrolysis so that the fiber particles could be effectively separated from the insoluble proteins by a low G centrifugal separation force.

[0205] As shown in Figures 41 and 42, the processes of the present disclosure are, in one embodiment, performed using a concurrent process (FIG. 41), or in another embodiment, a counter-current process (FIG. 42). In the counter-current process, there is substantial savings of water and energy as well as much better production throughput because the volume of the process streams is greatly reduced. For example, with a three stage counter-current process, the volume of the process streams can be reduced by 35-50%. This greatly reduces the amount of water used in the process. The volume of process streams is also greatly reduced leading to higher production throughput, short processing time and better processing efficiency. In addition, the amount of water to be removed from the production process is also

greatly reduced resulting in energy savings.

Table 1: Results of Proximate Analysis of Toasted Canola Meal

Sample	% Moisture	% Protein (dwb)	% Ash (dwb)	% Oil (dwb)	% Crude Fiber (dwb)
Canola Seed (B Napus)	8.27	22.8	3.9	47.3	7.49
Canola Press Cake	7.92	35.9	6.09	16.6	11.5
Toasted defatted and Toasted Canola Meal	6.48	42.5	7.25	2.31	12.7
Washed Fiber Solids	5.11	40.0	5.21	3.23	22.4
Canola Protein Concentrate	3.98	70.0	8.71	0.63	5.97

Table 2: Results of Proximate Analysis of Toasted Canola Meal

Sample	% Moisture	% Protein (dwb)	% Ash (dwb)	% Oil (dwb)	% Crude Fiber (dwb)
Canola Seed (B. napus)	8.27	22.8	3.9	47.3	7,49
Canola Press Cake	7.92	35.9	6.09	16.6	11.5
Toasted defatted and Toasted Canola Meal	6.48	42.5	7.25	2.31	12.7
Dried Canola Fiber Solids	0.02	40.1	5.65	3.41	21.7
Dried Canola Protein Concentrate	0.24	66.2	2.54	1.55	8.15

Table 3: Results of Proximate Analysis on Samples From Ethanol-based Process

Sample	% Moisture	% Protein (dwb)	% Ash (dwb)	% Oil (dwb)	% Crude Fiber (dwb)	% Carbohydrate (dwb)
Toasted defatted and Toasted Canola Meal (*B.napus*)	6.48	42.5	7.25	2.31	12.7	35.24
Canola Fiber Solids	81.6	41.6	6.59	3.27	15	33.54
First Washed Canola Fiber Solids	81.3	39.8	5.64	3.76	17.9	32.9
Second Washed Canola Fiber Solids	82.3	38.2	5.06	4.02	20.2	32.52
Canola Protein Slurry - 1	95.8	46.9	9.59	0.38	1.34	41.79
Canola Protein Slurry - 2	97.9	49.7	11.2	0.47	0.97	37.66
Canola Protein Slurry - 3	98.7	52.6	12.7	1.01	0.99	32.70
Ethanol Precipitated Protein Solids	80.0	71.5	10.9	0.33	1.89	15.38
First Washed Ethanol Precipitated Protein Solids	78.9	75.3	11.2	0.25	1.94	11.31
Second Washed Ethanol Precipitated Protein Solids	68.8	76.8	11.5	0.08	0.99	10.63
Canola Protein Concentrate	68.8	76.8	11.5	0.08	0.99	10.63

dwb = dry weight basis
% Carbohydrate = 100 - (%protein + %ash + %oil + %crude fiber)

Table 4: Results of Proximate Analysis on Samples From Aqueous Process

Sample	% Moisture	% Protein (dwb)	% Ash (dwb)	% Oil (dwb)	% Crude Fiber (dwb)	% Carbohydrate (dwb)
Toasted defatted and Toasted Canola Meal (*B.napus*)	6.48	42.5	7.25	2.31	12.7	35.24
Canola Fiber Solids	79.8	40.3	6.4	3.3	17.0	33.00
Washed Canola Fiber Solids	81	38.1	5.6	3.92	19.1	33.28
Canola Protein Slurry - 1	95.2	48.9	9.6	0.23	0.8	40.47
Canola Protein Slurry - 2	96.9	48.8	10	0.16	0.2	40.84
Recovered Precipitated Proteins by Decanter	75.6	75.4	5.35	1.56	2.56	15.13
First Washed Precipitated Protein Solids Recovered by Decanter	76.9	76.9	3.84	1.94	2.88	14.44
Second Washed Precipitated Protein Solids Recovered by Decanter	75.2	77.4	3.2	1.95	3.18	14.27
Canola Protein Concentrate	1.64	74.7	5.34	1.30	0.31	18.35

dwb = dry weight basis
% Carbohydrate = 100 - (%protein + %ash + %oil + %crude fiber)

Table 5: Results of Proximate Analysis for Toasted Canola Meal (*B.napus*) and Protein Concentrate.

Sample	Moisture (%)	Protein (%, dwb [a])	Ash (%, dwb [a])	Oil (%, dwb [a])	Crude Fiber (%, dwb [a])
Toasted Canola Meal (*B.napus*)	6.48	42.5	7.25	2.31	12.70
Protein Concentrate at 0% Protease	5.29	56.5	7.1	1.46	7.1
Protein Concentrate at 0.1% Alcalase	2.25	59.3	4.42	2.87	8.92
Protein Concentrate at 0.5% Alcalase	4.44	67.1	6.38	0.61	6.50
Protein Concentrate at 0.5% Protamex	3.43	57.3	5.71	1,59	9.82
Fiber Solids at 0% Protease	6.23	36.5	4.83	4.16	25.3
Fiber Solids at 0.1% Alcalase	3.82	28.2	3.93	5.88	33.6
Fiber Solids at 0.5% Alcalase	5.97	25.6	5.23	5.72	34.7
Fiber Solids at 0.5% Protamex	3.81	29.7	4.17	6.06	28.5
[a] dwb = dry weight basis					

Table 9. Yield of Protein Concentrates With and Without the Use of Protease.

Lab Trials	Yield of Protein Concentrate from Toasted Canola Meal (*B.napus*) (%, w/w)
Protein Concentrate at 0% Protease	25
Protein Concentrate at 0.1% Alcalase	33
Protein Concentrate at 0.5% Alcalase	31

(continued)

Lab Trials	Yield of Protein Concentrate from Toasted Canola Meal (*B.napus*) (%, w/w)
Protein Concentrate at 0.5% Protamex	34

Claims

1. A process for the production of a protein concentrate from a toasted oilseed meal comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to solubilize proteins in the mixture;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) a protein fraction comprising

(i) an insoluble protein fraction, and
(ii) a soluble protein fraction;

v) separating the fiber fraction from the protein fraction and mixing the fiber fraction with a second blending solvent to form a fiber mixture;
vi) treating the fiber mixture with a protease at a temperature and a pH suitable for protease activity;
vii) subjecting the fiber mixture to a g-force sufficient to separate the fiber mixture to form:

a) a second fiber fraction, and
b) a hydrolyzed protein fraction, comprising

(i) an insoluble protein fraction comprising partially hydrolyzed and un-hydrolyzed protein, and
(ii) a soluble hydrolyzed protein fraction;

viii) optionally adjusting the pH of the protein fraction from step iv(b) to a pH suitable to precipitate proteins;
ix) separating the precipitated proteins from the protein fraction;
x) optionally combining the precipitated proteins and the hydrolyzed protein fraction to form the protein concentrate.

2. The process according to claim 1, wherein the first and second blending solvents comprise water.

3. The process according to claim 1 or 2, wherein the temperature suitable for phytase activity is between 20° and 60°C and the pH suitable for phytase activity is between 2.0 and 7.0.

4. The process according to any one of claims 1 to 3, wherein the mixture and/or the fiber mixture is subjected to a g-force of between 100g and 500g.

5. The process according to any one of claims 1 to 4, wherein separating the mixture and/or the fiber mixture comprises using a centrifuge or a hydrocyclone.

6. The process according to any one of claims 1 to 5, wherein the pH suitable to precipitate the proteins in the protein fraction is between 4.0 and 6.0.

7. The process according to any one of claims 1 to 6, further comprising the step of drying the protein concentrate to a moisture of between 4% and 8% (w/w).

8. The process according to any one of claims 1 to 7, wherein the protein concentrate also comprises peptides and free amino acids.

9. The process according to any one of claims 1 to 8, wherein the toasted oilseed meal comprises canola meal.

10. A process for the production of a protein isolate from a toasted oilseed meal comprising:

i) mixing the toasted oilseed meal with a first blending solvent to form a mixture;
ii) optionally treating the mixture with phytase at a temperature and a pH suitable for phytase activity;
iii) optionally adjusting the pH of the mixture to solubilize proteins in the mixture;
iv) subjecting the mixture to a g-force sufficient to separate the mixture to form

a) a fiber fraction, and
b) a protein fraction comprising

(i) an insoluble protein fraction, and
(ii) a soluble protein fraction;

v) separating the insoluble protein fraction from the soluble protein fraction to recover therefrom an insoluble protein concentrate and a soluble protein extract; and
vi) subjecting the soluble protein extract to membrane filtration to recover therefrom the protein isolate.

11. The process according to claim 10, wherein the first blending solvent comprises water, a saline solution or a polysaccharide solution.

12. The process according to claim 11, wherein the first blending solvent comprises water.

13. The process according to any one of claims 10 to 12, wherein the temperature suitable for phytase activity is between 20° and 60°C and the pH suitable for phytase activity is between 2.0 and 7.0.

14. The process according to any one of claims 10 to 13, wherein the mixture is subjected to a g-force of between 100g and 500g.

15. The process according to any one of claims 10 to 14, wherein the toasted oilseed meal comprises canola meal.

Patentansprüche

1. Ein Verfahren zur Herstellung eines Proteinkonzentrats aus einem gerösteten Ölsaatmehl, welches das:

I) Mischen des gerösteten Ölsaatmehls mit einem ersten Blending-Lösungsmittel, um ein Gemisch zu bilden,
II) wahlweise Behandeln des Gemischs mit Phytase bei einer Temperatur und einem pH-Wert, die für die Phytaseaktivität geeignet sind,
III) wahlweise Einstellen des pH-Werts des Gemischs, um die Proteine des Gemischs zu solubilisieren,
IV) Aussetzen des Gemischs einer Zentrifugalbeschleunigung, die ausreicht, das Gemisch aufzutrennen, um:

a) eine Faserfraktion und
b) eine Proteinfraktion, die:

I) eine unlösliche Proteinfraktion und
II) eine lösliche Proteinfraktion umfasst,

zu bilden,
V) Trennen der Faserfraktion von der Proteinfraktion und Mischen der Faserfraktion mit einem zweiten Blending-Lösungsmittel, um ein Fasergemisch zu bilden,
VI) Behandeln des Fasergemischs mit einer Protease bei einer Temperatur und einem pH-Wert, die für die Proteaseaktivität geeignet sind,
VII) Aussetzen des Fasergemischs einer Zentrifugalbeschleunigung, die ausreicht, das Fasergemisch aufzutrennen, um:

a) eine zweite Faserfraktion und
b) eine hydrolysierte Proteinfraktion, die:

I) eine teilweise hydrolysiertes und unhydrolysiertes Protein umfassende unlösliche Proteinfraktion und
II) eine lösliche hydrolysierte
Proteinfraktion
umfasst,

zu bilden,

VIII) wahlweise Einstellen des pH-Werts der Proteinfraktion aus Stufe IV b) auf einen für das Ausfällen der Proteine geeigneten pH-Wert,
IX) Trennen der ausgefällten Proteine von der Proteinfraktion und
X) wahlweise Vereinigen der ausgefällten Proteine mit der hydrolysierten Proteinfraktion, um das Proteinkonzentrat zu bilden,

umfasst.

2. Das Verfahren nach Anspruch 1, wobei das erste und das zweite Blending-Lösungsmittel Wasser umfasst.

3. Das Verfahren nach Anspruch 1 oder 2, wobei die für die Phytaseaktivität geeignete Temperatur zwischen 20 °C und 60 °C und der für die Phytaseaktivität geeignete pH-Wert zwischen 2,0 und 7,0 beträgt.

4. Das Verfahren nach einem der Ansprüche 1 bis 3, wobei das Gemisch und/oder das Fasergemisch einer Zentrifugalbeschleunigung von zwischen 100 g und 500 g ausgesetzt wird.

5. Das Verfahren nach einem der Ansprüche 1 bis 4, wobei das Auftrennen des Gemischs und/oder des Fasergemischs die Verwendung einer Zentrifuge oder eines Hydrozyklons umfasst.

6. Verfahren nach einem der Ansprüche 1 bis 5, wobei der für das Ausfällen der Proteine der Proteinfraktion geeignete pH-Wert zwischen 4,0 und 6,0 beträgt.

7. Das Verfahren nach einem der Ansprüche 1 bis 6, das weiterhin die Stufe des Trocknens des Proteinkonzentrats auf einen Feuchtigkeitsgehalt von zwischen 4 % und 8 % (Gew./Gew.) umfasst.

8. Das Verfahren nach einem der Ansprüche 1 bis 7, wobei das Proteinkonzentrat auch Peptide und freie Aminosäuren umfasst.

9. Das Verfahren nach einem der Ansprüche 1 bis 8, wobei das geröstete Ölsaatmehl Canolamehl umfasst.

10. Ein Verfahren zur Herstellung eines Proteinisolats aus einem gerösteten Ölsaatmehl, welches das:

I) Mischen des gerösteten Ölsaatmehls mit einem ersten Blending-Lösungsmittel, um ein Gemisch zu bilden,
II) wahlweise Behandeln des Gemischs mit Phytase bei einer Temperatur und einem pH-Wert, die für die Phytaseaktivität geeignet sind,
III) wahlweise Einstellen des pH-Werts des Gemischs, um die Proteine des Gemischs zu solubilisieren,
IV) Aussetzen des Gemischs einer Zentrifugalbeschleunigung, die ausreicht, das Gemisch aufzutrennen, um:

a) eine Faserfraktion und
b) eine Proteinfraktion, die:

I) eine unlösliche Proteinfraktion und
II) eine lösliche Proteinfraktion umfasst,

zu bilden,

V) Trennen der unlöslichen Proteinfraktion von der löslichen Proteinfraktion, um daraus ein unlösliches Proteinkonzentrat und einen löslichen Proteinextrakt zu gewinnen, und

VI) Unterwerfen des löslichen Proteinextrakts einer Membranfiltration, um daraus das Proteinisolat zu gewinnen,

umfasst.

11. Das Verfahren nach Anspruch 10, wobei das erste Blending-Lösungsmittel Wasser, eine Salzlösung oder eine Polysaccharidlösung umfasst.

12. Das Verfahren nach Anspruch 11, wobei das erste Blending-Lösungsmittel Wasser umfasst.

13. Das Verfahren nach einem der Ansprüche 10 bis 12, wobei die für die Phytaseaktivität geeignete Temperatur zwischen 20 °C und 60 °C und der für die Phytaseaktivität geeignete pH-Wert zwischen 2,0 und 7,0 beträgt.

14. Das Verfahren nach einem der Ansprüche 10 bis 13, wobei das Gemisch einer Zentrifugalbeschleunigung von zwischen 100 g und 500 g ausgesetzt wird.

15. Das Verfahren nach einem der Ansprüche 10 bis 14, wobei das geröstete Ölsaatmehl Canolamehl umfasst.

Revendications

1. Procédé de production d'un concentré de protéine à partir d'une farine d'oléagineux grillée, comprenant :

i) mélange de la farine d'oléagineux grillée à un premier solvant pour obtenir un mélange ;
ii) le cas échéant, traitement du mélange par une phytase à une température et un pH appropriés pour l'activité de la phytase ;
iii) le cas échéant, ajustement du pH du mélange pour solubiliser les protéines dans le mélange ;
iv) soumission du mélange à une force g suffisante pour séparer le mélange pour former

a) une fraction de fibres, et
b) une fraction de protéines comprenant

(i) une fraction de protéines insolubles, et
(ii) une fraction de protéines solubles ;

v) séparation de la fraction de fibres depuis la fraction de protéines et mélange de la fraction de fibres à un deuxième solvant et former un mélange de fibres ;
vi) traitement du mélange de fibres par une protéase à une température et un pH appropriés pour l'activité de la protéase ;
vii) soumission du mélange de fibres à une force g suffisante pour séparer le mélange de fibres et former

a) une deuxième fraction de fibres, et
b) une fraction de protéines hydrolysées, comprenant

(i) une fraction de protéines insolubles comprenant des protéines partiellement hydrolysées et non hydrolysées, et
(ii) une fraction de protéines hydrolysées solubles ;

viii) le cas échéant, ajustement du pH de la fraction de protéines de l'étape iv(b) à un pH approprié pour précipiter les protéines ;
ix) séparation des protéines précipitées de la fraction des protéines ;
x) le cas échéant, combinaison des protéines précipitées et de la fraction de protéines hydrolysées pour former le concentré de protéines.

2. Procédé selon la revendication 1, où les premier et deuxième solvants comprennent de l'eau.

3. Procédé selon la revendication 1 ou 2, où la température appropriée pour l'activité de la phytase se situe dans l'intervalle allant de 20 à 60°C et le pH approprié pour l'activité de la phytase se situe dans l'intervalle allant de 2,0 à 7,0.

4. Procédé selon l'une quelconque des revendications 1 à 3, où le mélange et/ou le mélange de fibres est soumis à une force g allant de 100g à 500g.

5. Procédé selon l'une quelconque des revendications 1 à 4, où la séparation du mélange et/ou du mélange de fibres comprend l'utilisation d'une centrifugeuse ou d'un hydrocyclone.

6. Procédé selon l'une quelconque des revendications 1 à 5, où le pH approprié pour la précipitation de la fraction de protéines se situe dans l'intervalle allant de 4,0 à 6,0.

7. Procédé selon l'une quelconque des revendications 1 à 6, comprenant en outre, l'étape de séchage du concentré de protéine jusqu'à un taux d'humidité situé dans l'intervalle allant de 4% à 8% (p/p).

8. Procédé selon l'une quelconque des revendications 1 à 7, où le concentré de protéine comprend également, des peptides et des acides aminés libres.

9. Procédé selon l'une quelconque des revendications 1 à 8, où la farine d'oléagineux grillée comprend la farine de canola.

10. Procédé de production d'un isolat de protéine à partir d'une farine d'oléagineux grillée, comprenant :

i) mélange de la farine d'oléagineux grillée à un premier solvant pour obtenir un mélange ;
ii) le cas échéant, traitement du mélange par une phytase à une température et un pH appropriés pour l'activité de la phytase ;
iii) le cas échéant, ajustement du pH du mélange pour solubiliser les protéines dans le mélange ;
iv) soumission du mélange à une force g suffisante pour séparer le mélange pour former

c) une fraction de fibres, et
d) une fraction de protéines comprenant

(iii) une fraction de protéines insolubles, et
(iv) une fraction de protéines solubles ;

v) séparation de la fraction de de protéines insolubles et de la fraction de protéines solubles pour récupérer un concentré de protéines insolubles et un extrait de protéines solubles, et
vii) soumission de l'extrait de protéines solubles à une filtration sur membrane pour en récupérer l'isolat de protéine.

11. Procédé selon la revendication 10, où le premier solvant comprend de l'eau, une solution saline ou une solution de polysaccharide.

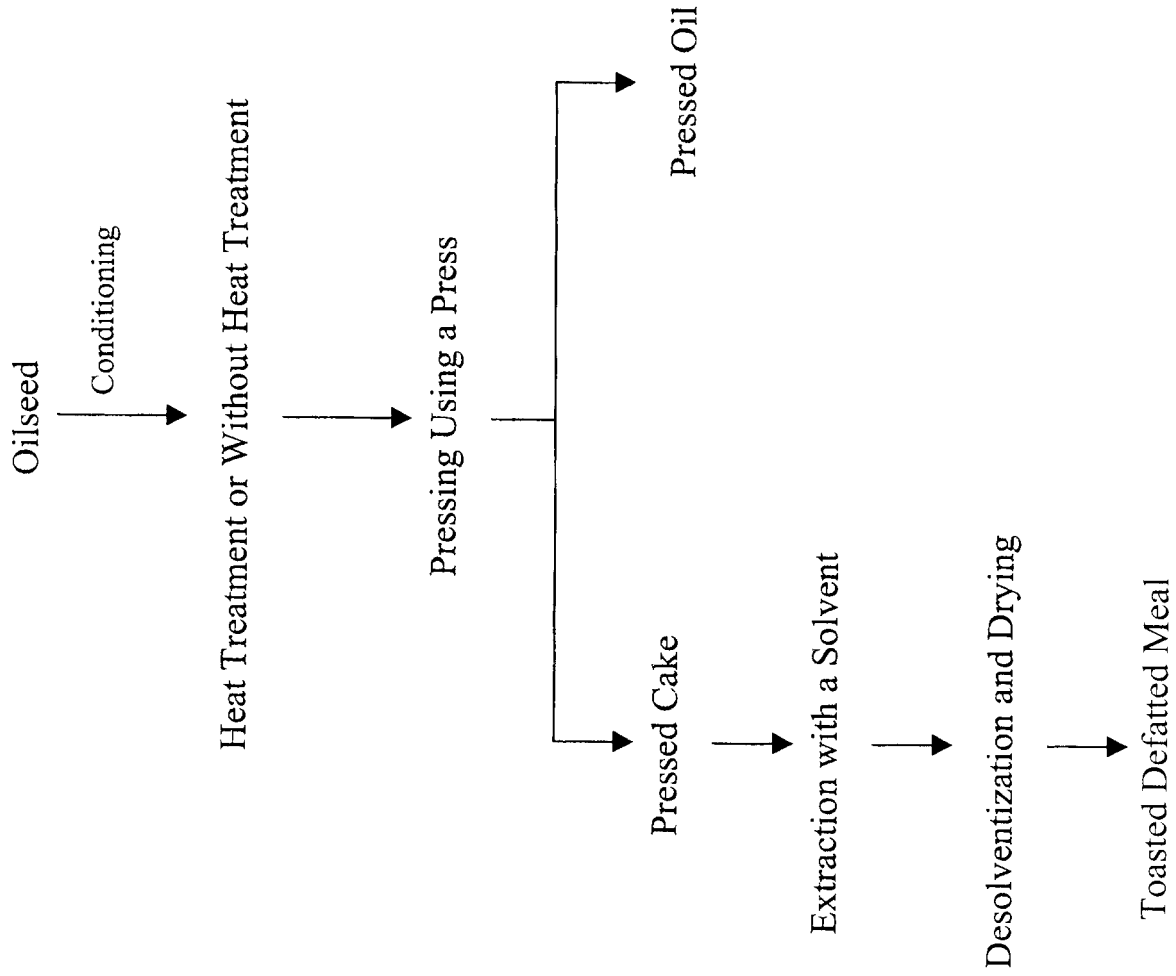
12. Procédé selon la revendication 11, où le premier solvant comprend de l'eau.

13. Procédé selon l'une quelconque des revendications 10 à 12, où la température appropriée pour l'activité de la phytase se situe dans l'intervalle allant de 20 à 60°C et le pH approprié pour l'activité de la phytase se situe dans l'intervalle allant de 2,0 à 7,0.

14. Procédé selon l'une quelconque des revendications 10 à 13, où le mélange et/ou le mélange de fibres est soumis à une force g allant de 100g à 500g.

15. Procédé selon l'une quelconque des revendications 10 à 14, où la farine d'oléagineux grillée comprend la farine de canola.

FIGURE 1


Oilseed
Conditioning
Heat Treatment or Without Heat Treatment
Pressing Using a Press
Pressed Oil
Pressed Cake
Extraction with a Solvent
Desolventization and Drying
Toasted Defatted Meal

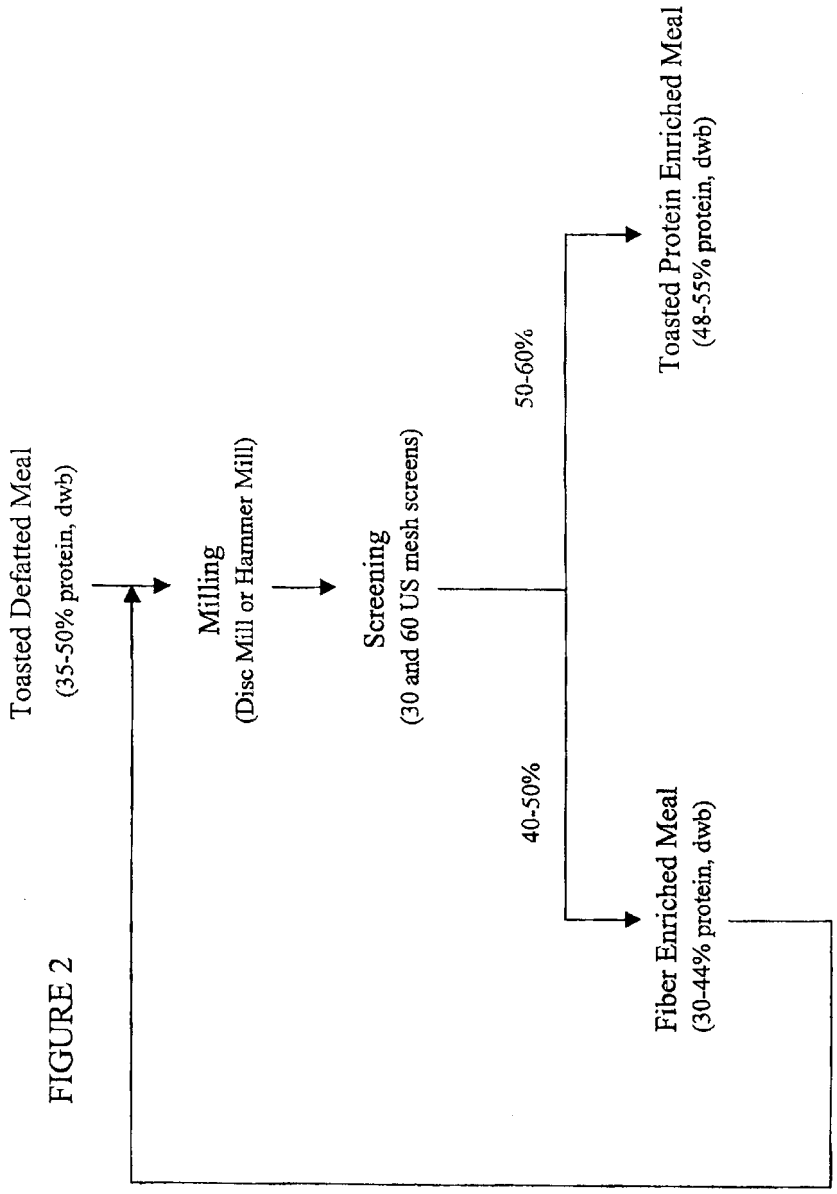

Toasted Defatted Meal
(35-50% protein, dwb)
Milling
(Disc Mill or Hammer Mill)
Screening
(30 and 60 US mesh screens)
50-60%
Toasted Protein Enriched Meal
(48-55% protein, dwb)
40-50%
Fiber Enriched Meal
(30-44% protein, dwb)

FIGURE 2

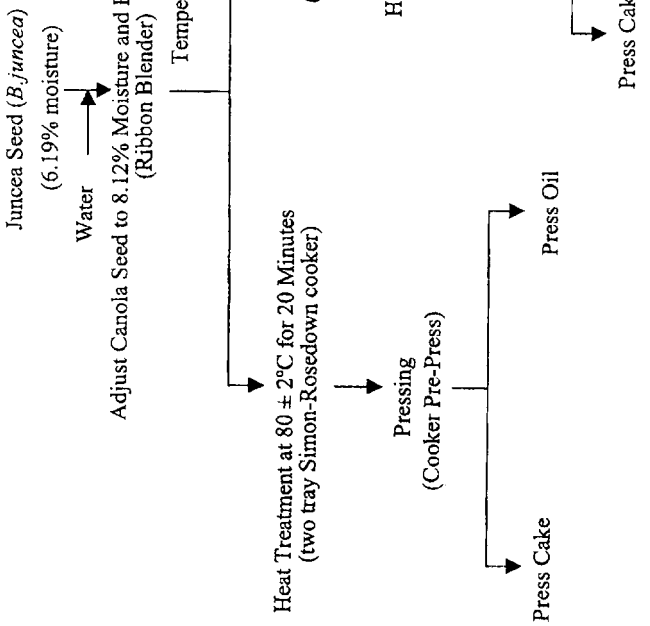

Juncea Seed (*B juncea*)
(6.19% moisture)
Water
Adjust Canola Seed to 8.12% Moisture and Blend for 5 Minutes
(Ribbon Blender)
Temper for 24 – 48 hours
Heat Treatment at 80 ± 2°C for 20 Minutes
(two tray Simon-Rosedown cooker)
Pressing
(Cooker Pre-Press)
Press Oil
Press Cake
Flaking
(Flaking Mill, 0.3 ± 0.1 mm Flake Thickness)
Heat Treatment at 80 ± 2°C for 20 Minutes
(two tray Simon-Rosedown cooker)
Pressing
(Cooker Pre-Press)
Press Oil
Press Cake
Extraction with a Solvent Mixture of Butane and R134a
Desolventization and Drying
Toasted Defatted Juncea Meal
(47.02% protein, dwb)

FIGURE 3

FIGURE 4

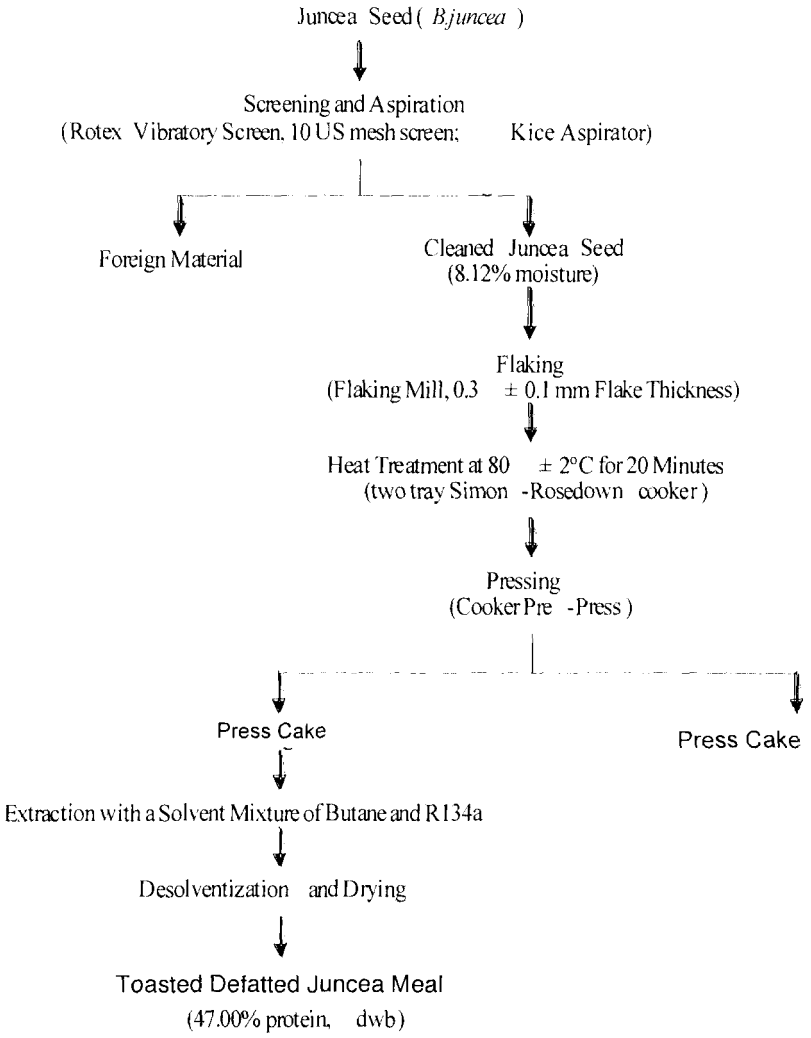
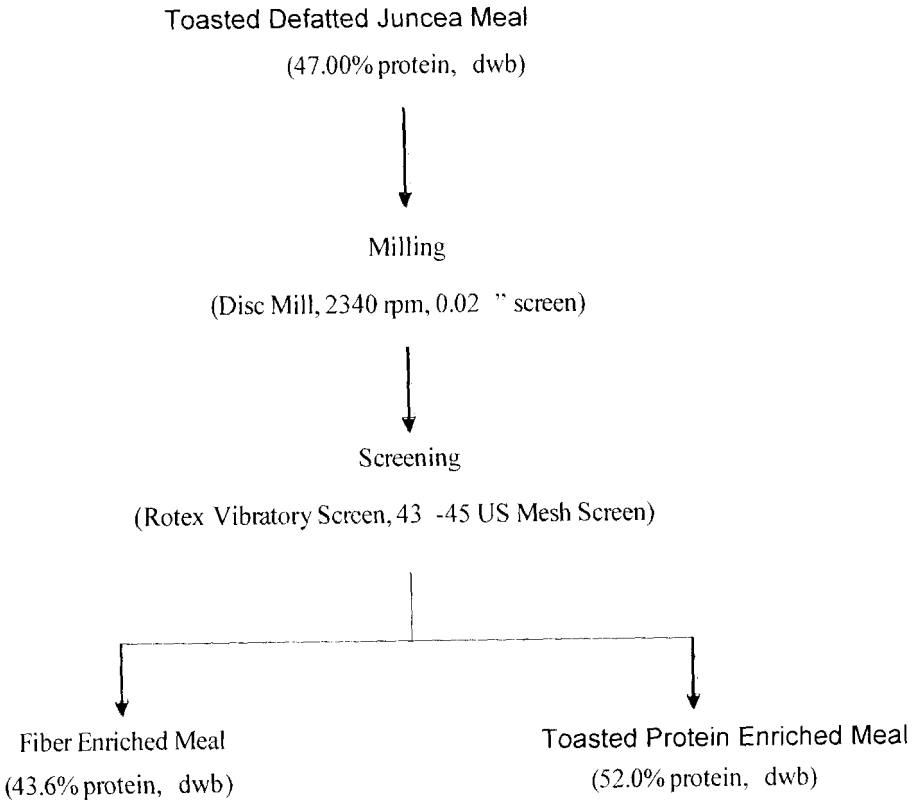

Juncea Seed (Bjuncea)
Screening and Aspiration
(Rotex Vibratory Screen, 10 US mesh screen; Kice Aspirator)
Foreign Material
Cleaned Juncea Seed
(8.12% moisture)
Flaking
(Flaking Mill, 0.3 ± 0.1 mm Flake Thickness)
Heat Treatment at 80 ± 2°C for 20 Minutes
(two tray Simon -Rosedown cooker)
Pressing
(Cooker Pre -Press)
Press Cake
Press Cake
Extraction with a Solvent Mixture of Butane and R134a
Desolventization and Drying
Toasted Defatted Juncea Meal
(47.00% protein, dwb)

FIGURE 5


Toasted Defatted Juncea Meal
(47.00% protein, dwb)
Milling
(Disc Mill, 2340 rpm, 0.02 " screen)
Screening
(Rotex Vibratory Screen, 43 -45 US Mesh Screen)
Fiber Enriched Meal
(43.6% protein, dwb)
Toasted Protein Enriched Meal
(52.0% protein, dwb)

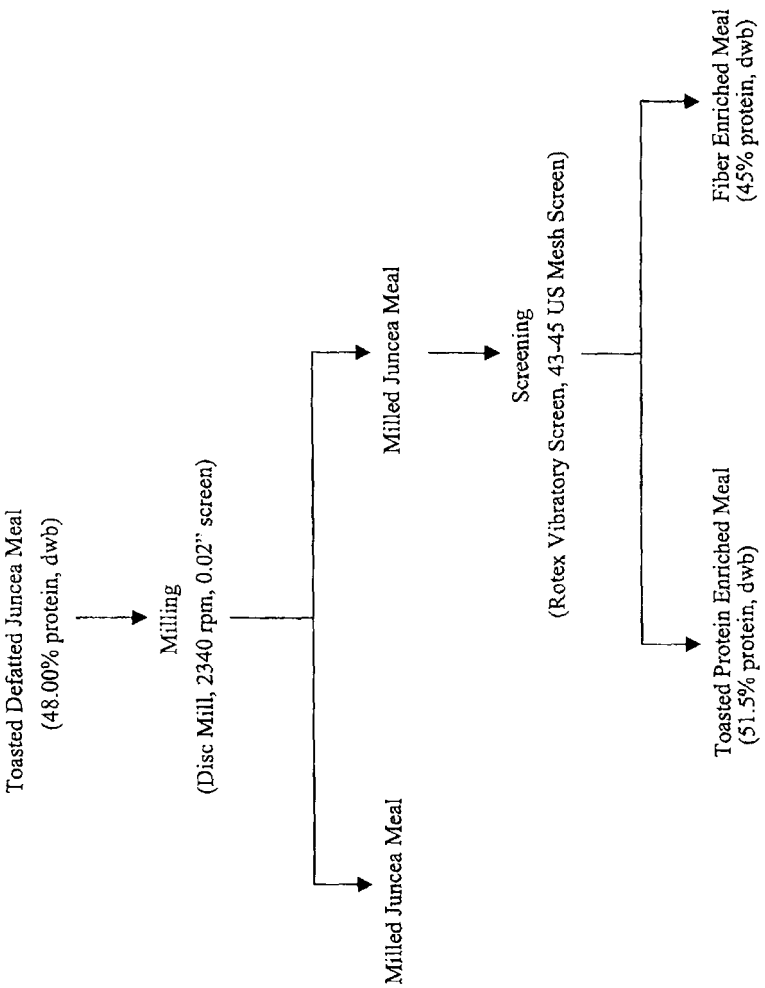

Toasted Defatted Juncea Meal
(48.00% protein, dwb)
Milling
(Disc Mill, 2340 rpm, 0.02" screen)
Milled Juncea Meal
Milled Juncea Meal
Screening
(Rotex Vibratory Screen, 43-45 US Mesh Screen)
Fiber Enriched Meal
(45% protein, dwb)
Toasted Protein Enriched Meal
(51.5% protein, dwb)

FIGURE 6

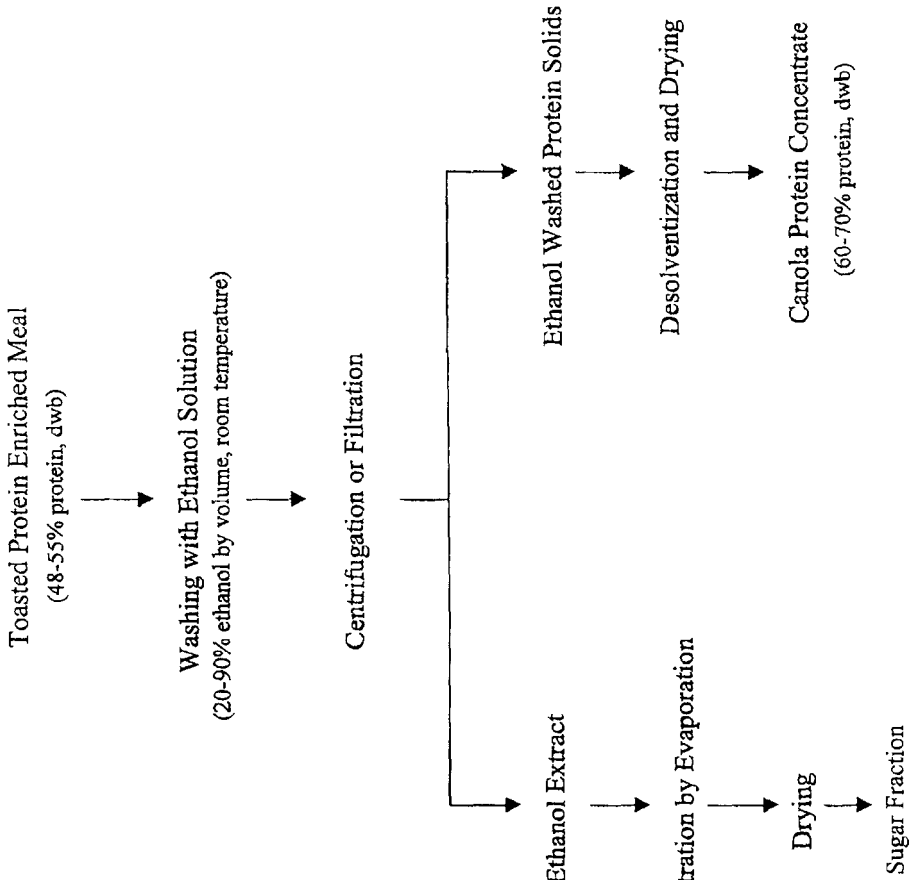

Toasted Protein Enriched Meal
(48-55% protein, dwb)
Washing with Ethanol Solution
(20-90% ethanol by volume, room temperature)
Centrifugation or Filtration
Ethanol Extract
Concentration by Evaporation
Drying
Sugar Fraction
Ethanol Washed Protein Solids
Desolventization and Drying
Canola Protein Concentrate
(60-70% protein, dwb)

FIGURE 7

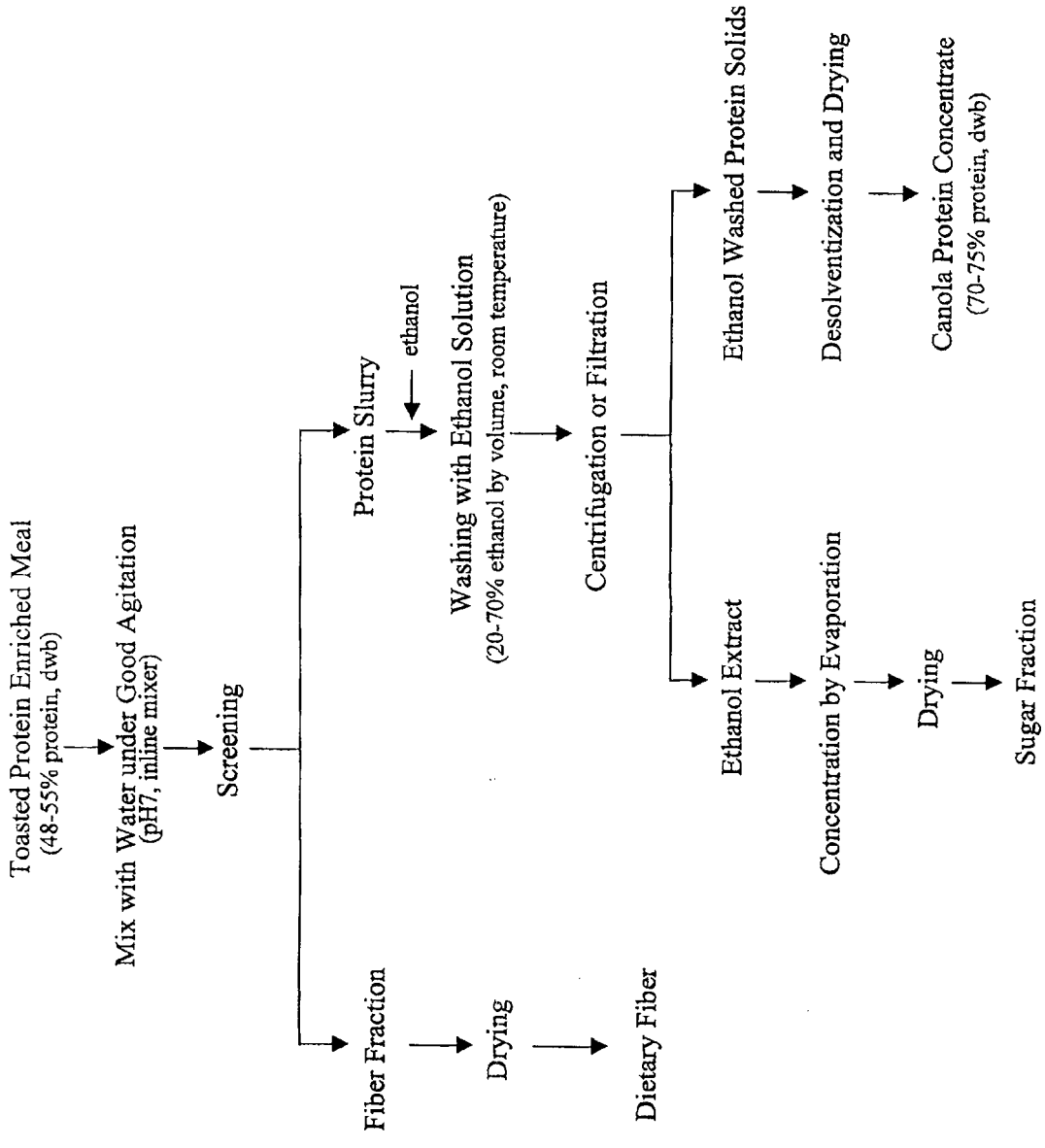

Toasted Protein Enriched Meal
(48-55% protein, dwb)
Mix with Water under Good Agitation
(pH7, inline mixer)
Screening
Protein Slurry
ethanol
Washing with Ethanol Solution
(20-70% ethanol by volume, room temperature)
Centrifugation or Filtration
Ethanol Washed Protein Solids
Desolventization and Drying
Canola Protein Concentrate
(70-75% protein, dwb)
Ethanol Extract
Concentration by Evaporation
Drying
Sugar Fraction
Fiber Fraction
Drying
Dietary Fiber

FIGURE 8

FIGURE 9

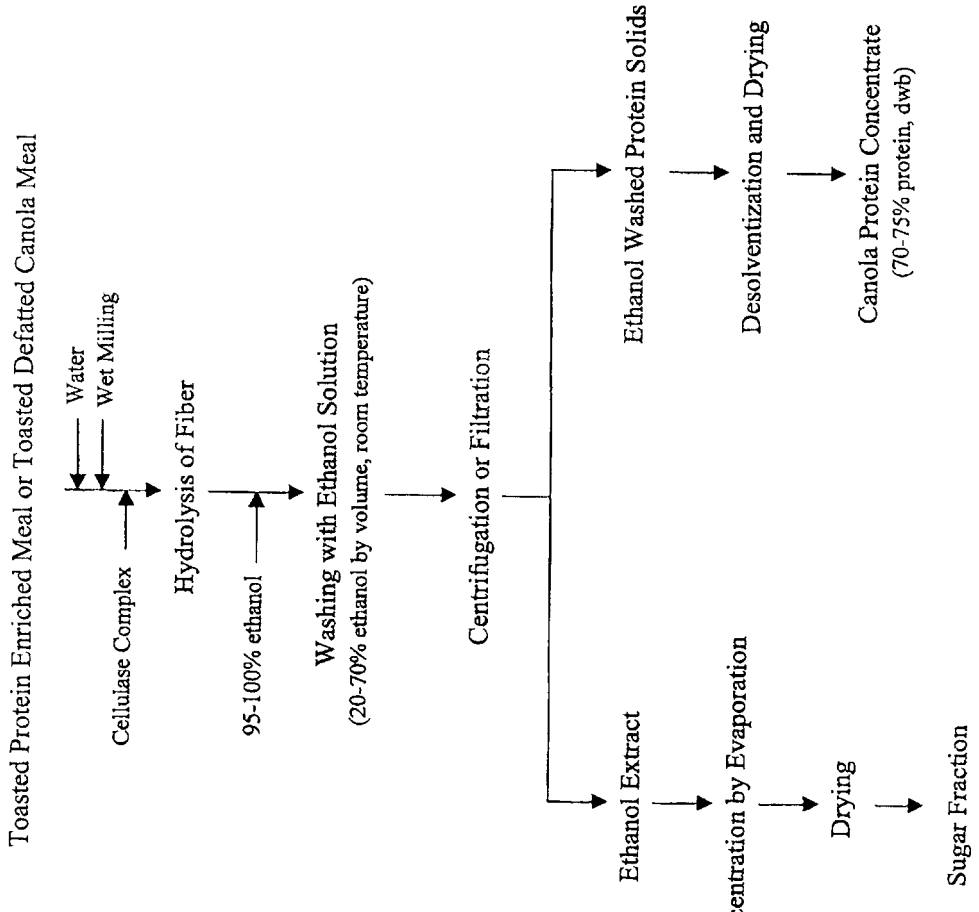

Toasted Protein Enriched Meal or Toasted Defatted Canola Meal
Water
Wet Milling
Cellulase Complex
Hydrolysis of Fiber
95-100% ethanol
Washing with Ethanol Solution
(20-70% ethanol by volume, room temperature)
Centrifugation or Filtration
Ethanol Extract
Concentration by Evaporation
Drying
Sugar Fraction
Ethanol Washed Protein Solids
Desolventization and Drying
Canola Protein Concentrate
(70-75% protein, dwb)

FIGURE 10

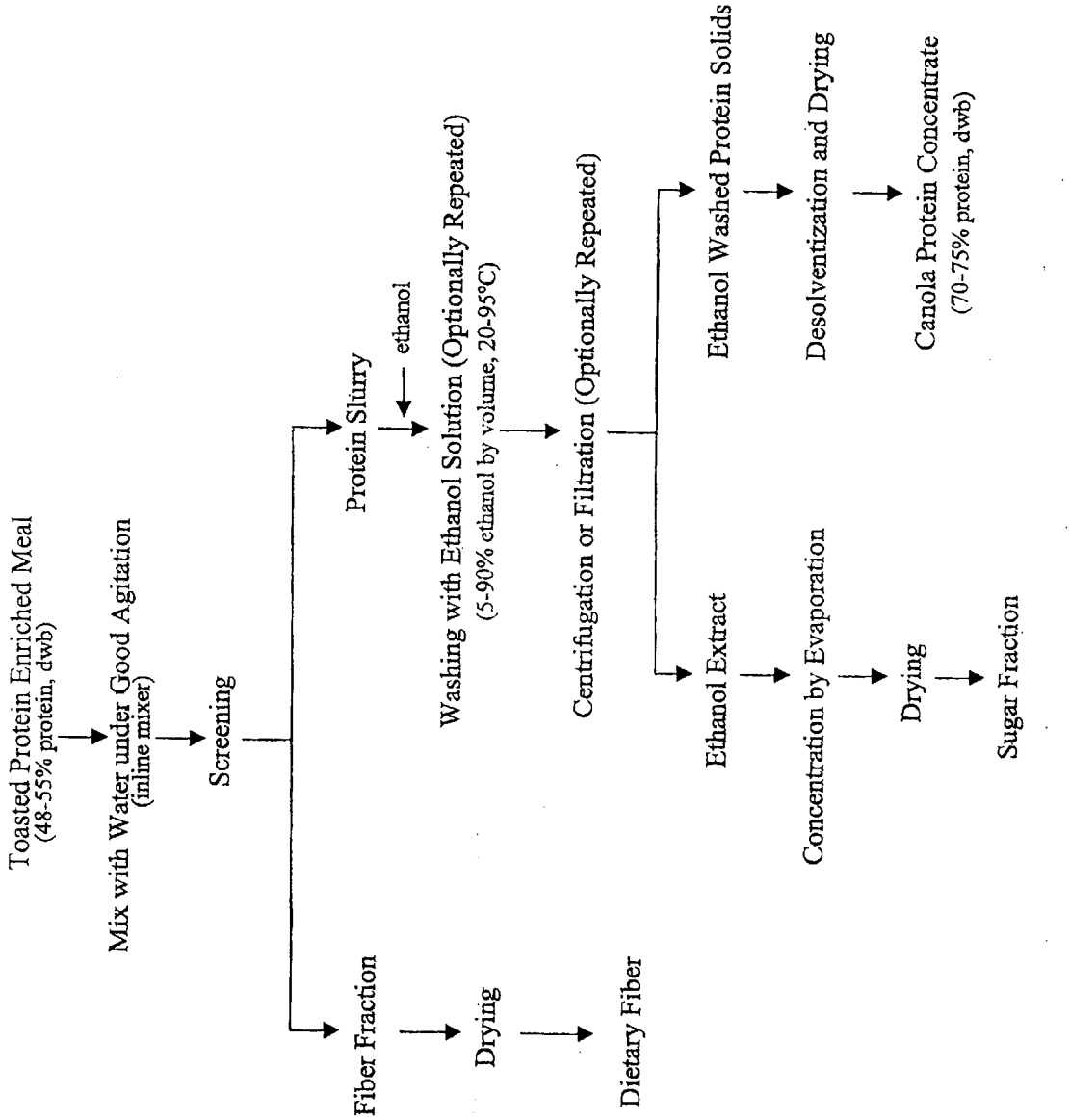

Toasted Protein Enriched Meal
(48-55% protein, dwb)
Mix with Water under Good Agitation
(inline mixer)
Screening
Protein Slurry
ethanol
Washing with Ethanol Solution (Optionally Repeated)
(5-90% ethanol by volume, 20-95°C)
Centrifugation or Filtration (Optionally Repeated)
Fiber Fraction
Drying
Dietary Fiber
Ethanol Extract
Concentration by Evaporation
Drying
Sugar Fraction
Ethanol Washed Protein Solids
Desolventization and Drying
Canola Protein Concentrate
(70-75% protein, dwb)

FIGURE 11

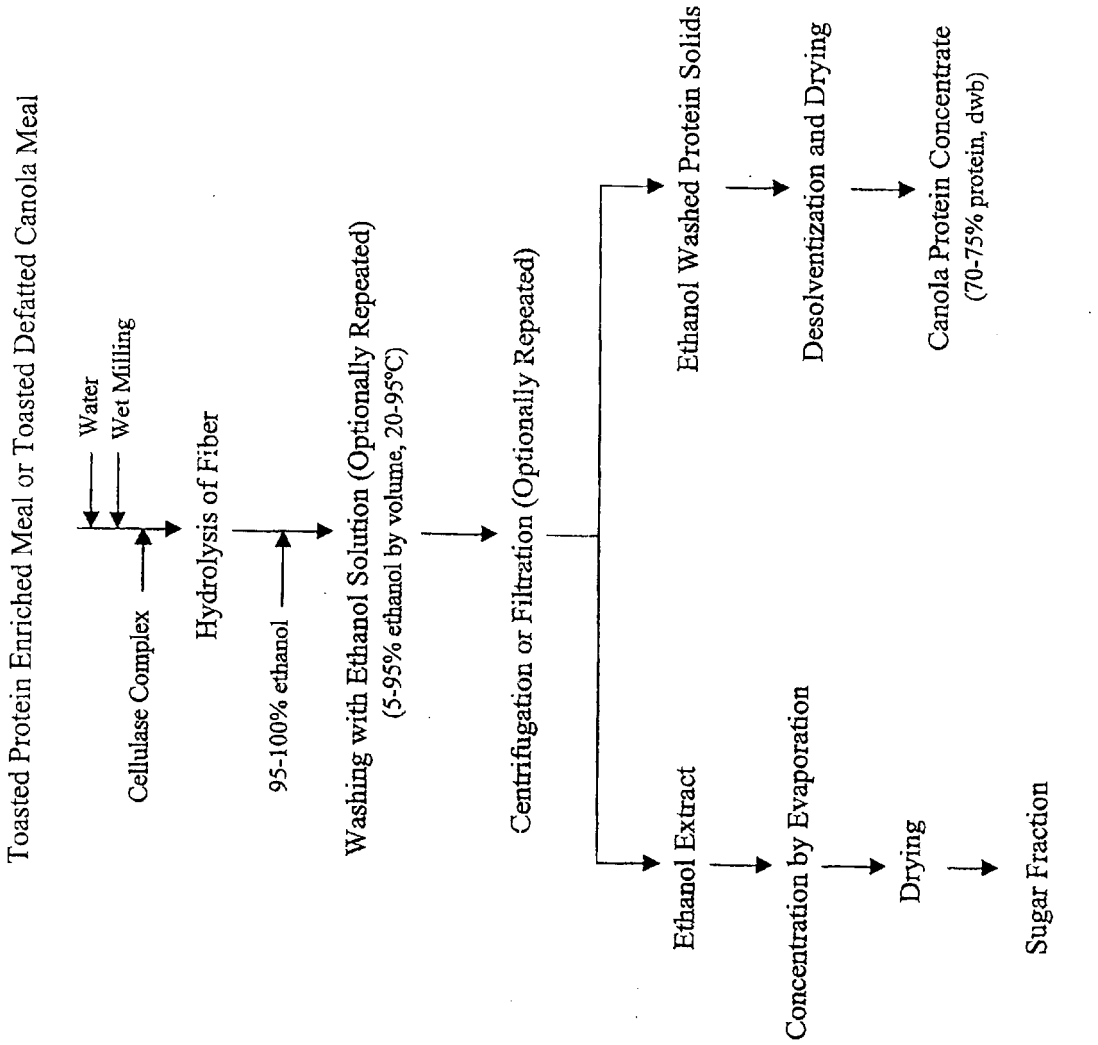

Toasted Protein Enriched Meal or Toasted Defatted Canola Meal
Water
Wet Milling
Cellulase Complex
Hydrolysis of Fiber
95-100% ethanol
Washing with Ethanol Solution (Optionally Repeated)
(5-95% ethanol by volume, 20-95°C)
Centrifugation or Filtration (Optionally Repeated)
Ethanol Extract
Concentration by Evaporation
Drying
Sugar Fraction
Ethanol Washed Protein Solids
Desolventization and Drying
Canola Protein Concentrate
(70-75% protein, dwb)

FIGURE 12

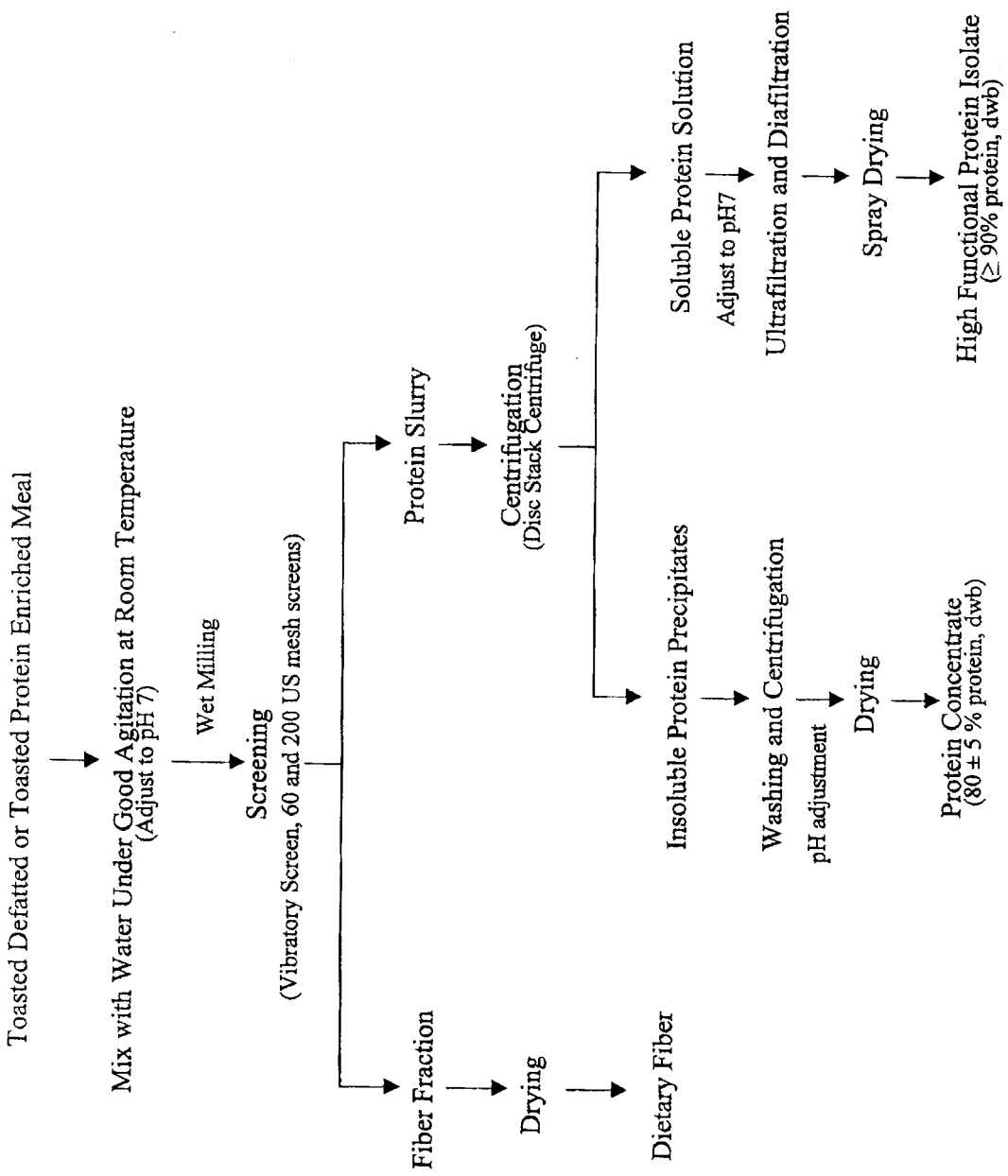

Toasted Defatted or Toasted Protein Enriched Meal
Mix with Water Under Good Agitation at Room Temperature
(Adjust to pH 7)
Wet Milling
Screening
(Vibratory Screen, 60 and 200 US mesh screens)
Fiber Fraction
Drying
Dietary Fiber
Protein Slurry
Centrifugation
(Disc Stack Centrifuge)
Insoluble Protein Precipitates
Washing and Centrifugation
pH adjustment
Drying
Protein Concentrate
(80 ± 5 % protein, dwb)
Soluble Protein Solution
Adjust to pH7
Ultrafiltration and Diafiltration
Spray Drying
High Functional Protein Isolate
(≥ 90% protein, dwb)

FIGURE 13

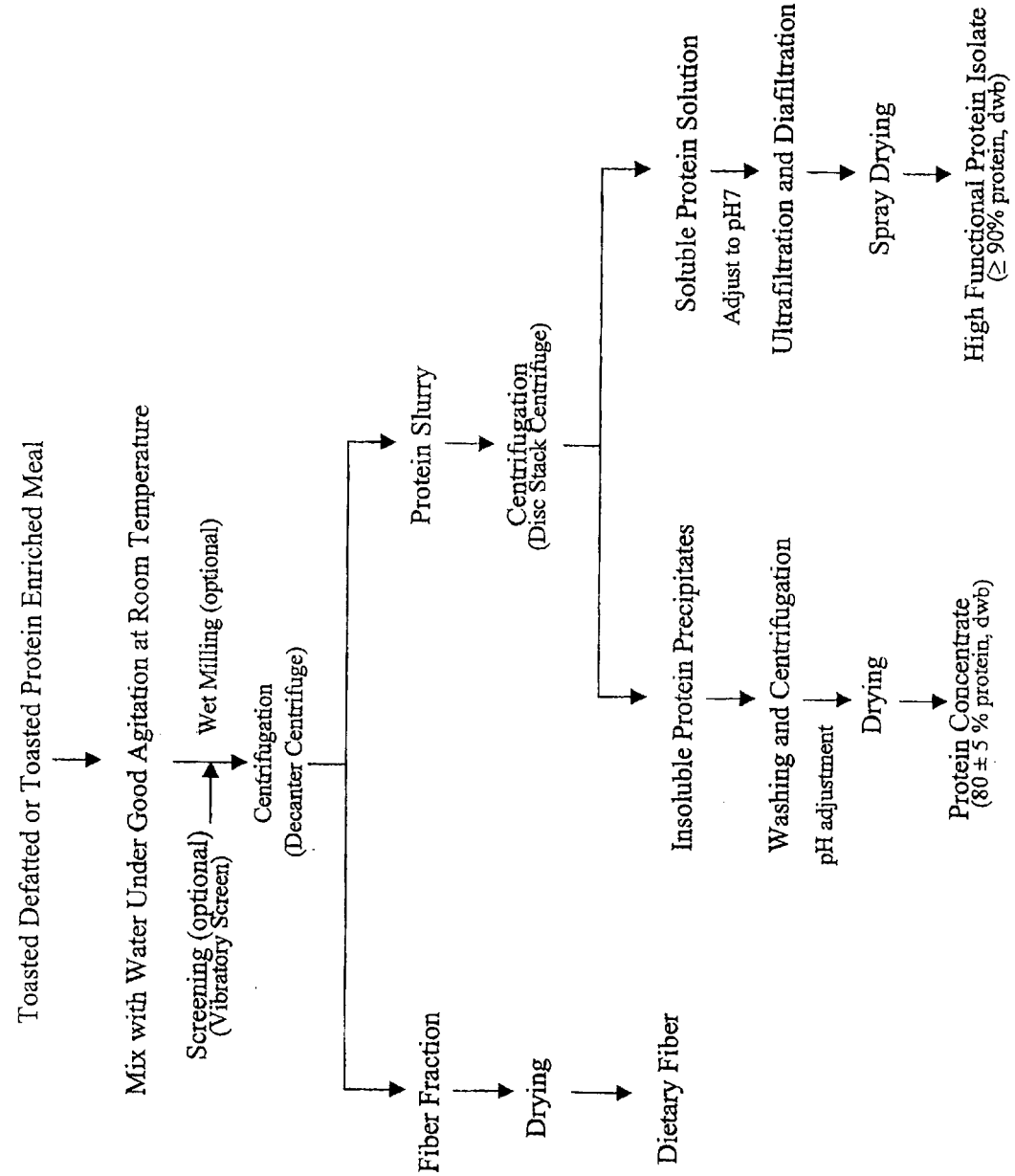

Toasted Defatted or Toasted Protein Enriched Meal
Mix with Water Under Good Agitation at Room Temperature
Screening (optional)
(Vibratory Screen)
Wet Milling (optional)
Centrifugation
(Decanter Centrifuge)
Protein Slurry
Fiber Fraction
Drying
Dietary Fiber
Centrifugation
(Disc Stack Centrifuge)
Soluble Protein Solution
Adjust to pH7
Ultrafiltration and Diafiltration
Spray Drying
High Functional Protein Isolate
(≥ 90% protein, dwb)
Insoluble Protein Precipitates
Washing and Centrifugation
pH adjustment
Drying
Protein Concentrate
(80 ± 5 % protein, dwb)

FIGURE 14

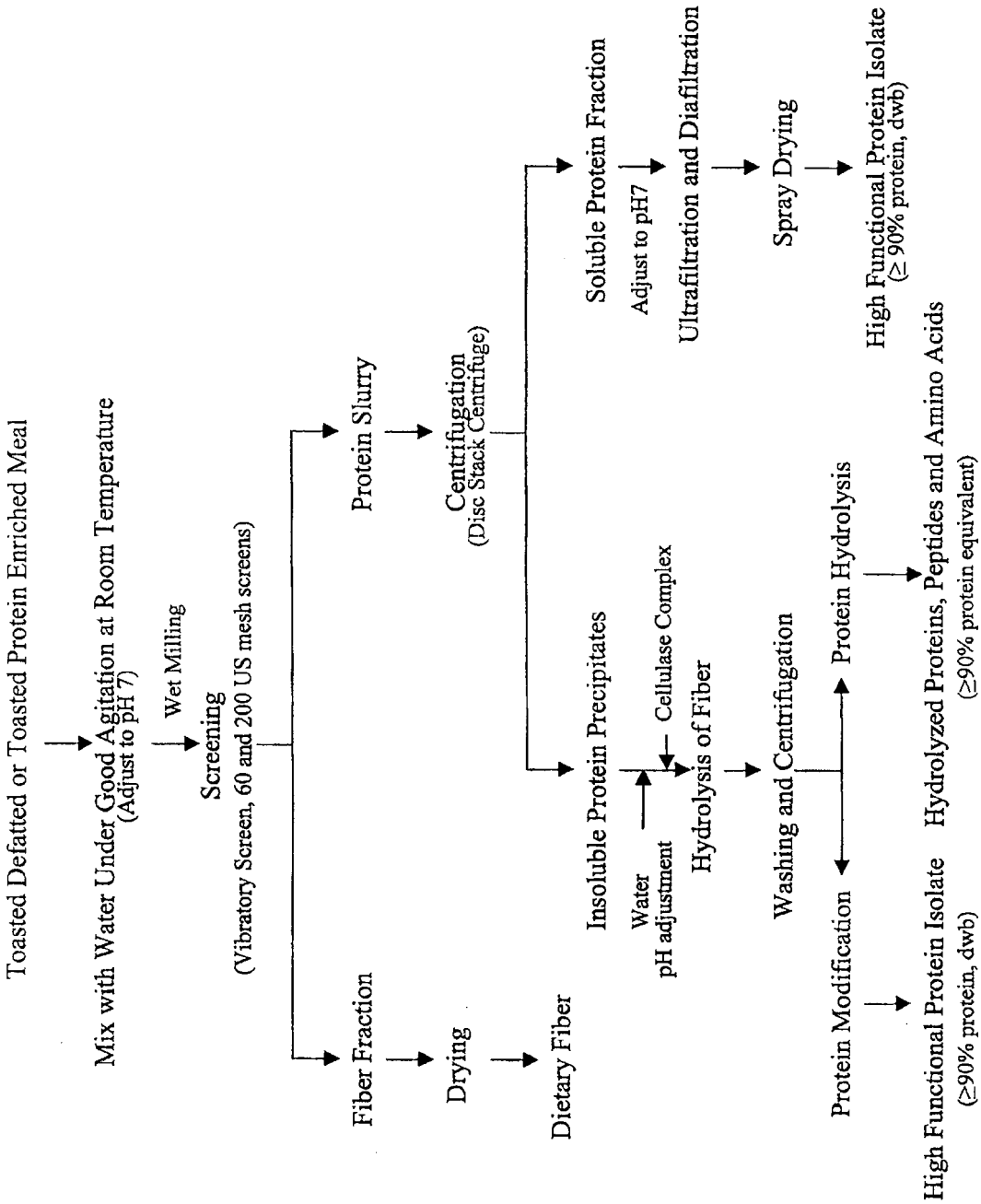
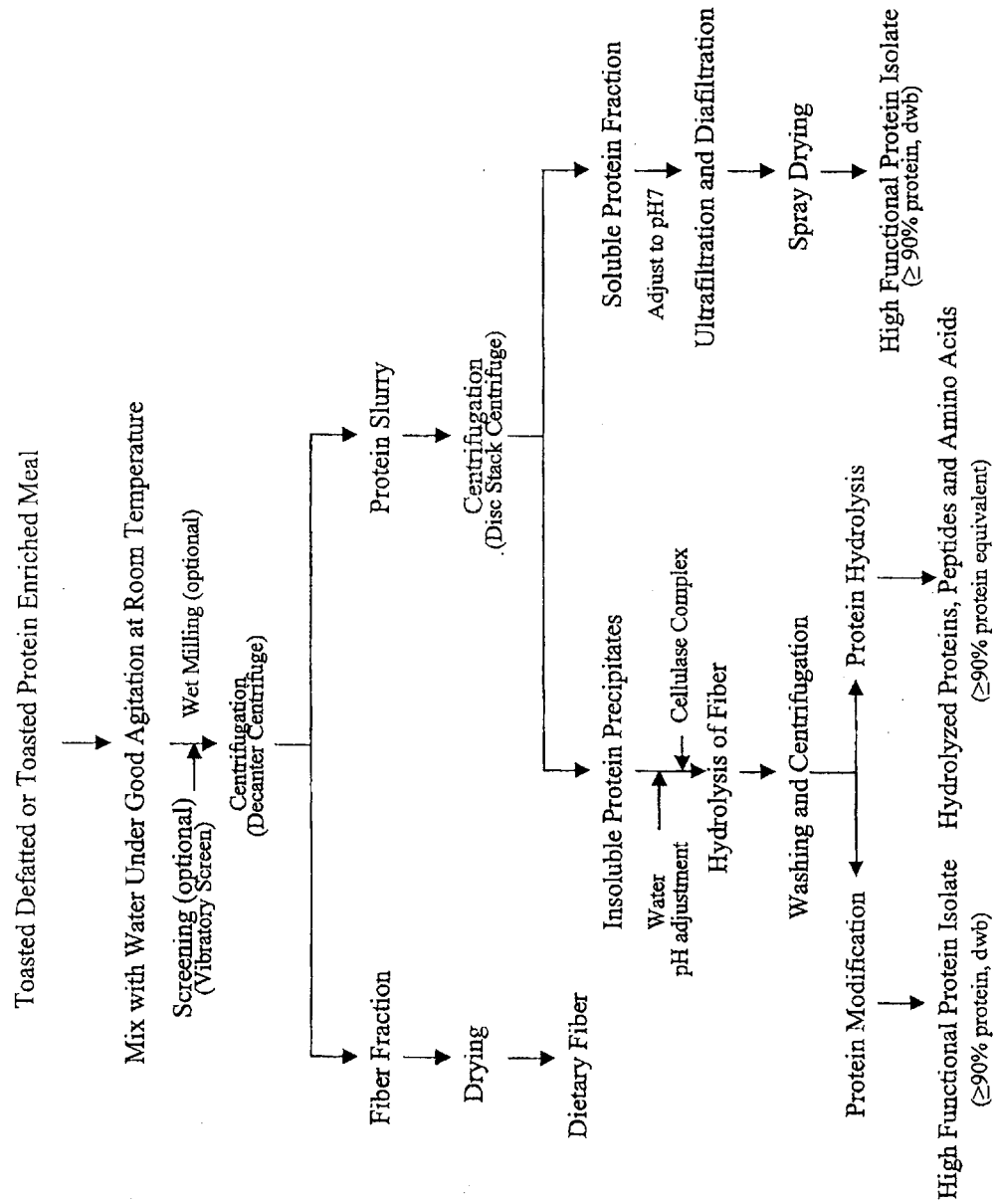

Toasted Defatted or Toasted Protein Enriched Meal
Mix with Water Under Good Agitation at Room Temperature
(Adjust to pH 7)
Wet Milling
Screening
(Vibratory Screen, 60 and 200 US mesh screens)
Protein Slurry
Centrifugation
(Disc Stack Centrifuge)
Soluble Protein Fraction
Adjust to pH7
Ultrafiltration and Diafiltration
Spray Drying
High Functional Protein Isolate
(≥ 90% protein, dwb)
Fiber Fraction
Drying
Dietary Fiber
Insoluble Protein Precipitates
Water
pH adjustment
Cellulase Complex
Hydrolysis of Fiber
Washing and Centrifugation
Protein Hydrolysis
Protein Modification
Hydrolyzed Proteins, Peptides and Amino Acids
(≥90% protein equivalent)
High Functional Protein Isolate
(≥90% protein, dwb)

FIGURE 15


Toasted Defatted or Toasted Protein Enriched Meal
Mix with Water Under Good Agitation at Room Temperature
Screening (optional)
(Vibratory Screen)
Wet Milling (optional)
Centrifugation
(Decanter Centrifuge)
Fiber Fraction
Drying
Dietary Fiber
Protein Slurry
Centrifugation
(Disc Stack Centrifuge)
Insoluble Protein Precipitates
Water
pH adjustment
Cellulase Complex
Hydrolysis of Fiber
Washing and Centrifugation
Protein Modification
Protein Hydrolysis
High Functional Protein Isolate
(≥90% protein, dwb)
Hydrolyzed Proteins, Peptides and Amino Acids
(≥90% protein equivalent)
Soluble Protein Fraction
Adjust to pH7
Ultrafiltration and Diafiltration
Spray Drying
High Functional Protein Isolate
(≥ 90% protein, dwb)

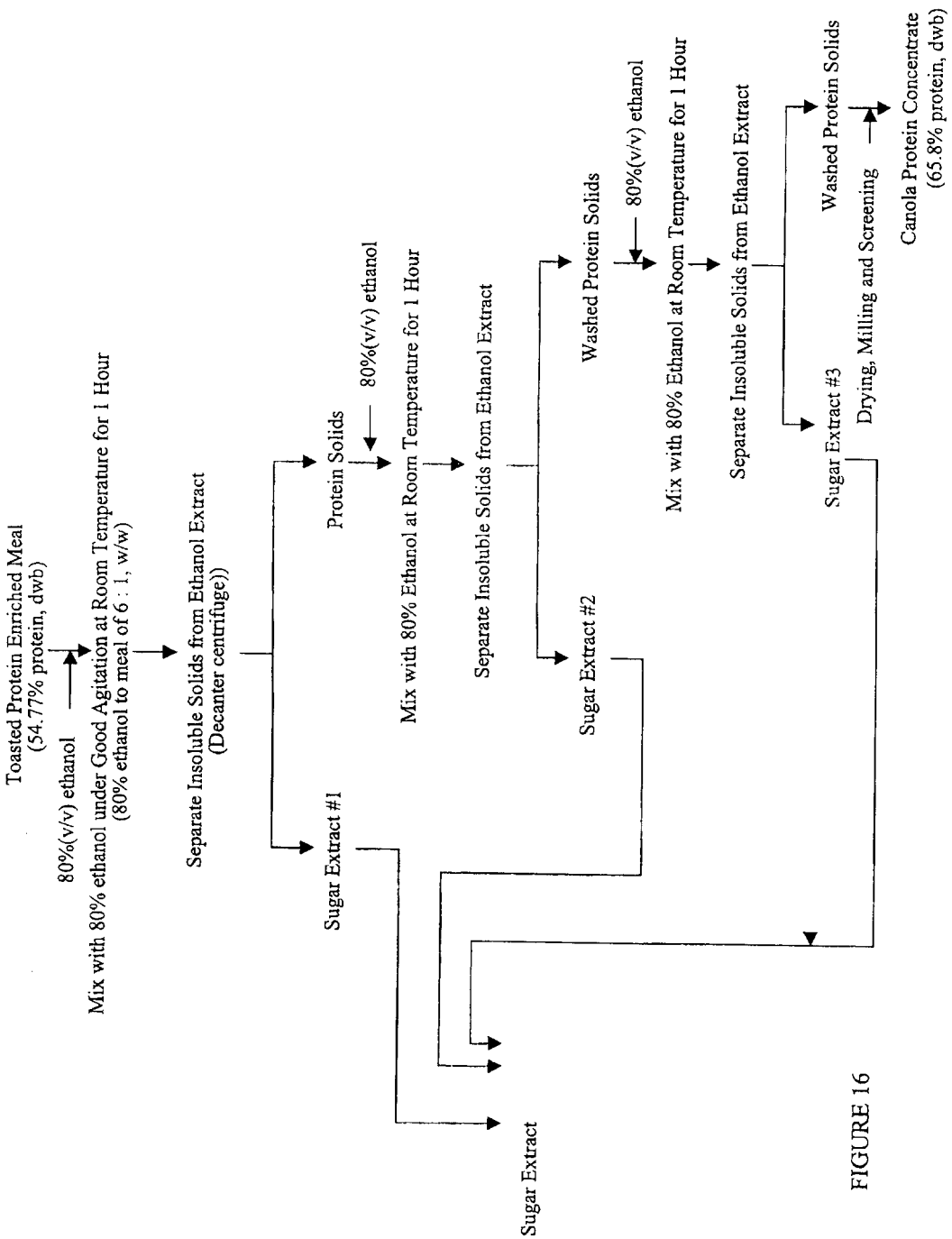

Toasted Protein Enriched Meal
(54.77% protein, dwb)
80%(v/v) ethanol
Mix with 80% ethanol under Good Agitation at Room Temperature for 1 Hour
(80% ethanol to meal of 6 : 1, w/w)
Separate Insoluble Solids from Ethanol Extract
(Decanter centrifuge))
Sugar Extract #1
Protein Solids
80%(v/v) ethanol
Mix with 80% Ethanol at Room Temperature for 1 Hour
Separate Insoluble Solids from Ethanol Extract
Sugar Extract #2
Washed Protein Solids
80%(v/v) ethanol
Mix with 80% Ethanol at Room Temperature for 1 Hour
Separate Insoluble Solids from Ethanol Extract
Sugar Extract #3
Washed Protein Solids
Drying, Milling and Screening
Canola Protein Concentrate
(65.8% protein, dwb)
Sugar Extract

FIGURE 16

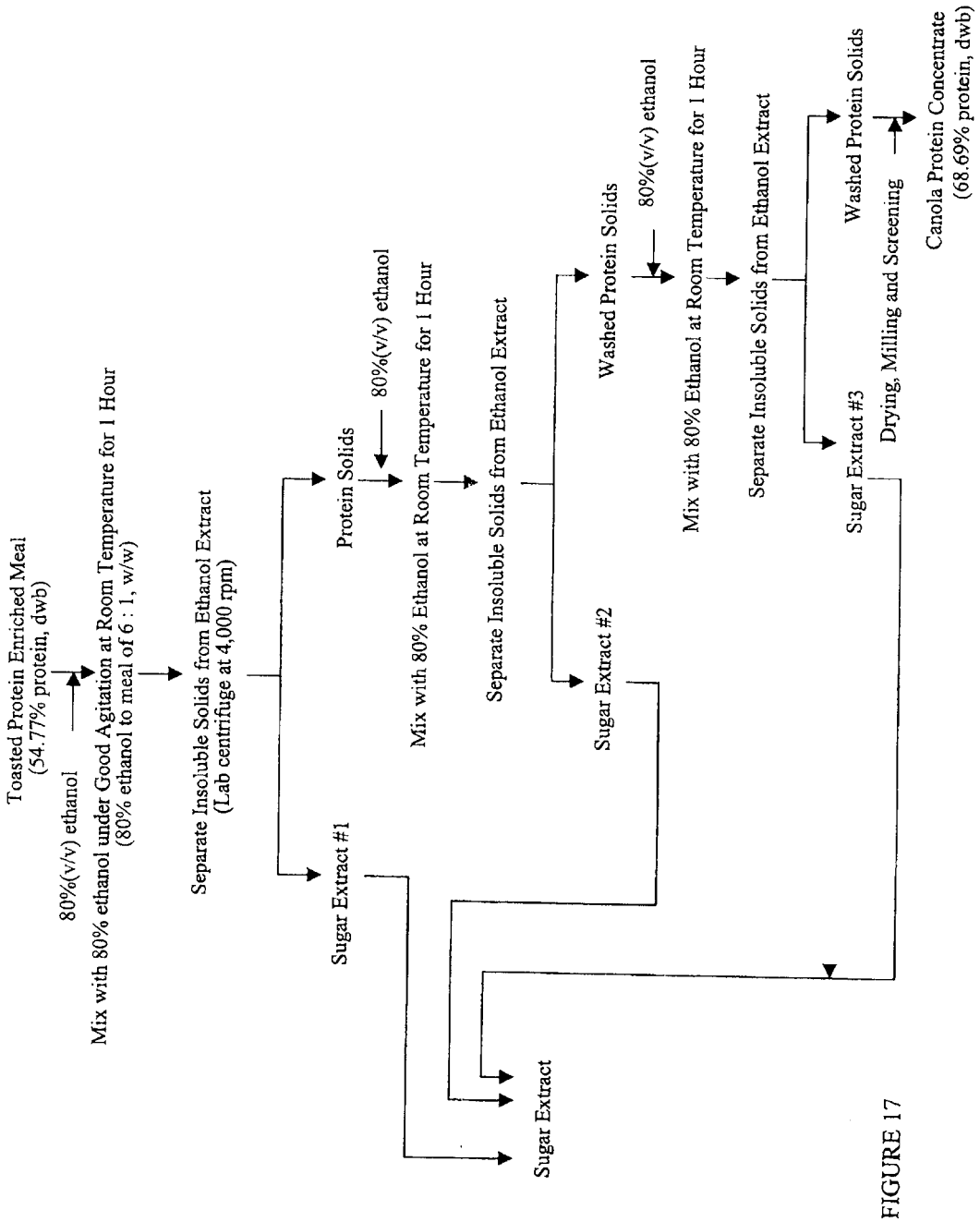

Toasted Protein Enriched Meal
(54.77% protein, dwb)
80%(v/v) ethanol
Mix with 80% ethanol under Good Agitation at Room Temperature for 1 Hour
(80% ethanol to meal of 6 : 1, w/w)
Separate Insoluble Solids from Ethanol Extract
(Lab centrifuge at 4,000 rpm)
Sugar Extract #1
Protein Solids
80%(v/v) ethanol
Mix with 80% Ethanol at Room Temperature for 1 Hour
Separate Insoluble Solids from Ethanol Extract
Sugar Extract #2
Washed Protein Solids
80%(v/v) ethanol
Mix with 80% Ethanol at Room Temperature for 1 Hour
Separate Insoluble Solids from Ethanol Extract
Sugar Extract #3
Washed Protein Solids
Drying, Milling and Screening
Canola Protein Concentrate
(68.69% protein, dwb)
Sugar Extract

FIGURE 17

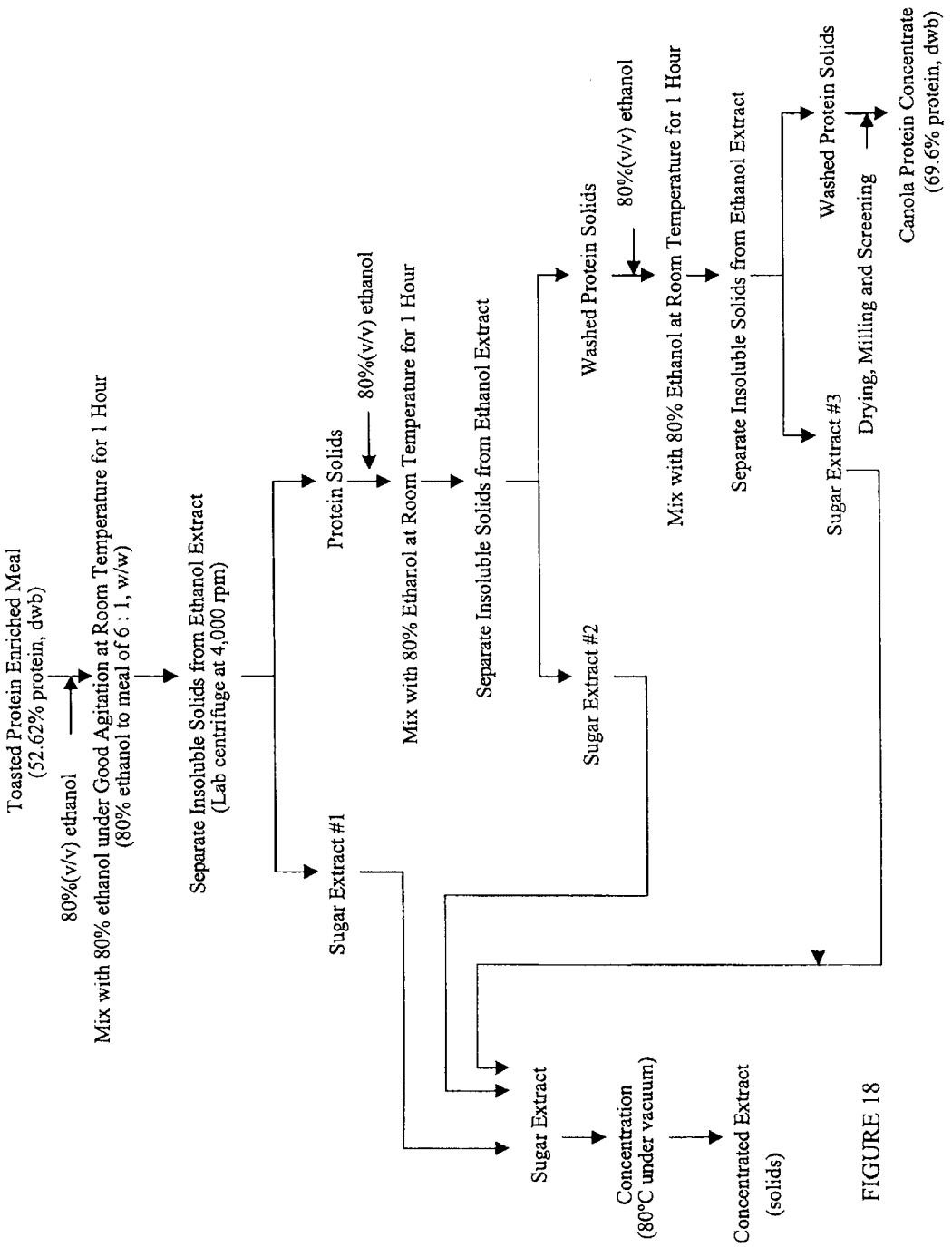

Toasted Protein Enriched Meal
(52.62% protein, dwb)
80%(v/v) ethanol
Mix with 80% ethanol under Good Agitation at Room Temperature for 1 Hour
(80% ethanol to meal of 6 : 1, w/w)
Separate Insoluble Solids from Ethanol Extract
(Lab centrifuge at 4,000 rpm)
Sugar Extract #1
Protein Solids
80%(v/v) ethanol
Mix with 80% Ethanol at Room Temperature for 1 Hour
Separate Insoluble Solids from Ethanol Extract
Sugar Extract #2
Washed Protein Solids
80%(v/v) ethanol
Mix with 80% Ethanol at Room Temperature for 1 Hour
Separate Insoluble Solids from Ethanol Extract
Sugar Extract #3
Washed Protein Solids
Drying, Milling and Screening
Canola Protein Concentrate
(69.6% protein, dwb)
Sugar Extract
Concentration
(80°C under vacuum)
Concentrated Extract
(solids)

FIGURE 18

FIGURE 19

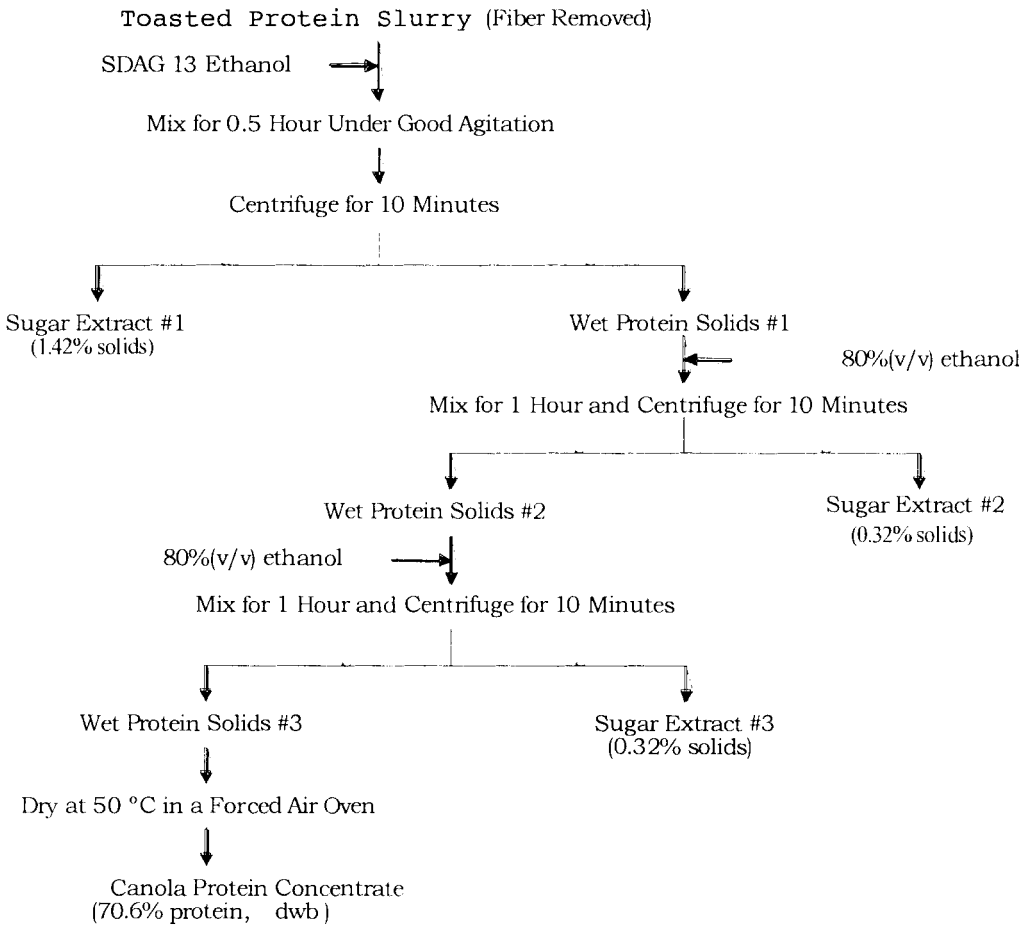
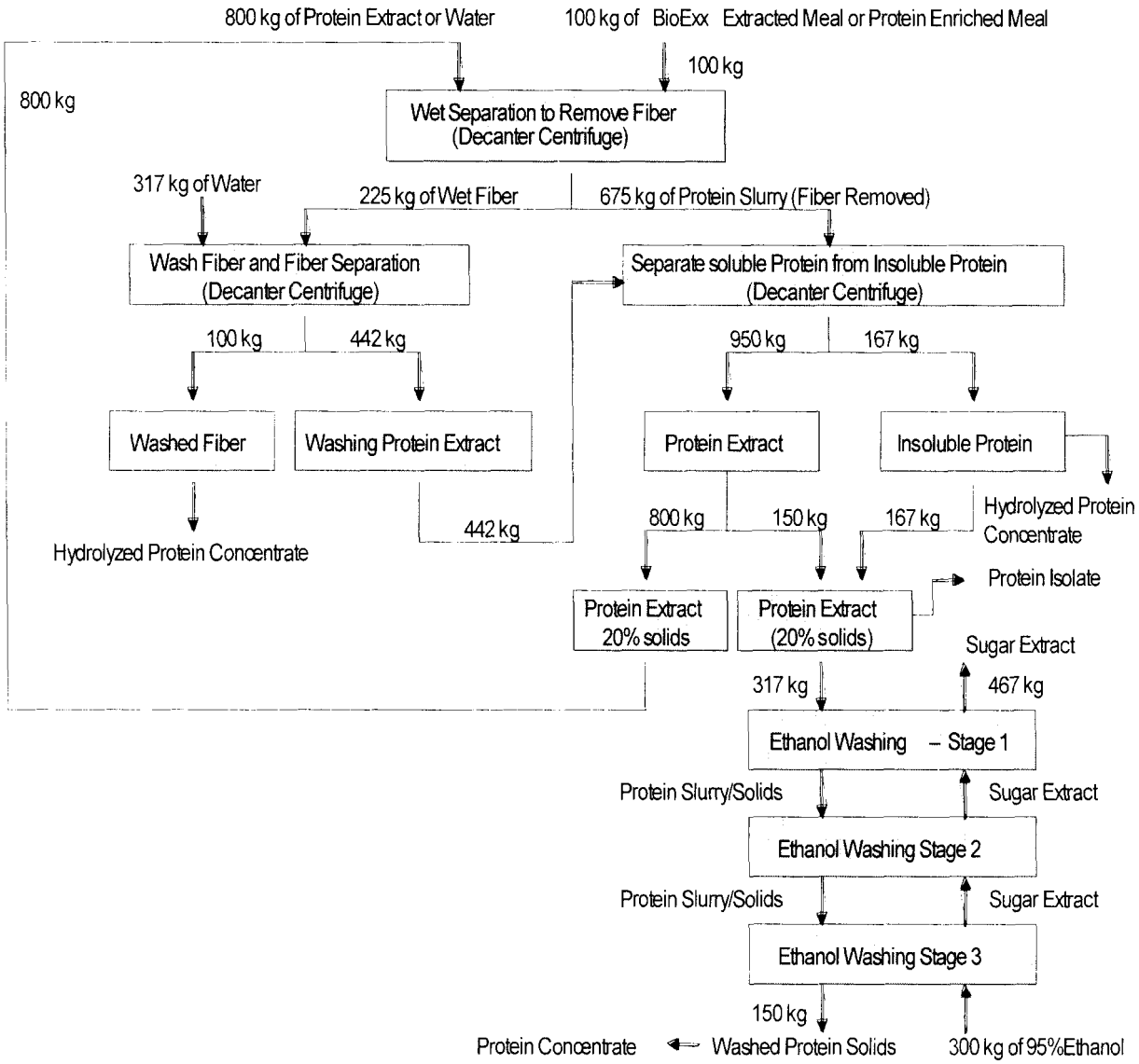

Toasted Protein Slurry (Fiber Removed)
SDAG 13 Ethanol
Mix for 0.5 Hour Under Good Agitation
Centrifuge for 10 Minutes
Sugar Extract #1
(1.42% solids)
Wet Protein Solids #1
80%(v/v) ethanol
Mix for 1 Hour and Centrifuge for 10 Minutes
Wet Protein Solids #2
Sugar Extract #2
(0.32% solids)
80%(v/v) ethanol
Mix for 1 Hour and Centrifuge for 10 Minutes
Wet Protein Solids #3
Sugar Extract #3
(0.32% solids)
Dry at 50 °C in a Forced Air Oven
Canola Protein Concentrate
(70.6% protein, dwb)

FIGURE 20


800 kg of Protein Extract or Water
100 kg of BioExx Extracted Meal or Protein Enriched Meal
100 kg
800 kg
Wet Separation to Remove Fiber (Decanter Centrifuge)
317 kg of Water
225 kg of Wet Fiber
675 kg of Protein Slurry (Fiber Removed)
Wash Fiber and Fiber Separation (Decanter Centrifuge)
Separate soluble Protein from Insoluble Protein (Decanter Centrifuge)
100 kg
442 kg
950 kg
167 kg
Washed Fiber
Washing Protein Extract
Protein Extract
Insoluble Protein
Hydrolyzed Protein Concentrate
442 kg
800 kg
150 kg
167 kg
Hydrolyzed Protein Concentrate
Protein Isolate
Protein Extract 20% solids
Protein Extract (20% solids)
Sugar Extract
317 kg
467 kg
Ethanol Washing – Stage 1
Protein Slurry/Solids
Sugar Extract
Ethanol Washing Stage 2
Protein Slurry/Solids
Sugar Extract
Ethanol Washing Stage 3
150 kg
Protein Concentrate
Washed Protein Solids
300 kg of 95%Ethanol

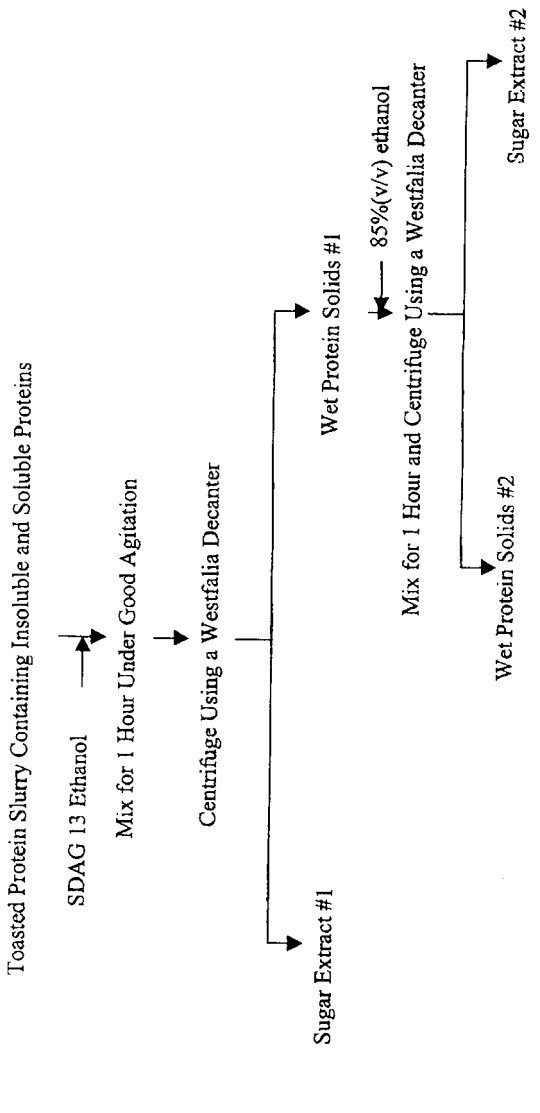

Toasted Protein Slurry Containing Insoluble and Soluble Proteins
SDAG 13 Ethanol
Mix for 1 Hour Under Good Agitation
Centrifuge Using a Westfalia Decanter
Sugar Extract #1
Wet Protein Solids #1
85%(v/v) ethanol
Mix for 1 Hour and Centrifuge Using a Westfalia Decanter
Sugar Extract #2
Wet Protein Solids #2
80%(v/v) ethanol
Mix for 1 Hour and Centrifuge Using a Westfalia Decanter
Sugar Extract #3
Wet Protein Solids #3
Dry at 50 ± 3°C Under Vacuum in a Littleford Dryer
Canola Protein Concentrate
(68.2% protein, dwb)

FIGURE 21

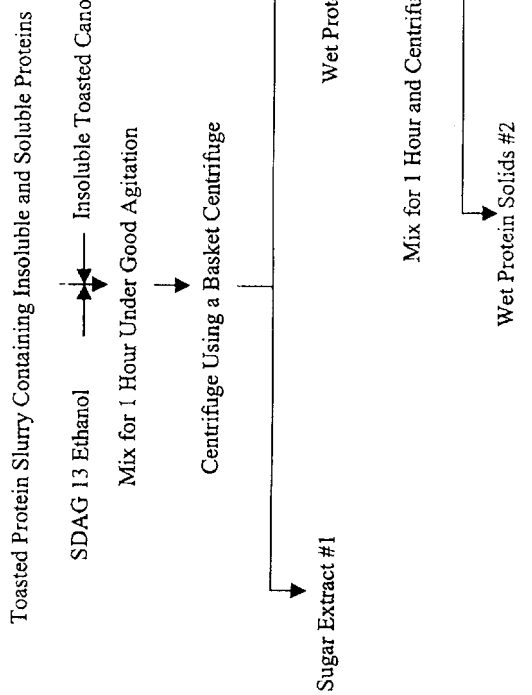

Toasted Protein Slurry Containing Insoluble and Soluble Proteins
SDAG 13 Ethanol
Insoluble Toasted Canola Protein Solids #1C – 5C
Mix for 1 Hour Under Good Agitation
Centrifuge Using a Basket Centrifuge
Sugar Extract #1
Wet Protein Solids #1
85%(v/v) ethanol
Mix for 1 Hour and Centrifuge Using the Basket Centrifuge
Sugar Extract #2
Wet Protein Solids #2
85%(v/v) ethanol
Mix for 1 Hour and Centrifuge Using the Basket Centrifuge
Sugar Extract #3
Wet Protein Solids #3
Air Desolventization and Dry at 60°C
Canola Protein Concentrate
(73.3% protein, dwb)

FIGURE 22

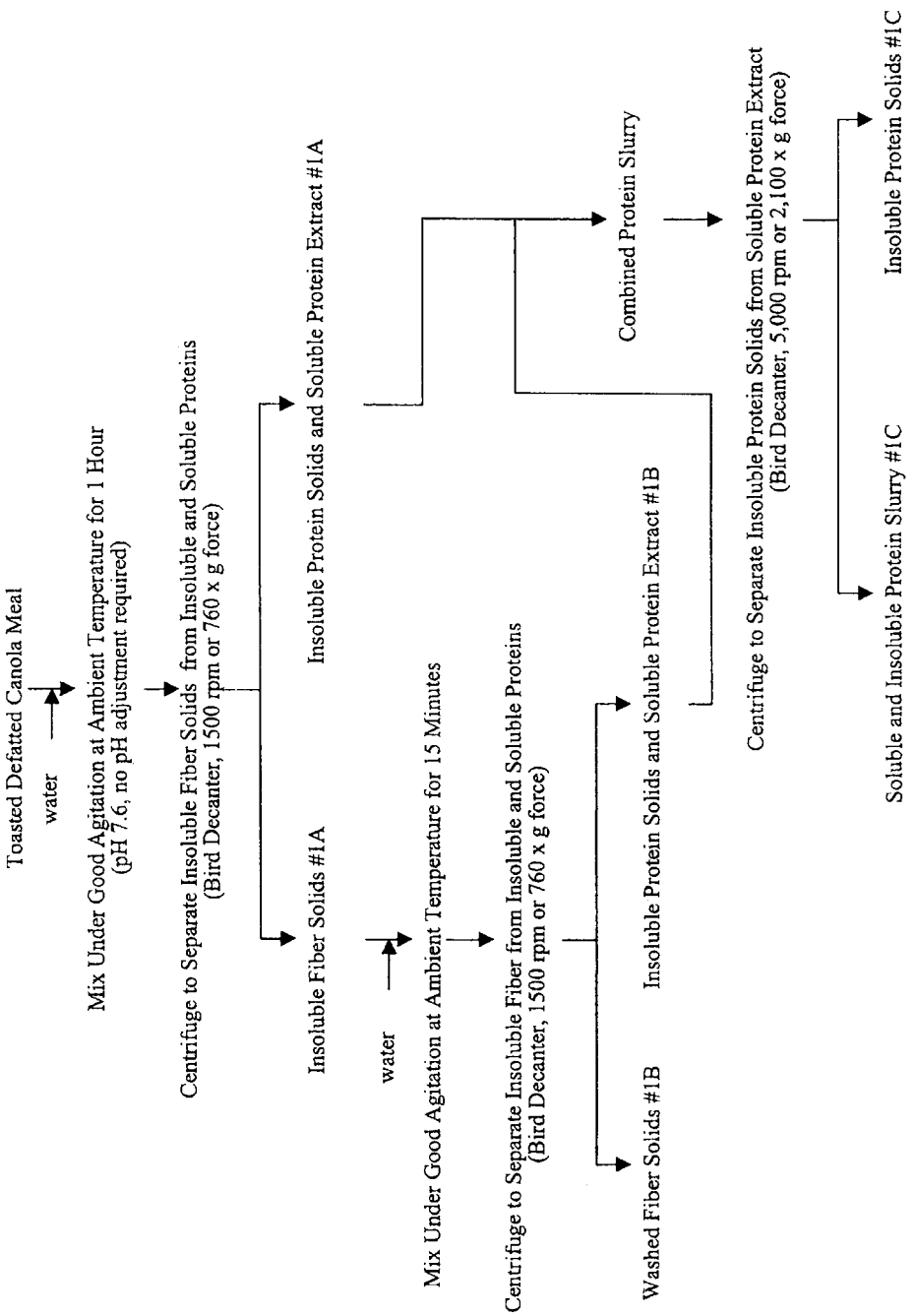

Toasted Defatted Canola Meal
water
Mix Under Good Agitation at Ambient Temperature for 1 Hour
(pH 7.6, no pH adjustment required)
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Insoluble Fiber Solids #1A
Insoluble Protein Solids and Soluble Protein Extract #1A
water
Mix Under Good Agitation at Ambient Temperature for 15 Minutes
Centrifuge to Separate Insoluble Fiber from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Washed Fiber Solids #1B
Insoluble Protein Solids and Soluble Protein Extract #1B
Combined Protein Slurry
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract
(Bird Decanter, 5,000 rpm or 2,100 x g force)
Soluble and Insoluble Protein Slurry #1C
Insoluble Protein Solids #1C

FIGURE 23

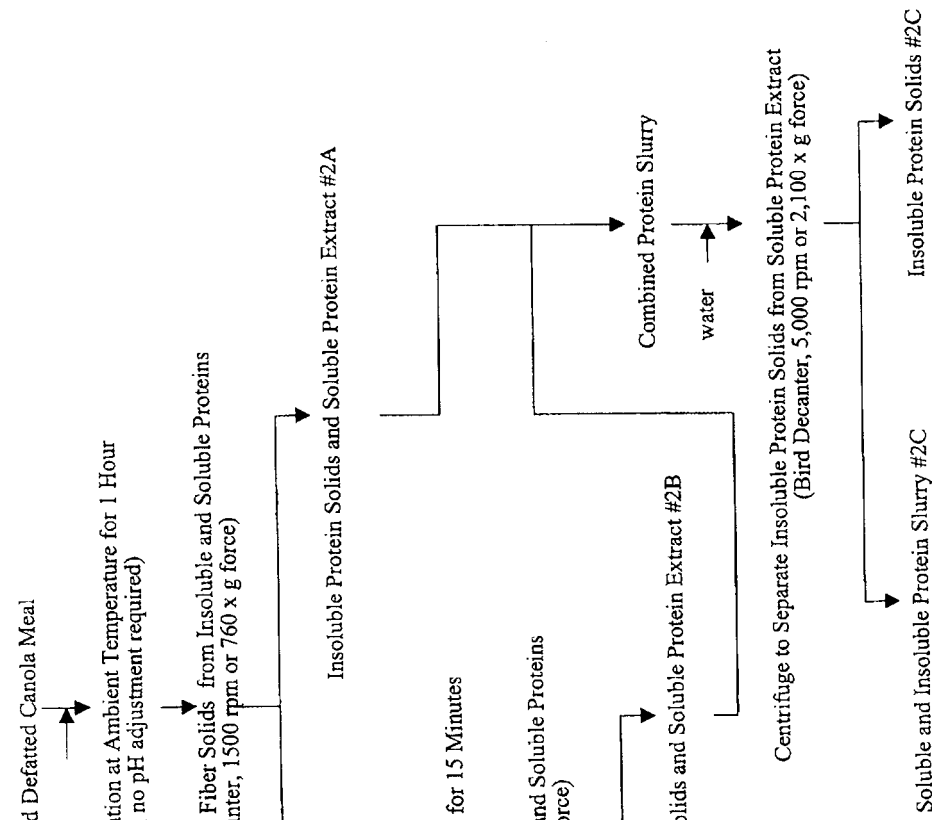

Toasted Defatted Canola Meal
soluble and insoluble protein slurry #1C
Mix Under Good Agitation at Ambient Temperature for 1 Hour
(pH 7.6, no pH adjustment required)
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Insoluble Fiber Solids #2A
Insoluble Protein Solids and Soluble Protein Extract #2A
water
Mix Under Good Agitation at Ambient Temperature for 15 Minutes
Centrifuge to Separate Insoluble Fiber from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Washed Fiber Solids #2B
Insoluble Protein Solids and Soluble Protein Extract #2B
Combined Protein Slurry
water
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract
(Bird Decanter, 5,000 rpm or 2,100 x g force)
Soluble and Insoluble Protein Slurry #2C
Insoluble Protein Solids #2C

FIGURE 24

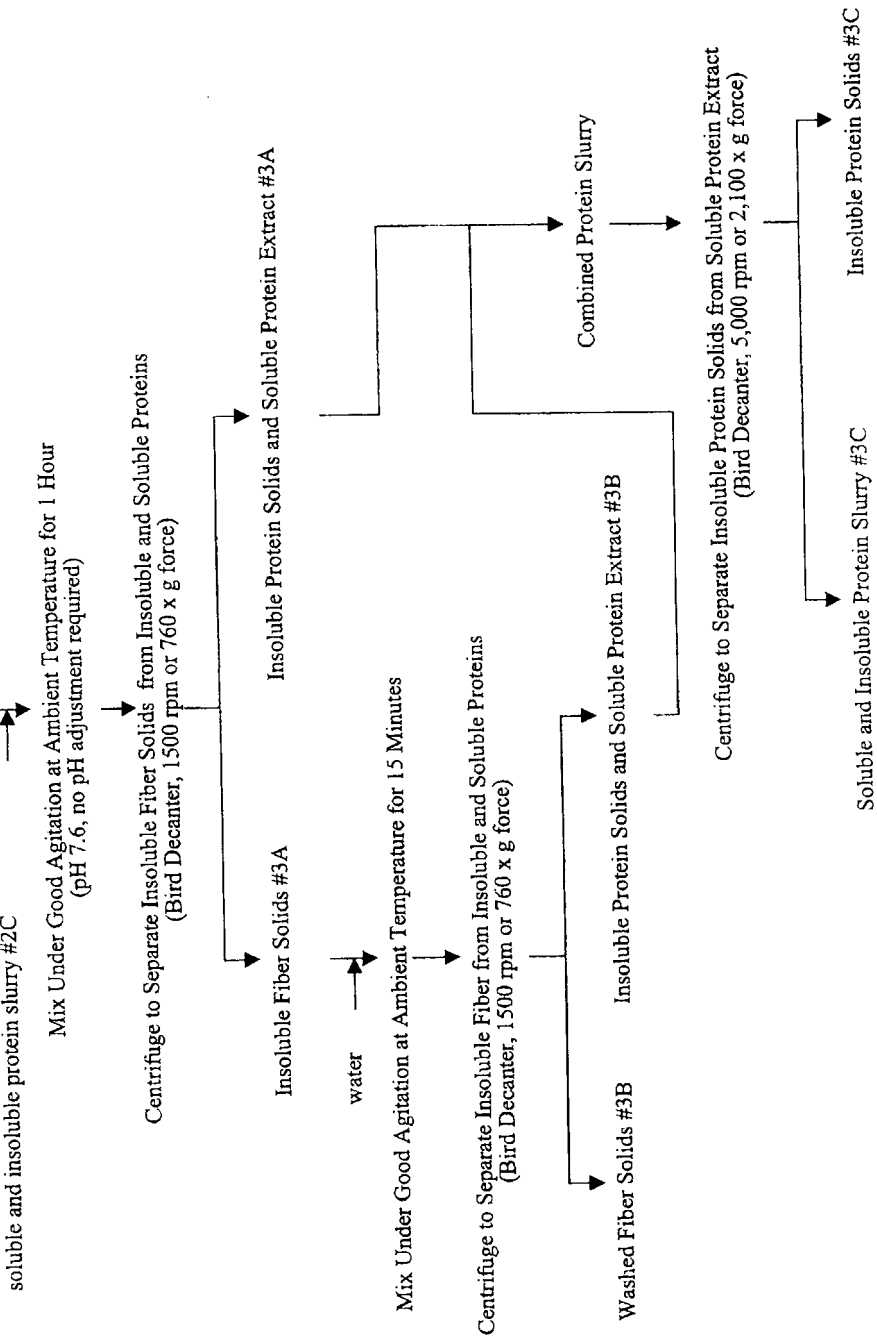

Toasted Defatted Canola Meal
soluble and insoluble protein slurry #2C
Mix Under Good Agitation at Ambient Temperature for 1 Hour
(pH 7.6, no pH adjustment required)
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Insoluble Fiber Solids #3A
Insoluble Protein Solids and Soluble Protein Extract #3A
water
Mix Under Good Agitation at Ambient Temperature for 15 Minutes
Centrifuge to Separate Insoluble Fiber from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Washed Fiber Solids #3B
Insoluble Protein Solids and Soluble Protein Extract #3B
Combined Protein Slurry
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract
(Bird Decanter, 5,000 rpm or 2,100 x g force)
Soluble and Insoluble Protein Slurry #3C
Insoluble Protein Solids #3C

FIGURE 25

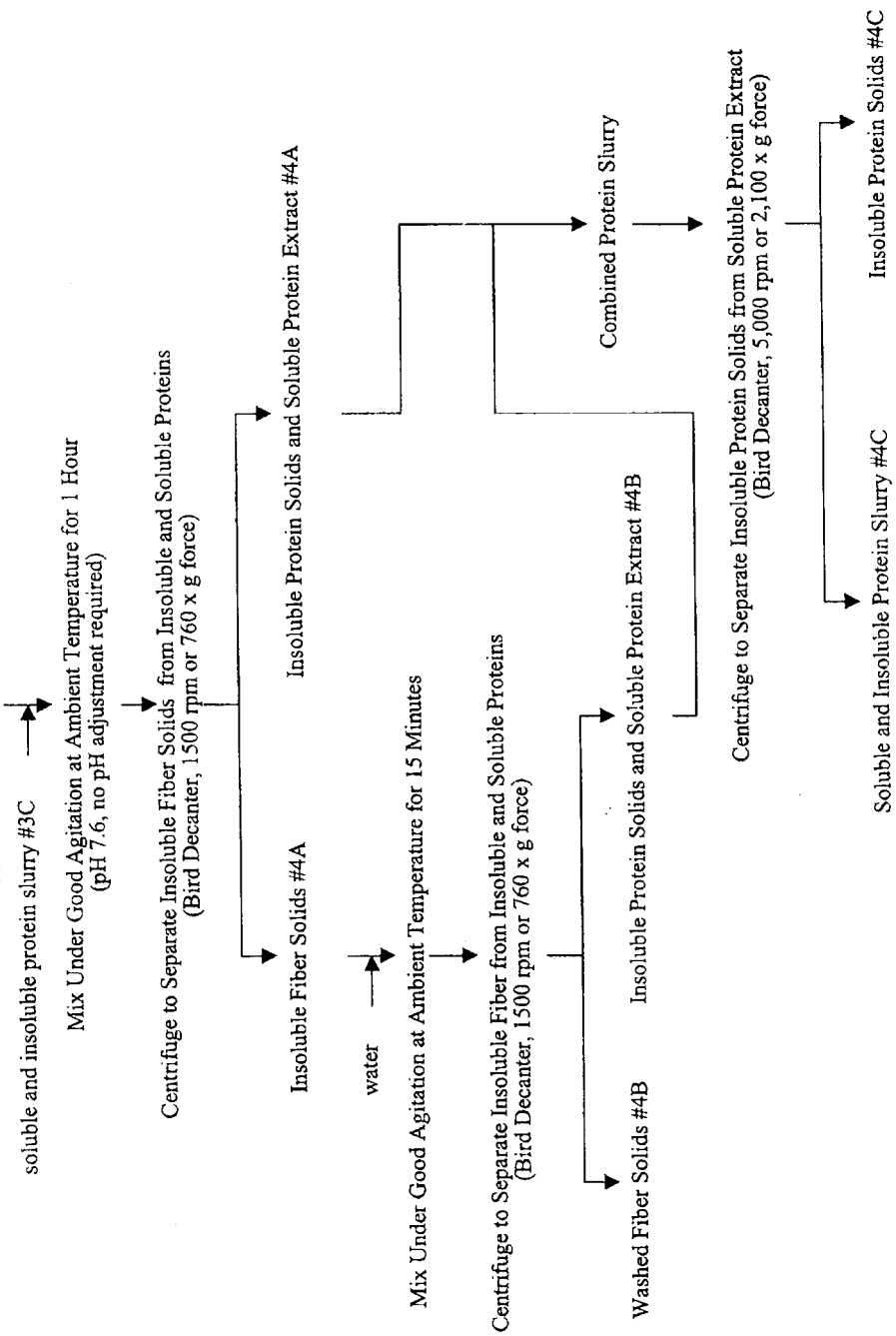

Toasted Defatted Canola Meal
soluble and insoluble protein slurry #3C
Mix Under Good Agitation at Ambient Temperature for 1 Hour
(pH 7.6, no pH adjustment required)
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Insoluble Fiber Solids #4A
Insoluble Protein Solids and Soluble Protein Extract #4A
water
Mix Under Good Agitation at Ambient Temperature for 15 Minutes
Centrifuge to Separate Insoluble Fiber from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Washed Fiber Solids #4B
Insoluble Protein Solids and Soluble Protein Extract #4B
Combined Protein Slurry
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract
(Bird Decanter, 5,000 rpm or 2,100 x g force)
Soluble and Insoluble Protein Slurry #4C
Insoluble Protein Solids #4C

FIGURE 26

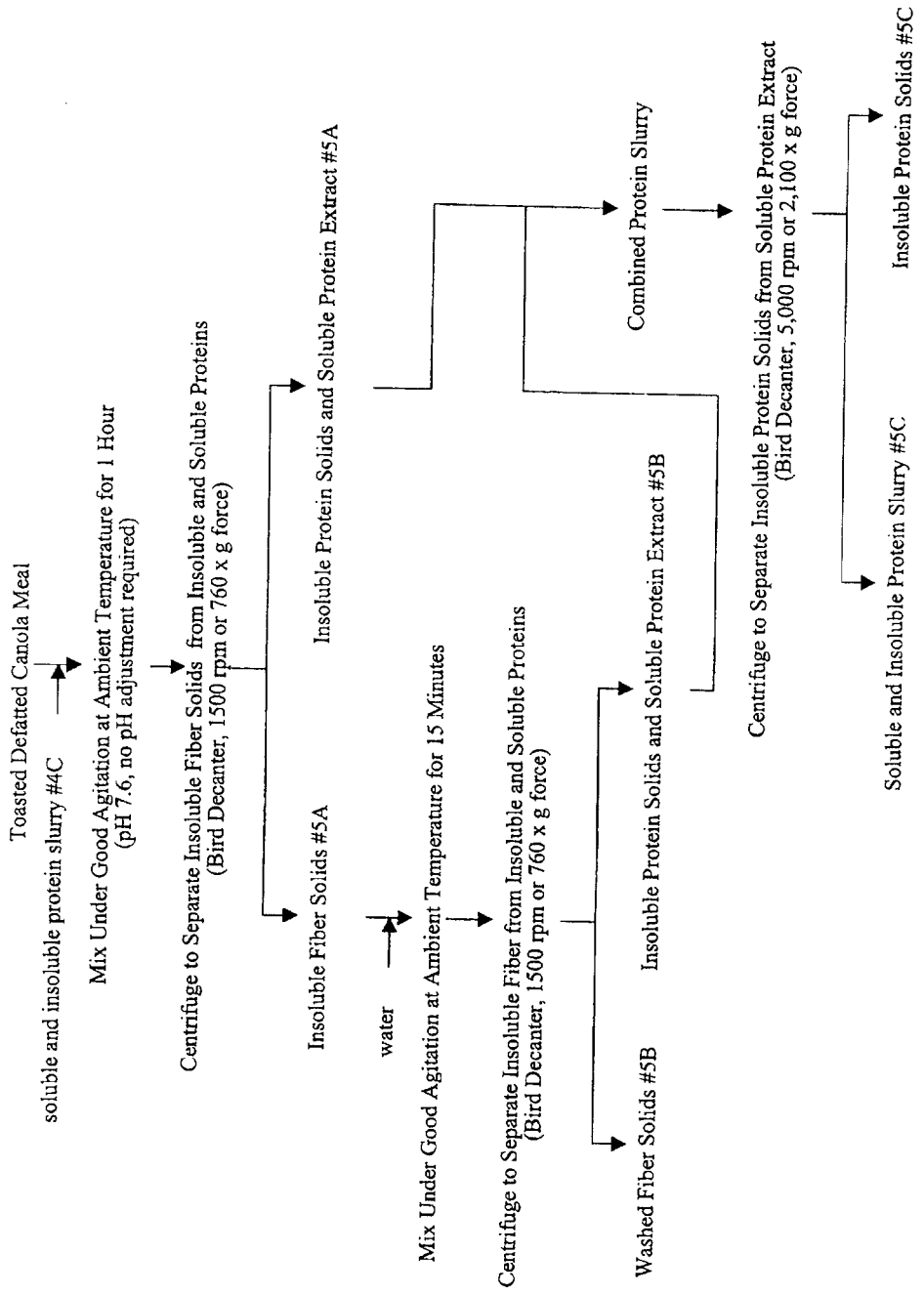

Toasted Defatted Canola Meal
soluble and insoluble protein slurry #4C
Mix Under Good Agitation at Ambient Temperature for 1 Hour
(pH 7.6, no pH adjustment required)
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Insoluble Fiber Solids #5A
Insoluble Protein Solids and Soluble Protein Extract #5A
water
Mix Under Good Agitation at Ambient Temperature for 15 Minutes
Centrifuge to Separate Insoluble Fiber from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Washed Fiber Solids #5B
Insoluble Protein Solids and Soluble Protein Extract #5B
Combined Protein Slurry
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract
(Bird Decanter, 5,000 rpm or 2,100 x g force)
Soluble and Insoluble Protein Slurry #5C
Insoluble Protein Solids #5C

FIGURE 27

FIGURE 28

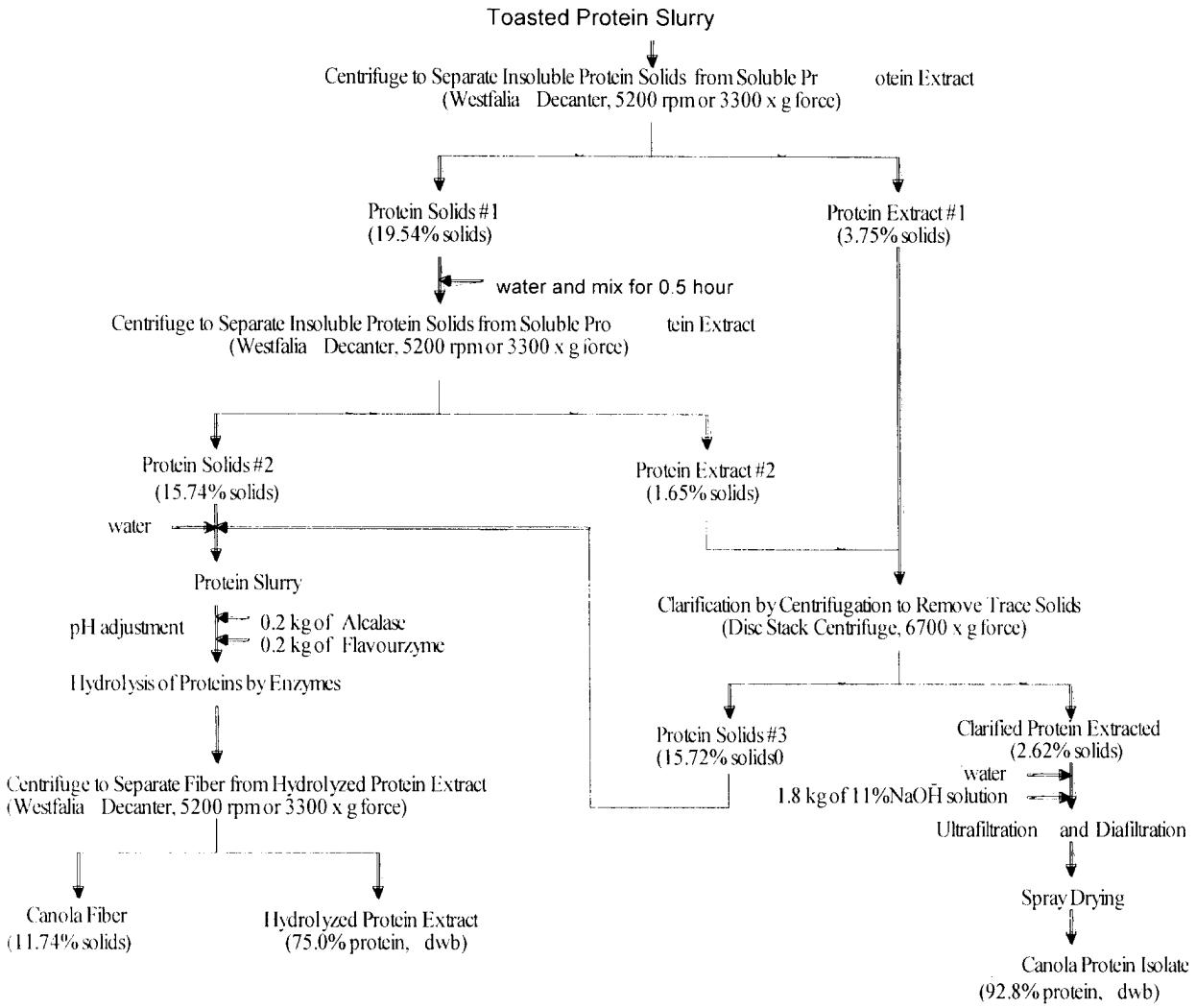
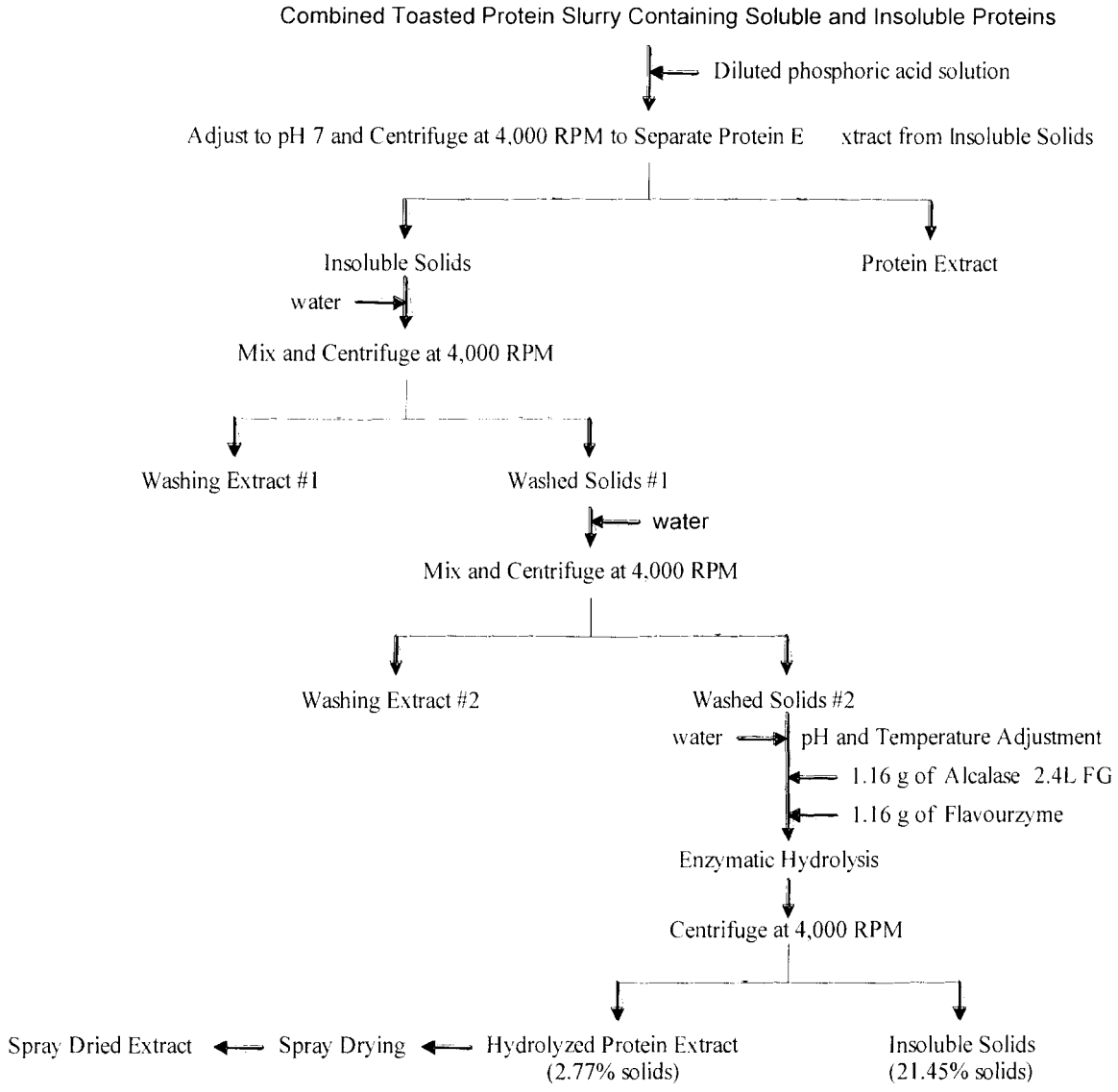

Toasted Protein Slurry
Centrifuge to Separate Insoluble Protein Solids from Soluble Pr otein Extract
(Westfalia Decanter, 5200 rpm or 3300 x g force)
Protein Solids #1
(19.54% solids)
Protein Extract #1
(3.75% solids)
water and mix for 0.5 hour
Centrifuge to Separate Insoluble Protein Solids from Soluble Pro tein Extract
(Westfalia Decanter, 5200 rpm or 3300 x g force)
Protein Solids #2
(15.74% solids)
Protein Extract #2
(1.65% solids)
water
Protein Slurry
pH adjustment
0.2 kg of Alcalase
0.2 kg of Flavourzyme
Hydrolysis of Proteins by Enzymes
Centrifuge to Separate Fiber from Hydrolyzed Protein Extract
(Westfalia Decanter, 5200 rpm or 3300 x g force)
Canola Fiber
(11.74% solids)
Hydrolyzed Protein Extract
(75.0% protein, dwb)
Clarification by Centrifugation to Remove Trace Solids
(Disc Stack Centrifuge, 6700 x g force)
Protein Solids #3
(15.72% solids0
Clarified Protein Extracted
(2.62% solids)
water
1.8 kg of 11%NaOH solution
Ultrafiltration and Diafiltration
Spray Drying
Canola Protein Isolate
(92.8% protein, dwb)

FIGURE 29


Combined Toasted Protein Slurry Containing Soluble and Insoluble Proteins
Diluted phosphoric acid solution
Adjust to pH 7 and Centrifuge at 4,000 RPM to Separate Protein E xtract from Insoluble Solids
Insoluble Solids
Protein Extract
water
Mix and Centrifuge at 4,000 RPM
Washing Extract #1
Washed Solids #1
water
Mix and Centrifuge at 4,000 RPM
Washing Extract #2
Washed Solids #2
water
pH and Temperature Adjustment
1.16 g of Alcalase 2.4L FG
1.16 g of Flavourzyme
Enzymatic Hydrolysis
Centrifuge at 4,000 RPM
Spray Dried Extract
Spray Drying
Hydrolyzed Protein Extract
(2.77% solids)
Insoluble Solids
(21.45% solids)

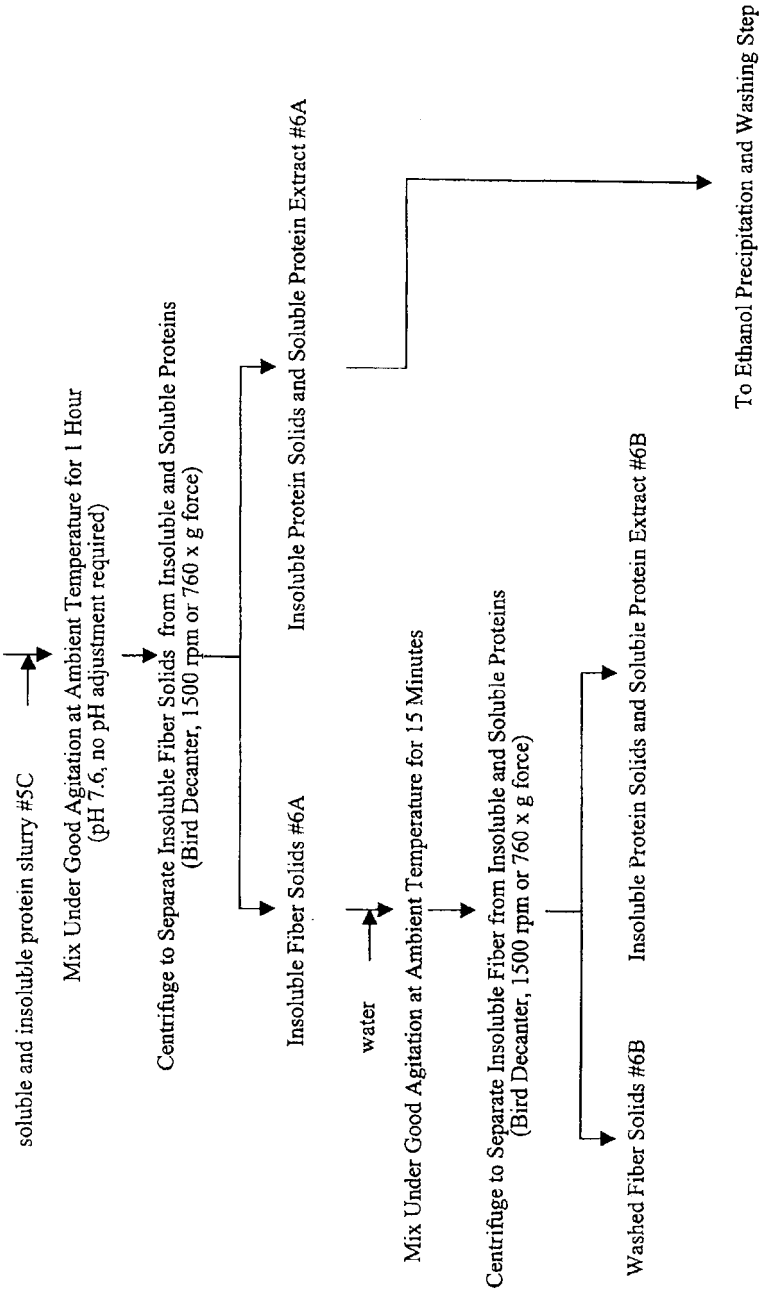

Toasted Defatted Canola Meal
soluble and insoluble protein slurry #5C
Mix Under Good Agitation at Ambient Temperature for 1 Hour
(pH 7.6, no pH adjustment required)
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Insoluble Fiber Solids #6A
Insoluble Protein Solids and Soluble Protein Extract #6A
water
Mix Under Good Agitation at Ambient Temperature for 15 Minutes
Centrifuge to Separate Insoluble Fiber from Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm or 760 x g force)
Washed Fiber Solids #6B
Insoluble Protein Solids and Soluble Protein Extract #6B
To Ethanol Precipitation and Washing Step

FIGURE 30

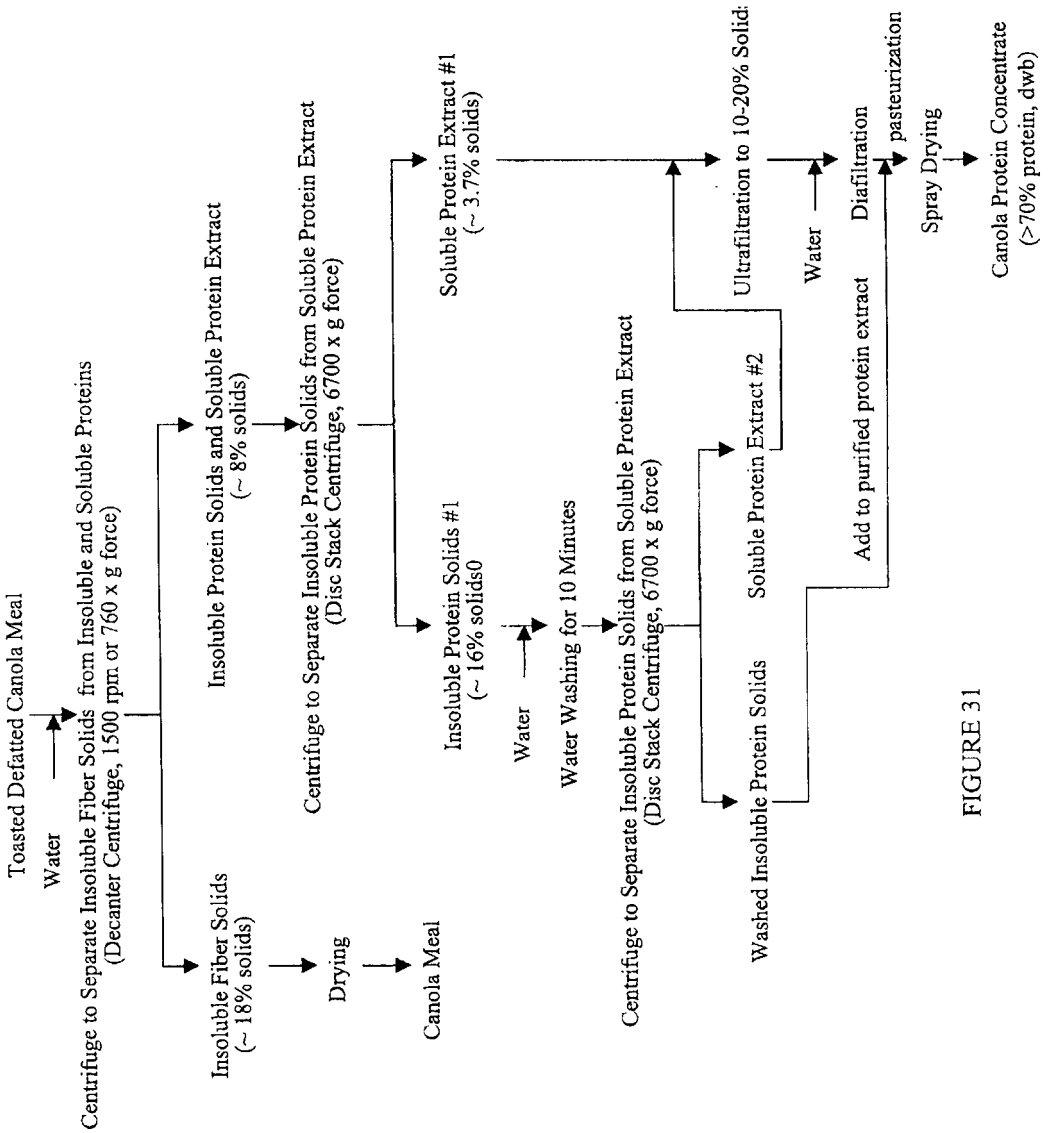

Toasted Defatted Canola Meal
Water
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins (Decanter Centrifuge, 1500 rpm or 760 x g force)
Insoluble Fiber Solids (~ 18% solids)
Drying
Canola Meal
Insoluble Protein Solids and Soluble Protein Extract (~ 8% solids)
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract (Disc Stack Centrifuge, 6700 x g force)
Insoluble Protein Solids #1 (~ 16% solids0
Water
Water Washing for 10 Minutes
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract (Disc Stack Centrifuge, 6700 x g force)
Washed Insoluble Protein Solids
Soluble Protein Extract #1 (~ 3.7% solids)
Soluble Protein Extract #2
Ultrafiltration to 10-20% Solid
Water
Add to purified protein extract
Diafiltration
pasteurization
Spray Drying
Canola Protein Concentrate (>70% protein, dwb)

FIGURE 31

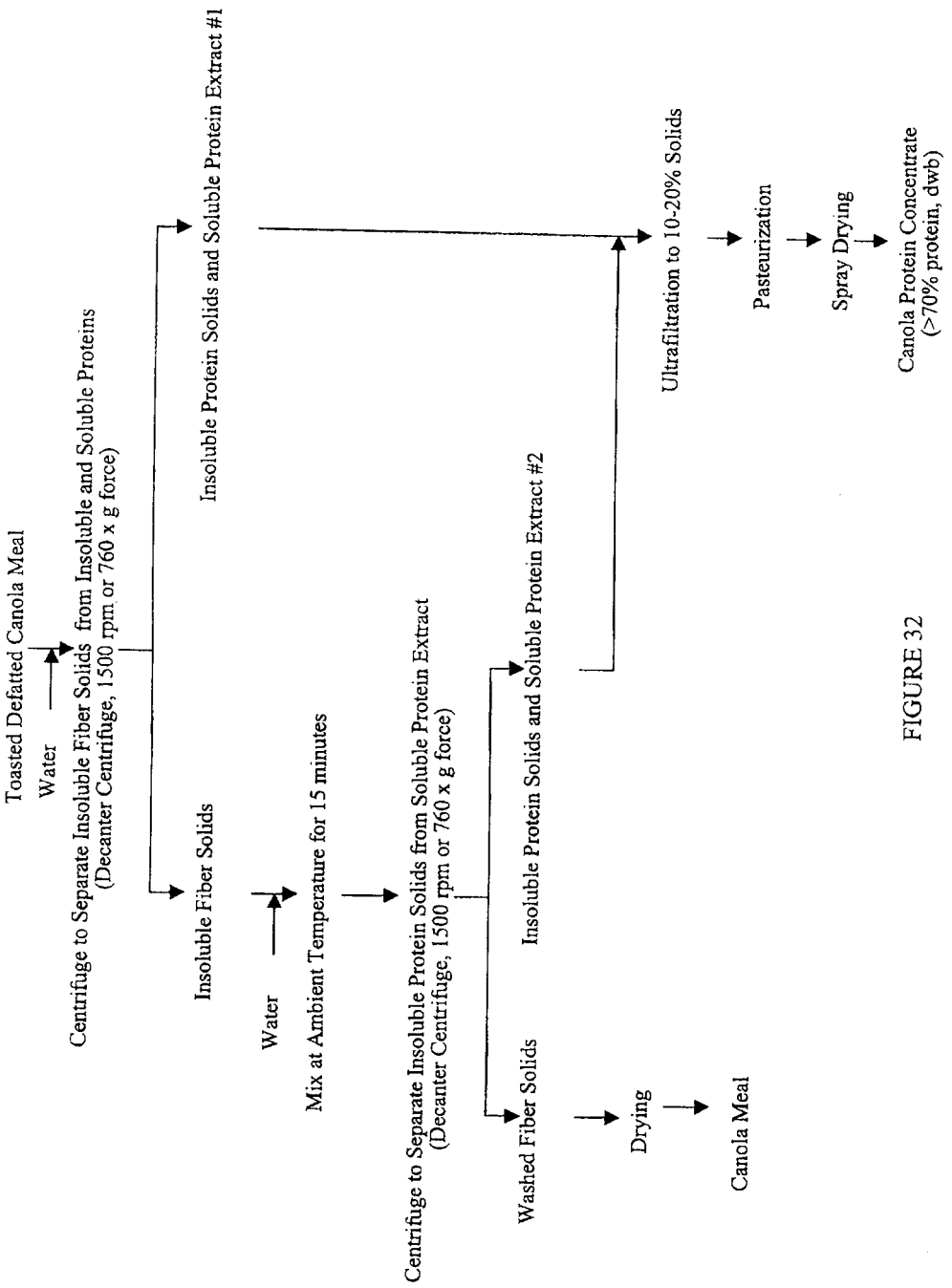
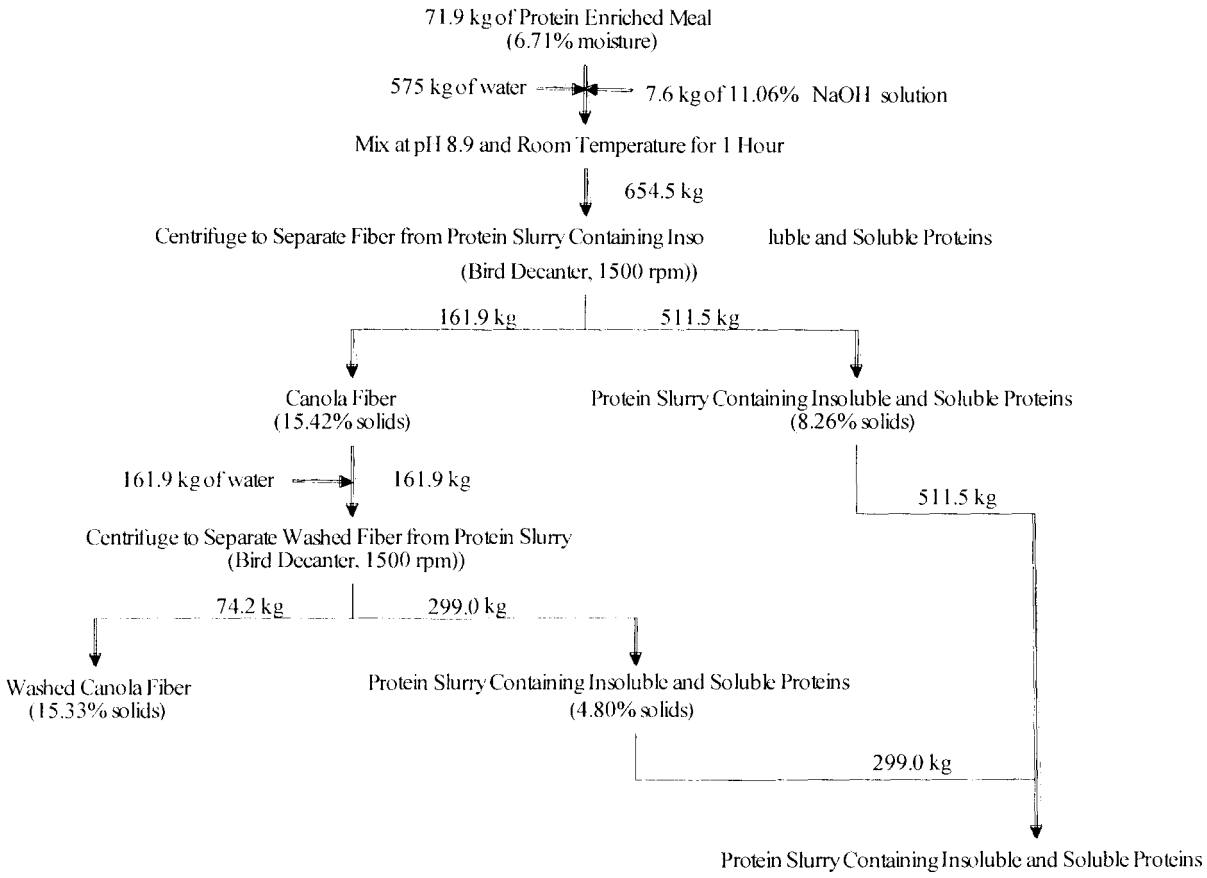

Toasted Defatted Canola Meal
Water
Centrifuge to Separate Insoluble Fiber Solids from Insoluble and Soluble Proteins
(Decanter Centrifuge, 1500 rpm or 760 x g force)
Insoluble Fiber Solids
Insoluble Protein Solids and Soluble Protein Extract #1
Water
Mix at Ambient Temperature for 15 minutes
Centrifuge to Separate Insoluble Protein Solids from Soluble Protein Extract
(Decanter Centrifuge, 1500 rpm or 760 x g force)
Washed Fiber Solids
Insoluble Protein Solids and Soluble Protein Extract #2
Drying
Canola Meal
Ultrafiltration to 10-20% Solids
Pasteurization
Spray Drying
Canola Protein Concentrate
(>70% protein, dwb)

FIGURE 32

FIGURE 33


71.9 kg of Protein Enriched Meal
(6.71% moisture)
575 kg of water
7.6 kg of 11.06% NaOH solution
Mix at pH 8.9 and Room Temperature for 1 Hour
654.5 kg
Centrifuge to Separate Fiber from Protein Slurry Containing Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm))
161.9 kg
511.5 kg
Canola Fiber
(15.42% solids)
Protein Slurry Containing Insoluble and Soluble Proteins
(8.26% solids)
161.9 kg of water
161.9 kg
511.5 kg
Centrifuge to Separate Washed Fiber from Protein Slurry
(Bird Decanter, 1500 rpm))
74.2 kg
299.0 kg
Washed Canola Fiber
(15.33% solids)
Protein Slurry Containing Insoluble and Soluble Proteins
(4.80% solids)
299.0 kg
Protein Slurry Containing Insoluble and Soluble Proteins

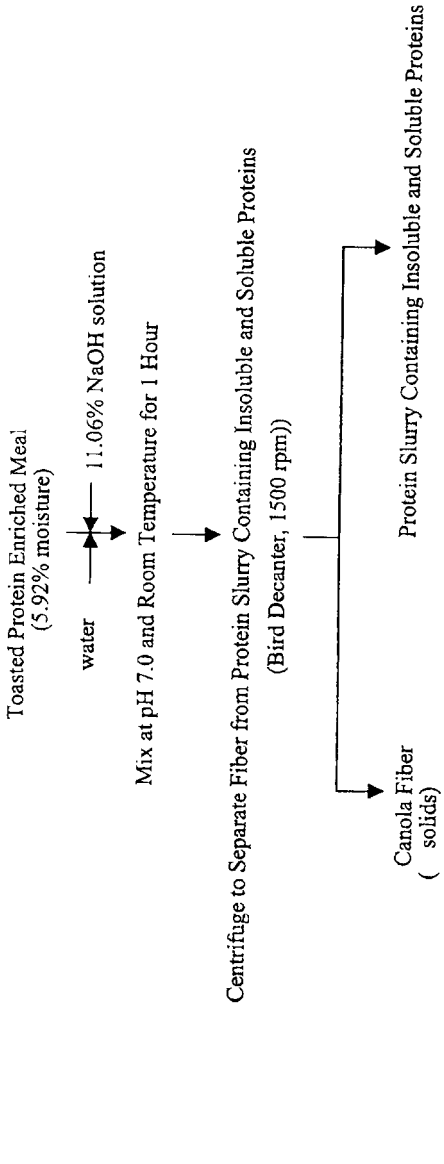

Toasted Protein Enriched Meal
(5.92% moisture)
water
11.06% NaOH solution
Mix at pH 7.0 and Room Temperature for 1 Hour
Centrifuge to Separate Fiber from Protein Slurry Containing Insoluble and Soluble Proteins
(Bird Decanter, 1500 rpm))
Protein Slurry Containing Insoluble and Soluble Proteins
Canola Fiber
(solids)
water
Centrifuge to Separate Washing Extract from Fiber Fraction
(Bird Decanter, 4,000 rpm))
Insoluble Fiber Solids
Washing Extract

FIGURE 34

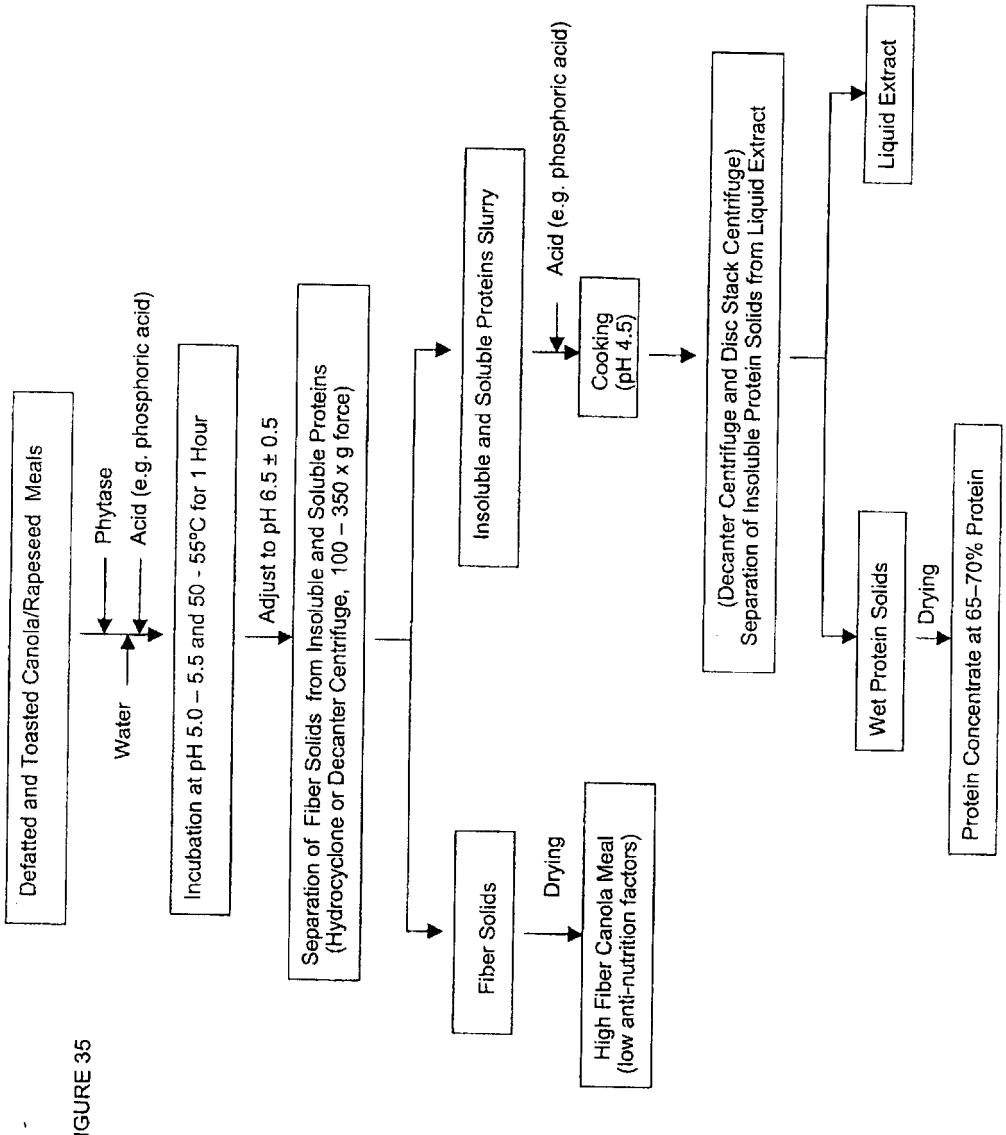

Defatted and Toasted Canola/Rapeseed Meals
Water
Phytase
Acid (e.g. phosphoric acid)
Incubation at pH 5.0 – 5.5 and 50 - 55°C for 1 Hour
Adjust to pH 6.5 ± 0.5
Separation of Fiber Solids from Insoluble and Soluble Proteins (Hydrocyclone or Decanter Centrifuge, 100 – 350 x g force)
Fiber Solids
Drying
High Fiber Canola Meal (low anti-nutrition factors)
Insoluble and Soluble Proteins Slurry
Acid (e.g. phosphoric acid)
Cooking (pH 4.5)
(Decanter Centrifuge and Disc Stack Centrifuge) Separation of Insoluble Protein Solids from Liquid Extract
Liquid Extract
Wet Protein Solids
Drying
Protein Concentrate at 65–70% Protein

FIGURE 35

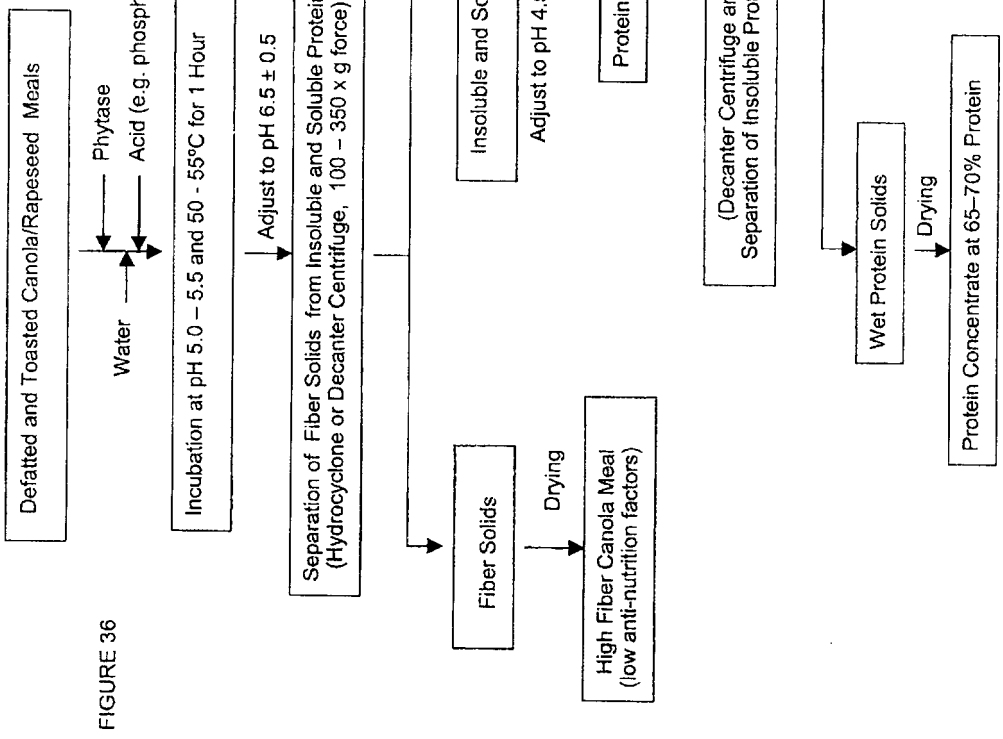

Defatted and Toasted Canola/Rapeseed Meals
Water
Phytase
Acid (e.g. phosphoric acid)
Incubation at pH 5.0 – 5.5 and 50 - 55°C for 1 Hour
Adjust to pH 6.5 ± 0.5
Separation of Fiber Solids from Insoluble and Soluble Proteins (Hydrocyclone or Decanter Centrifuge, 100 – 350 x g force)
Fiber Solids
Drying
High Fiber Canola Meal (low anti-nutrition factors)
Insoluble and Soluble Proteins Slurry
Adjust to pH 4.5
Ethanol
Protein Precipitation
(Decanter Centrifuge and Disc Stack Centrifuge) Separation of Insoluble Protein Solids from Liquid Extract
Liquid Extract
Wet Protein Solids
Drying
Protein Concentrate at 65–70% Protein

FIGURE 36

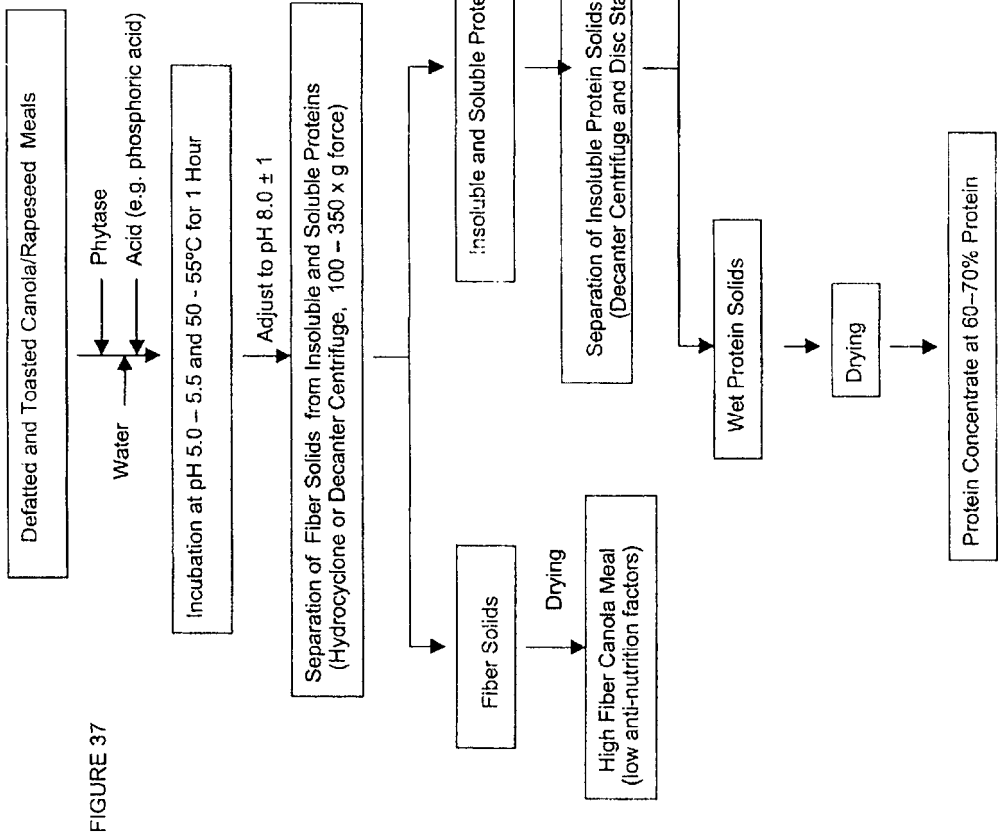

Defatted and Toasted Canola/Rapeseed Meals
Water
Phytase
Acid (e.g. phosphoric acid)
Incubation at pH 5.0 – 5.5 and 50 - 55°C for 1 Hour
Adjust to pH 8.0 ± 1
Separation of Fiber Solids from Insoluble and Soluble Proteins (Hydrocyclone or Decanter Centrifuge, 100 – 350 x g force)
Fiber Solids
Drying
High Fiber Canola Meal (low anti-nutrition factors)
Insoluble and Soluble Proteins Slurry
Separation of Insoluble Protein Solids from Liquid Extract (Decanter Centrifuge and Disc Stack Centrifuge)
Wet Protein Solids
Drying
Protein Concentrate at 60–70% Protein
Soluble Protein Extract
Ultrafiltration and Diafiltration
Spray Drying
Protein Isolate at ≥ 90% Protein

FIGURE 37

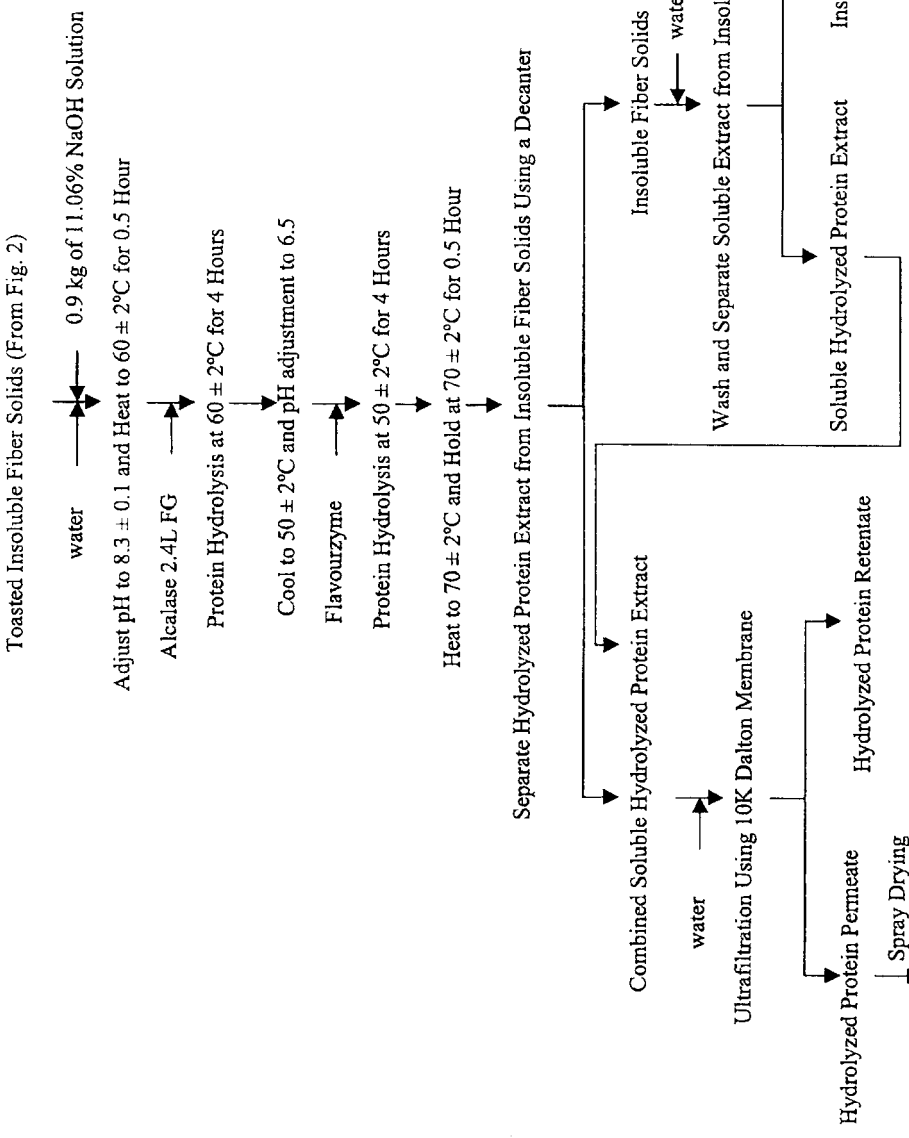

Toasted Insoluble Fiber Solids (From Fig. 2)
water
0.9 kg of 11.06% NaOH Solution
Adjust pH to 8.3 ± 0.1 and Heat to 60 ± 2°C for 0.5 Hour
Alcalase 2.4L FG
Protein Hydrolysis at 60 ± 2°C for 4 Hours
Cool to 50 ± 2°C and pH adjustment to 6.5
Flavourzyme
Protein Hydrolysis at 50 ± 2°C for 4 Hours
Heat to 70 ± 2°C and Hold at 70 ± 2°C for 0.5 Hour
Separate Hydrolyzed Protein Extract from Insoluble Fiber Solids Using a Decanter
Insoluble Fiber Solids
water
Wash and Separate Soluble Extract from Insoluble Fiber Solids
Soluble Hydrolyzed Protein Extract
Insoluble Fiber Solids
Combined Soluble Hydrolyzed Protein Extract
water
Ultrafiltration Using 10K Dalton Membrane
Hydrolyzed Protein Permeate
Hydrolyzed Protein Retentate
Spray Drying
Spray Dried Protein Concentrate
(82% protein, dwb)

FIGURE 38

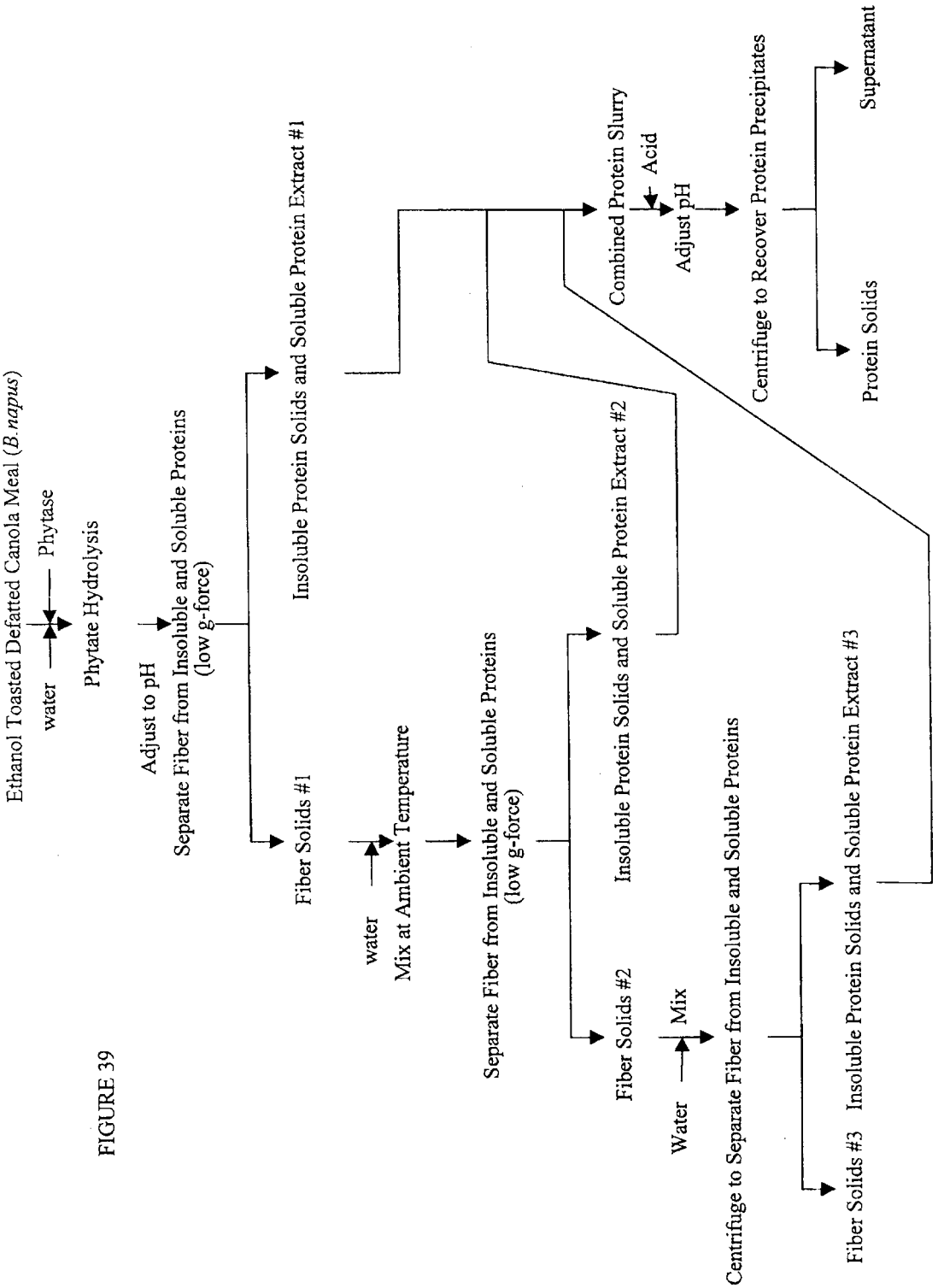

Ethanol Toasted Defatted Canola Meal (B.napus)
water
Phytase
Phytate Hydrolysis
Adjust to pH
Separate Fiber from Insoluble and Soluble Proteins
(low g-force)
Fiber Solids #1
Insoluble Protein Solids and Soluble Protein Extract #1
water
Mix at Ambient Temperature
Separate Fiber from Insoluble and Soluble Proteins
(low g-force)
Fiber Solids #2
Insoluble Protein Solids and Soluble Protein Extract #2
Water
Mix
Centrifuge to Separate Fiber from Insoluble and Soluble Proteins
Fiber Solids #3
Insoluble Protein Solids and Soluble Protein Extract #3
Combined Protein Slurry
Acid
Adjust pH
Centrifuge to Recover Protein Precipitates
Protein Solids
Supernatant

FIGURE 39

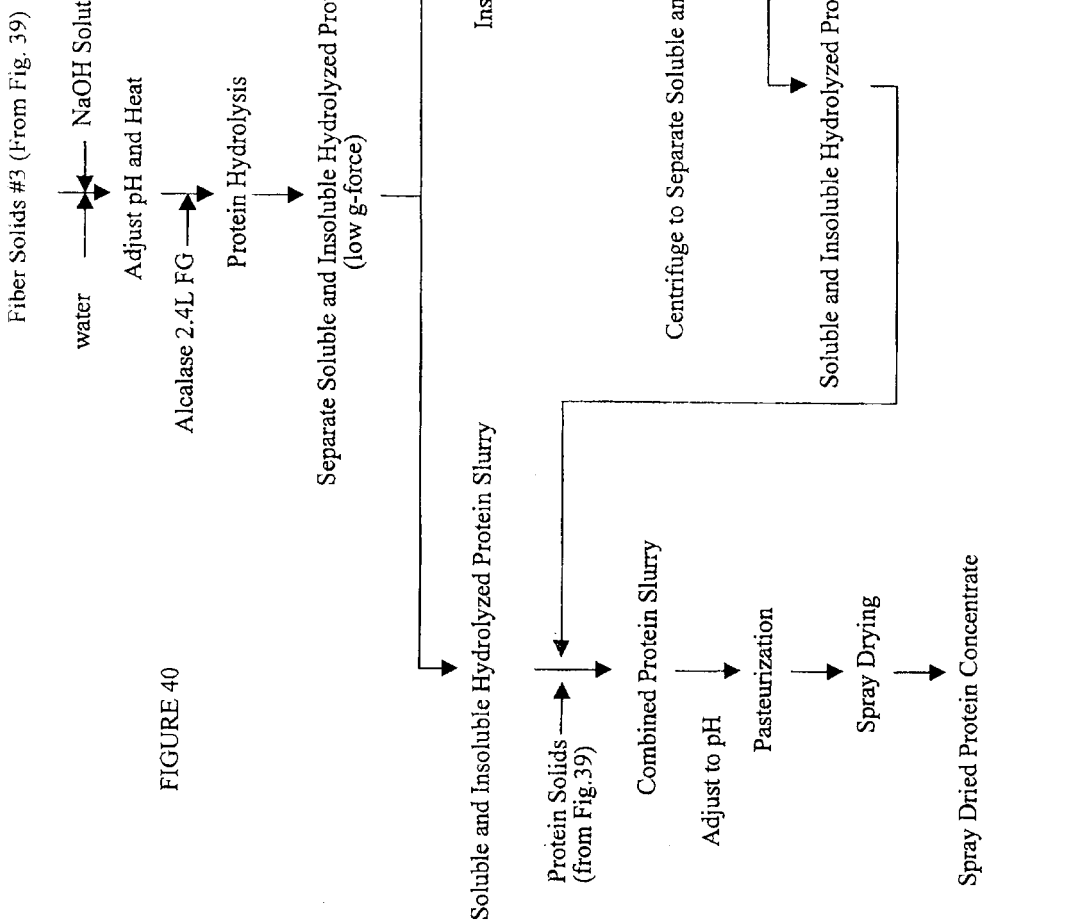

Fiber Solids #3 (From Fig. 39)
water
NaOH Solution
Adjust pH and Heat
Alcalase 2.4L FG
Protein Hydrolysis
Separate Soluble and Insoluble Hydrolyzed Proteins from Fiber Solids
(low g-force)
Insoluble Fiber Solids #4
water
Mix
Centrifuge to Separate Soluble and Insoluble Hydrolyzed Proteins from Fiber Solids
(low g-force)
Soluble and Insoluble Hydrolyzed Protein Slurry
Insoluble Fiber Solids #5
Drying
(Fluidized Bed Dryer)
Dried Canola Fiber Solids
Protein Solids
(from Fig.39)
Combined Protein Slurry
Adjust to pH
Pasteurization
Spray Drying
Spray Dried Protein Concentrate

FIGURE 40

FIGURE 41

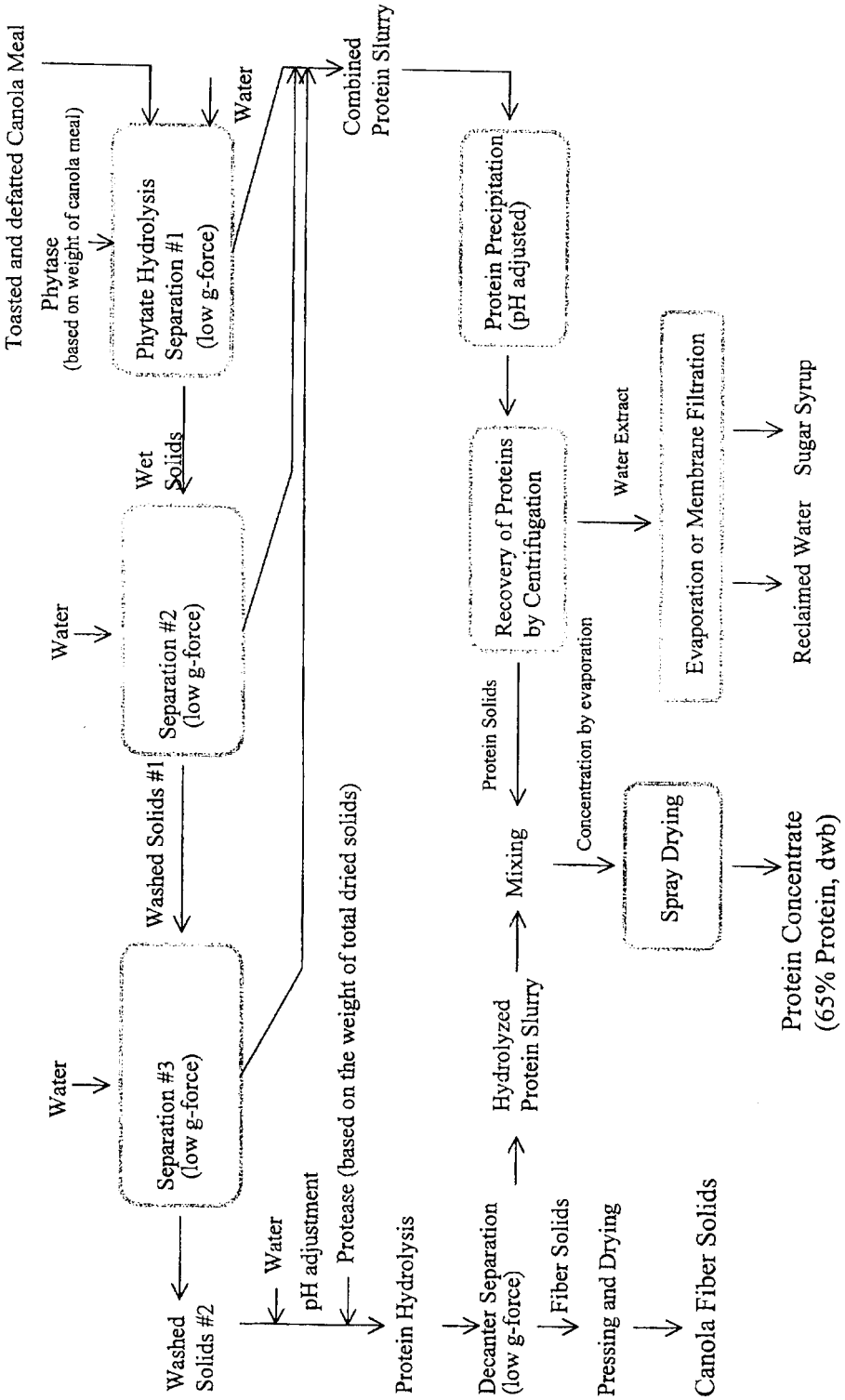
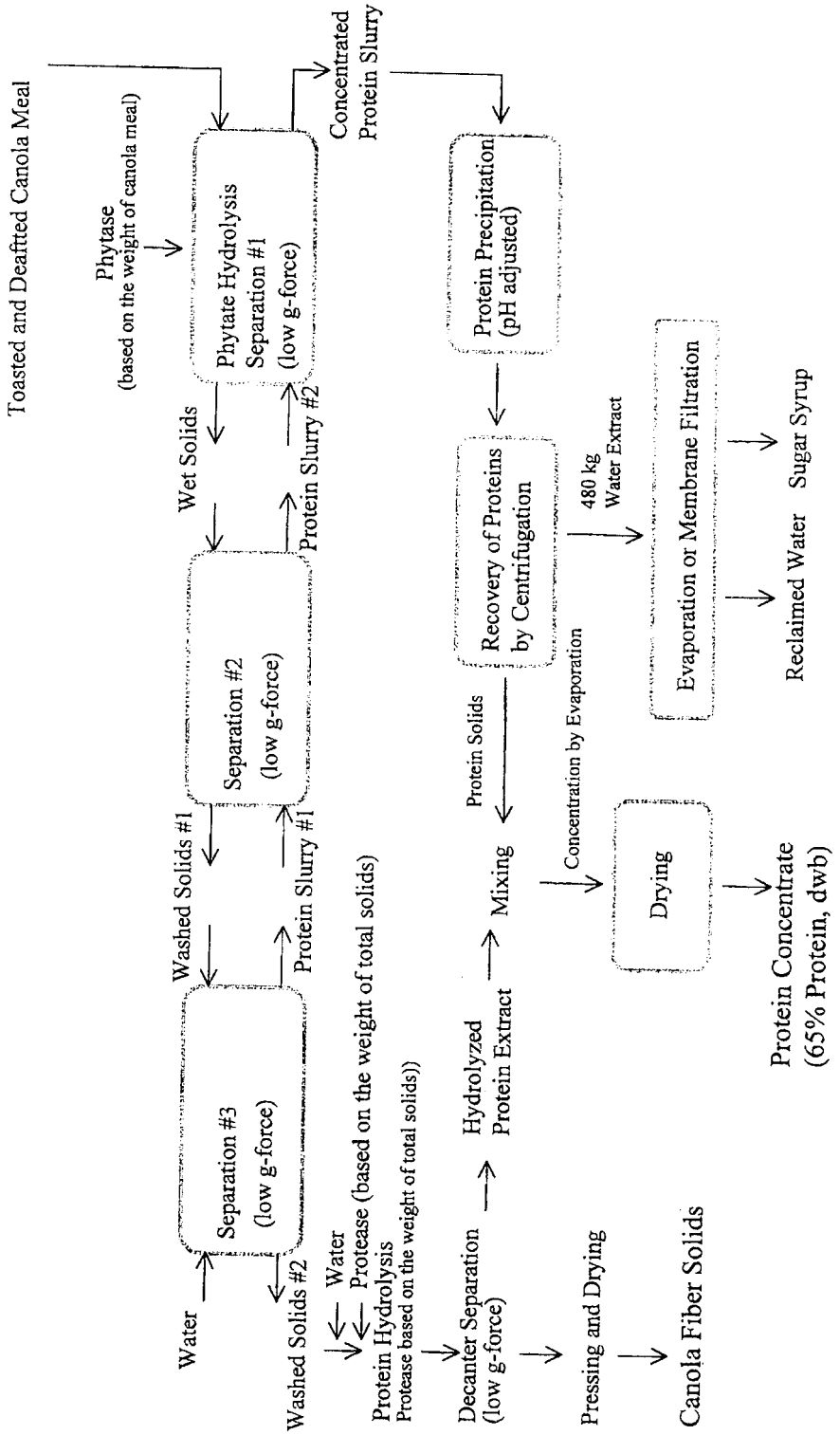

Toasted and defatted Canola Meal
Phytase
(based on weight of canola meal)
Phytate Hydrolysis
Separation #1
(low g-force)
Water
Combined
Protein Slurry
Wet
Solids
Water
Separation #2
(low g-force)
Washed Solids #1
Water
Separation #3
(low g-force)
Washed
Solids #2
Water
pH adjustment
Protease (based on the weight of total dried solids)
Protein Hydrolysis
Decanter Separation
(low g-force)
Fiber Solids
Pressing and Drying
Canola Fiber Solids
Hydrolyzed
Protein Slurry
Mixing
Protein Solids
Recovery of Proteins
by Centrifugation
Protein Precipitation
(pH adjusted)
Concentration by evaporation
Water Extract
Spray Drying
Evaporation or Membrane Filtration
Reclaimed Water
Sugar Syrup
Protein Concentrate
(65% Protein, dwb)

FIGURE 42


Toasted and Deaftted Canola Meal
Phytase
(based on the weight of canola meal)
Phytate Hydrolysis
Separation #1
(low g-force)
Concentrated
Protein Slurry
Wet Solids
Protein Slurry #2
Separation #2
(low g-force)
Washed Solids #1
Protein Slurry #1
Water
Separation #3
(low g-force)
Washed Solids #2
Water
Protease (based on the weight of total solids)
Protein Hydrolysis
Protease based on the weight of total solids))
Decanter Separation
(low g-force)
Hydrolyzed
Protein Extract
Mixing
Protein Solids
Recovery of Proteins
by Centrifugation
Protein Precipitation
(pH adjusted)
480 kg
Water Extract
Concentration by Evaporation
Evaporation or Membrane Filtration
Reclaimed Water
Sugar Syrup
Drying
Pressing and Drying
Canola Fiber Solids
Protein Concentrate
(65% Protein, dwb)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6335043 B1 **[0004]**

Non-patent literature cited in the description

- **DAUN, J.K. ; MCGREGOR, D.I.** *Glucosinolate Analysis of Rapeseed (Canola),* 15 December 1981 **[0170]**