



(22) Date de dépôt/Filing Date: 2013/03/15

(41) Mise à la disp. pub./Open to Public Insp.: 2013/11/02

(30) Priorité/Priority: 2012/05/02 (US61/641,551)

(51) Cl.Int./Int.Cl. *A23L 2/04* (2006.01),  
*A23L 1/212* (2006.01), *A23L 2/02* (2006.01),  
*A23L 2/08* (2006.01), *A23L 2/70* (2006.01),  
*A23N 1/00* (2006.01)

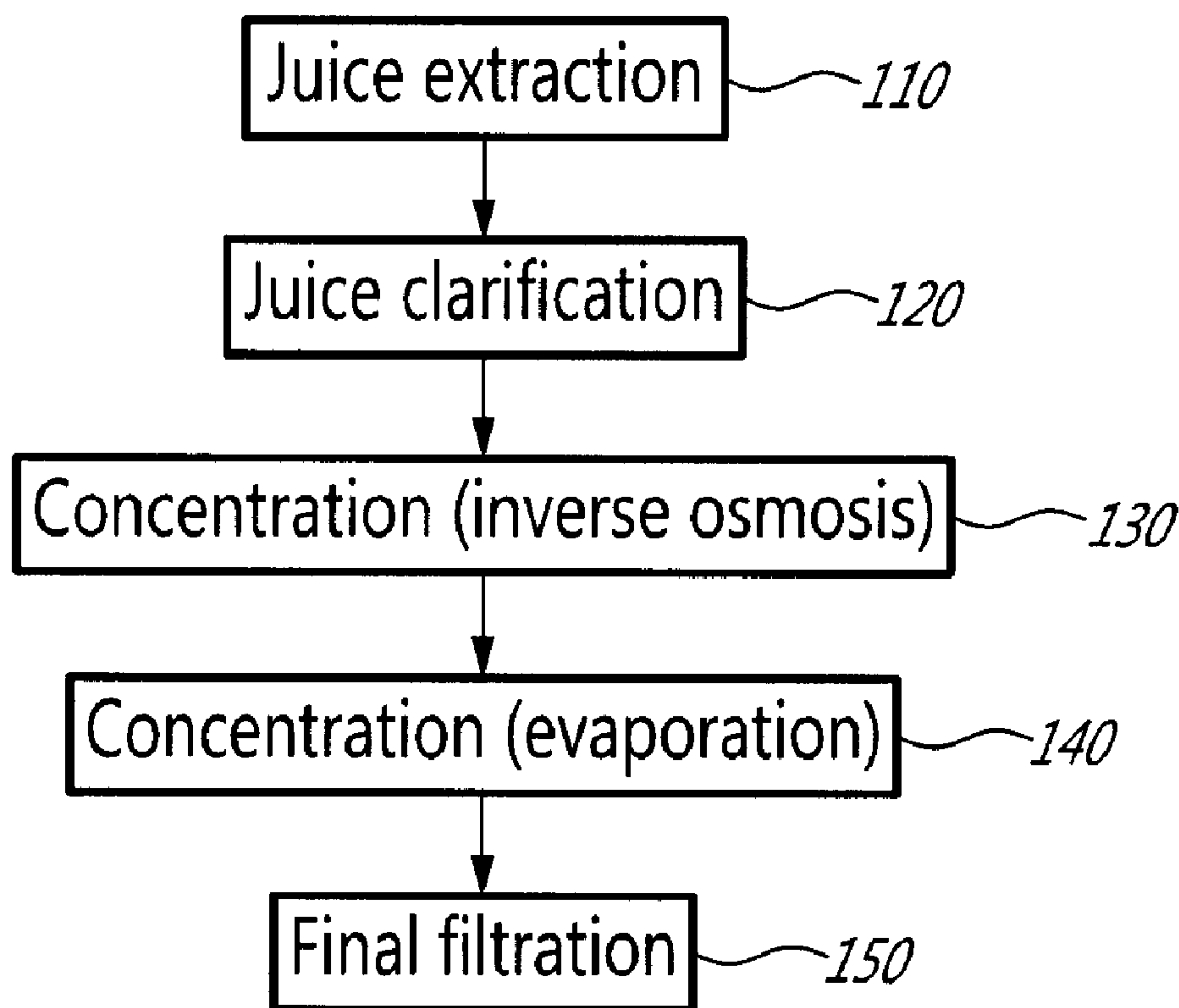
(71) Demandeur/Applicant:  
LES VERGERS CATAPHARD INC., CA

(72) Inventeurs/Inventors:  
CHADJAA, HASSAN, CA;  
RAHNI, MOHAMED, CA

(74) Agent: GOUDREAU GAGE DUBUC

(54) Titre : PROCÉDE ET SYSTÈME DE TRANSFORMATION DE LA POMME ET PRODUITS DE CEUX-CI

(54) Title: METHOD AND SYSTEM FOR PROCESSING APPLE AND PRODUCTS THEREFROM



(57) Abrégé/Abstract:

A method for processing apple, comprising juice extraction; clarification of the extracted juice; and concentration, and adjusting the quality of the final product, in terms of sugar and acidity content, depending on target use of the product. Moreover, the method allows maintaining a distinctive flavor, i.e. an apple flavor, in the final product, in particular by preserving the related chemical molecules up to the concentration steps and allowing an adjustable malic acid content.



## ABSTRACT

A method for processing apple, comprising juice extraction; clarification of the extracted juice; and concentration, and adjusting the quality of the final product, in terms of sugar and acidity content, depending on target use of the product. Moreover, the method allows maintaining a distinctive flavor, i.e. an apple flavor, in the final product, in particular by preserving the related chemical molecules up to the concentration steps and allowing an adjustable malic acid content.

## 5 TITLE OF THE INVENTION

Method and system for processing apple and products therefrom

## FIELD OF THE INVENTION

10 [0001] The present invention relates to fruit processing. More specifically, the present invention is concerned with a method and a system for processing apple and products therefrom.

## SUMMARY OF THE INVENTION

[0002] More specifically, in accordance with the present invention, there is provided for processing apple, comprising juice extraction, clarification of the extracted juice, and concentration.

15 [0003] There is further provided a system for processing apple juice, comprising a juice extraction unit extracting juice from apples, a clarification unit receiving the extracted juice, a concentration unit receiving clarified juice from said clarification unit, and a temperature controller connected to the juice extraction unit, the clarification unit and the concentration unit.

20 [0004] There is further provided apple products comprising fructose in an amount in a range between about 54 and about 66% w/w and malic acid in an amount between about 2 and 5.2% w/w, for a concentration rate of sugars comprised between about 20 and 60% w/w.

[0005] Other objects, advantages and features of the present invention will become more apparent upon reading of the following non-restrictive description of specific embodiments thereof, given by way of example only with reference to the accompanying  
25 drawings.

## 5 BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]** In the appended drawings:

**[0007]** Figures 1 show flowcharts of a method according to a) a first embodiment b) a second embodiment and c) a third embodiment of an aspect of the present invention;

**[0008]** Figure 2 is a schematic representation of a system according to an  
10 embodiment of an aspect of the present invention; and

**[0009]** Figure 3 shows an analysis of nutrition facts of apple extract as obtained according to an embodiment of an aspect of the present invention.

## DESCRIPTION OF EMBODIMENTS OF THE INVENTION

**[0010]** Different apples cultivars (McIntosh, Cortland) were characterized in terms of  
15 sugar (fructose, glucose and sucrose) contents: respective amounts of the different sugars, amount of sugars relative to the total organic matter as determined by measures of the total organic carbon, and amounts of sugars relative to the total quantity of apples. Juice extraction was performed using a commercial juice extracting machine of small capacity. The apples were crushed and the juice simultaneously extracted under a centrifugal force. For each apple cultivar, about 500 g of apples  
20 were used to produce a volume of juice sufficient for analysis.

**[0011]** The following results were obtained:

- i) the weight of produced juice varies between about 60 and 65% of weight of apples, depending on the apples;
- ii) the sugar concentrations varies between about 87g/l and 100g/l of  
25 juice;
- iii) the fructose content varies between about 49 and 61% in weight of total sugars in the apples, the glucose content varies between about 8

- 5 and 14% in weight of total sugars in the apples, and the sucrose content varies between about 25 and 37% in weight of total sugars in the apples;
- iv) the sugar content relative to the apple matter varies between about 5,9 and 7,1% in weight of apples. The sugars represent between  
10 about 89 and 97,8% of the total solid content of the juice.

**[0012]** According to the method of the present invention illustrated in Figures 1, a first step (110) comprises juice extraction. A centrifugal juice extracting machine, which allows separation of solid from liquid of the apples in a single pass, was tested. It proved to be difficult to operate and  
15 yield juice extraction results below 50% of the weight of the crushed and pressed apples. A juice extracting machine comprising a crushing unit and an extraction unit operating under hydraulic pressure was also tested, as will be described hereinbelow. Extraction yield was around 60% in weight of recovered juices relative to the apples.

**[0013]** A second step (120) comprises clarifying the juice by micro filtration or ultrafiltration. Figure 2 shows a system used for filtration. The solution to be processed is fed, from a  
20 feeding reservoir 12, using a variable-flow capacity pump 14, to a membrane filter unit 16. Under a pressure applied on the concentrate side, using a valve 17 at the output of the membrane filter unit 16, a permeate, accumulated in a permeate reservoir 18, is separated from a concentrate, which is returned to the feeding reservoir 12. The filtration is stopped when a desired concentration of sugars  
25 in the permeate is achieved. The concentration is determined from the volumes of the initial feeding solution, of the permeate and of the concentrate. During the filtration, the temperature was maintained constant using a heat exchanger located within the feeding reservoir 12, as will be described hereinbelow.

**[0014]** The objective of step 120 is to reduce the organic content of the pressed juice  
30 by removing the organic particles, such as fibers in suspension in the juice for example, and also pectin, which may otherwise form a gel during a subsequent evaporation step, while keeping savor molecules proper to the starting fruits. Thus, this step allows protecting the membranes used in a

5 following step of concentration (Step 130). Also, this step allows removing acids.

**[0015]** Each filtration test comprised the following steps:

- 10
- i) membranes permeability measurement using de-mineralized water, which characterized the membrane unit in a clean state;
  - ii) filtration of the solution to be processed. During filtration, the flow of permeate was measured, as well as the pressure on the permeate (which varied between 30 and 200 psi depending on the tested membranes) and the temperature of the permeate (which was between 6 and 8°C prior to filtration, and could reach a temperature between 20 and 25°C in absence of cooling during filtration).
- 15
- Moreover, samples of the permeate and of the concentrate were collected for analysis;
- iii) membrane unit cleaning;
  - iv) membranes permeability measurement using de-mineralized water, to assess the efficiency of the cleaning.

20

**[0016]** A number of analyses were performed to assess the quality and efficiency of the membrane units, including: total solid parts, pH, electric conductivity (which gives an indication on the presence of residual salts in samples), total organic carbon, and sugar analysis by High Performance Liquid Chromatography (HPLC), acids analysis by HPLC.

25 **[0017]** Performances of different membrane units were tested, on membranes of porosity of 0.2 µm, and membranes of molecular weight cut-offs of 300kD and 150kD respectively. A ceramic membrane 300kD was also compared with an organic tubular membrane (HFMP500), as will be described hereinbelow.

**[0018]** A third step (130) comprises concentrating the clarified juice. Concentration of  
30 the sugars contained in the juice was performed ;

5     **[0019]**                 A temp (BW30 by Filmtec). Performances of nanofiltration membranes were tested (NF270 and NF90 by Filmtec) so as to assess the possibility of improving the purity of the sugars, in particular the reduction of acids in the final permeate.

**[0020]**                 During steps 120 and 130, the temperature of the permeate is controlled, either by agitation, by rotating the permeate; or by using a double wall reservoir circulating glycol; or  
10    by air injection, for example, so as to maintain the temperature of the juice around 10-12°C., i.e. in a range of temperatures preventing growth of microbial biomass.

**[0021]**                 Step 130 allows reaching a sugar concentration of up to between about 20 and 23% w/w of the juice.

**[0022]**                 A further step (140) comprises evaporating the concentrate by elevating the  
15    temperature of the concentrate to above 100°C, typically between about 103°C and about 107°C. This step allows concentrating the sugars to obtain a Brix of about 65.

**[0023]**                 In an embodiment illustrated in Figure 1B, after step 120 of clarification, the method comprises a step (122) of discoloration of the clarified juice using a nanofiltration membrane for example (XN45 by Filmtec), and a step (124) of deacidification of the discolored juice, either by  
20    nanofiltration or ultrafiltration. Again, the temperature of the liquid is controlled during nanofiltration, ultrafiltration and reverse osmosis, to prevent growth of microbial biomass.

**[0024]**                 In an embodiment illustrated in Figure 1C, step 120' of clarification allows, in a single step, clarification, discoloration and deacidification. By adjusting the pH of the juice, initially comprised in a range between 3.2 and 3.4, at which acid functions are mainly present under a  
25    molecular form, to a pH of about 6, adding NaOH or Ca(OH)<sub>2</sub> for example, the majority of acid functions are obtained as acid salts, which may be filtered out of the juice. Tests showed a filtration rate of acids in the juice at pH 6 of about 61% and a separation rate of mineral ions (sodium, calcium and potassium) of about 38%, while the separation rate of fructose and glucose was kept minimal. Also, such filtration allows a discoloration rate of about 98%. As a result of step 120', a permeate

5 having concentrations of glucose and fructose essentially similar to the initial apple juice is obtained, with a concentration in sucrose reduced by about 40%, a reduction in organic acids concentration of about 61% and of mineral ions of about 38%, and 98% discoloration. Filtration was performed using an ultrafiltration membrane UA 60, by Trisep, i.e. a membrane with a molecular weight cut off MWCO of 3,5 Kd. Tests were done using a spiral type membrane of a filtering surface of about 7 m<sup>2</sup>, at a  
10 pressure of 100 psi and a feeding flowrate of 22l/min. At this pressure, the flowrate of the permeate was stable at about 20 l/h/ m<sup>2</sup> during filtration. The filtration comprised producing 15 l of permeate from 20 l of apple juice, i.e. a recuperation permeate rate of 75%. The filtration performances, in terms of flowrate of permeate and separation rate of acids, sugars and minerals, lead to believe that permeate recuperation rate may be increased to about 95%. Recuperation of sugars may further be  
15 increased by diafiltration, which, however, causes increasing the acid content in the permeate. The ultrafiltration membrane was cleaned with a NaOH solution at pH 11, which allowed recovering its initial permeability.

**[0025]** The method may further comprise a step 150 of final filtration. The final filtration step 150 is achieved by sheet filtration, using sheet filters of a variable size, between about  
20 2 µm and about 5 µm, in order to remove any remaining solid particles from the concentrate.

**[0026]** Then, the syrup may then be bulk racked. For bottling, it may first cooled down to a temperature of about 70°C.

**[0027]** As mentioned hereinabove, membranes of different porosities were tested for the clarification step (120). Three ceramic membranes provided by the company Tami were tested: a  
25 microfiltration membrane of porosity 0,2 µm, and two ultrafiltration membranes of molecular weight cut-offs of 300kD and 150kD respectively. These membranes comprised 23 channels of hydraulic diameter 3,5 mm, for a filtering surface of 0,35 m<sup>2</sup>. The tests comprised extracting 8 l of permeate from 10 l juice, i.e. a recovery rate of 80%. The three membranes tested yield essentially similar performances in terms of average flow rate. The 300kD membrane was selected for the remaining of  
30 the study.

5     **[0028]**               Tests were then performed to optimize the different filtration parameters, by  
 filtration under different pressures (10 and 20 psi) and at different juice feeding flow rates (15, 20 and  
 25l/min). Each test comprised extracting 8l of permeate from 10l of juice. Increasing the pressure did  
 not result in an increase of the average permeate flow rate. Although the permeate flow rate was  
 increased during the first few minutes of filtration under 20 psi compared to under 10 psi, the average  
 10   flow rate proved to be higher at 10 psi than at 20 psi. Tests at 20 psi and at different juice feeding  
 flow rates showed that increasing the juice feeding flow rate results in a slight increase of the  
 average permeate flow rate.

**[0029]**               In order to compare performances of ceramic and organic membranes,  
 filtration tests were performed with a unit comprising three ceramic membranes of molecular weight  
 15   cut-off of 300kD (i.e. filtrating surface of 1,05 m<sup>2</sup>), and a unit comprising an organic membrane  
 (HFMP500) of filtrating surface of 1,5 m<sup>2</sup>. Average permeate flow rates were measured with  
 demineralised water before clarification tests and after cleaning of the membranes, as well as during  
 clarification of the juice. The obtained results showed that:

- 20                   i)       the ceramic membranes allowed cleaning with highly acidic or basic  
                           solutions, as well as the use of an oxidator, such as sodium  
                           hypochlorite for example, and, as a result, it was easier to reinstate  
                           their initial permeability;
- 25                   ii)       organic membranes were cleaned using NaOH solutions at pH 11,  
                           which did not allow resetting their initial permeability; a decrease in  
                           the water flow rate was observed after each test, which did not  
                           appear to decrease significantly the flow rates obtained during  
                           filtration of the juice; an acidic (HCl) cleaning at pH 2.5 and at a  
                           temperature of 50°C allowed recovering part of the initial  
                           permeability;
- 30                   iii)       in terms of juice clarification, i.e. flow rate and quality as determined  
                           by acid content, coloration (amber or gold), flavour (caramel or apple  
                           favour), the content and nature of the sugars in the syrup, the two  
                           types of membranes proved essentially similar.

5     **[0030]**             Extraction, clarification and inverse osmosis concentration tests were performed. Extraction was done with a juice extracting machine performing crushing and extraction, clarification with ceramic membranes of 300kD cut-off, and concentration with a reverse osmosis membrane (BW30). The juice extraction rate was poor, between about 42 and 46% in weight, i.e. a sugar extraction rate of about 5,7% in weight compared to the initial weight of apples. In order to  
10    increase the recovery rate of the sugars, water was added to the solid part and a second extraction was performed, which increased the sugar extraction rate to about 7% w/w compared to the quantity of apples. However, such addition of water increased the value of liquid to be clarified and concentrated. After the concentration, the recovery rate of the sugars was between about 6.3 and 7% w/w.

15    **[0031]**             Further tests were performed in the case of extraction done with a juice extracting machine comprising a crushing unit and a pressing unit for separating solids from liquids, clarification using ceramic membranes of 300kD cut-off, and concentration with a reverse osmosis membrane (BW30). Extraction rates, i.e. amount of juice relative to quantity of apples, were between 56 and 63% w/w. The recovery rate of the sugars in the concentrate of reverse osmosis was about  
20    7% w/w.

**[0032]**             A number of organic acids (malic, ascorbic, lactic, acetic and citric acids) were quantified to assess the quality of the obtained products. Results showed that the predominant acid is the malic acid, with amounts between about 2 and 5.2% w/w, depending on the concentration rates of the sugars (20, 45 and 60% w/w).

25    **[0033]**             Nanofiltration membranes (NF270, NF400 and XN45) were tested for discoloration (step 122). Results showed that the XN45 membrane allowed a higher discoloration and yield the highest content of sugars through in the permeate with a through rate of fructose and glucose between about 50 and 60% w/w. In order to recover a maximum amount of sugars in the permeate, a diafiltration was performed with 10 volumes of demineralised water, 1 volume of  
30    diafiltration corresponding to a volume of concentrate to be filtered. All tested membranes held the sucrose within the concentrate.

5    **[0034]**               It was thus shown that ultrafiltration membranes, either ceramic or organic, allowed an effective clarification (step 120) of the apple juices. Ceramic membranes are more resistant to chemical agents such as acids and bases and therefore could be cleansed using these chemical agents at high concentrations for an effective cleaning thereof.

10   **[0035]**               The reverse osmosis membrane BW30 allowed concentrating sugars at rates up to about 20% w/w, which correspond to a water removal of about 50% w/w (in step 130). For higher sugars concentration rates, a water evaporation step was performed (step 140). As people in the art will appreciate, step 140 may be omitted.

15   **[0036]**               The XN45 membrane allowed an efficient discoloration of the clarified juices. However, using this membrane resulted in a loss of about 25% w/w of the sucrose (C12 sugar), while the loss of fructose and glucose (C6 sugars) was less than 2% w/w. A diafiltration with 10 l water volumes was necessary to recover a maximum amount of fructose and glucose in the permeate.

20   **[0037]**               As people in the art will appreciate, the method allows adjusting the quality of the final product, in terms of sugar and acidity content, depending on target use of the product. Moreover, the method allows maintaining a distinctive flavor, i.e. an apple flavor, in the final product, in particular by preserving the related chemical molecules up to the concentration steps and allowing an adjustable malic acid content.

25   **[0038]**               The obtained syrup comprises sugars, i.e. mainly fructose, in amounts of about 60% w/w, i.e. in a range between about 54 and about 66% w/w, as well as glucose in amounts of about 22% w/w, i.e. in a range between about 20 and about 25% w/w, sucrose in amounts of about 18% w/w, i.e. in a range between about 16 and about 20% w/w; and acids, i.e. mainly malic acid in amounts of about 4,30 %w/w, i.e. in a range between about 2 and 5.2% w/w, for example between about 3.5 and about 5.1 w/w, as well as citric acid (about 0,2%w/w  $\pm$  20%) and ascorbic acid (about 0,06%w/w  $\pm$  20%). It is a completely natural product, devoid of organic residues which might cause formation of gel or crystallization of the product over time. The resulting product has a high sweetening power, 1,5 times that of white sugar for example, and can thus be used to achieve a

30

- 5     desired sweet flavor. It has a lower glycemic index than sucrose or glucose. Produced apple sugars is totally natural and devoid of pectin. Figure 3 shows an analysis of nutrition facts of apple extract as obtained.

**[0039]**                    The present system and method allow using chopper fruits, which are otherwise standardly thrown away.

- 10    **[0040]**                    The present system and method allows producing apple syrup comprising mainly fructose, i.e. with a low glycemic index, and a range of juice-based products. The sweetening activity of the obtained product is about 1,5 times greater than that of maple syrup for example for a same quantity. The obtained products comprise malic acid.

- [0041]**                    The present method allows producing a range of juice-based products,  
15    including for example apple pulled sugar, apple molasses, and sweet products at high malic acid content.

**[0042]**                    The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

## WHAT IS CLAIMED IS:

1. A method for processing apple, comprising:  
juice extraction;  
clarification of the extracted juice; and  
concentration.
2. The method of claim 1, comprising, after said clarification, discoloration of the clarified juice and deacidification of the discolored juice.
3. The method of claim 2, wherein said discoloration comprises using a nanofiltration membrane and said deacidification comprises using one of: nanofiltration and ultrafiltration.
4. The method of claim 1, wherein said clarification of the extracted juice comprises clarification, discoloration and deacidification of the extracted juice.
5. The method of any one of claims 1 to 4, wherein said clarification comprises adjusting the pH of the extracted juice to a pH of about 6.
6. The method of any one of claims 1 to 5, wherein said clarification comprises using a filtration membrane with a molecular weight cut off MWCO of 3,5 Kd.
7. The method of any one of claims 1 to 6, wherein said juice extraction comprises using crushing unit and an extraction unit.
8. The method of any one of claims 1 to 7, wherein said juice extraction comprises using a centrifugal juice extracting machine.
9. The method of any one of claims 1 to 3, wherein said clarification of the extracted juice comprises one of: micro filtration and ultrafiltration.

10. The method of any one of claims 1 to 3, wherein said clarification of the extracted juice comprises passing the extracted juice to a membrane filter unit separating a permeate and a concentrate from said extracted juice.

11. The method of claim 10, further comprising passing the concentrate to the membrane filter unit.

12. The method of any one of claims 1 to 11, wherein said clarification comprises reducing an organic content of the extracted juice.

13. The method of any one of claims 1 to 11, wherein said clarification comprises removing pectin from the extracted juice.

14. The method of any one of claims 1 to 13, wherein said concentration comprises using a reverse osmosis membrane.

15. The method of any one of claims 1 to 14, comprising controlling the temperature of the juice in a range between about 10 and 12°C.

16. The method of any one of claims 1 to 15, further comprising evaporating a resulting concentrate by elevating the temperature of the concentrate to above 100°C.

17. The method of any one of claims 1 to 16, further comprising evaporating a resulting concentrate by elevating the temperature of the concentrate between about 103°C and about 107°C.

18. The method of any one of claims 1 to 17, further comprising final filtration.

19. The method of 18, wherein said final filtration is achieved by sheet filtration.

20. The method of any one of claims 18 and 19, wherein said final filtration comprises using sheet filters of a variable size between about 2 µm and about 5 µm.

21. The method of any one of claims 1-3, 10 and 11, wherein said clarification comprises using ultrafiltration membranes of molecular weight cut-offs of 300kD.

22. A system for processing apple juice, comprising:  
a juice extraction unit extracting juice from apples;  
a clarification unit receiving the extracted juice;  
a concentration unit receiving clarified juice from said clarification unit; and  
a temperature controller connected to said juice extraction unit, said clarification unit, and said concentration unit.

23. The system of claim 22, further comprising an evaporator unit receiving a concentrate from said concentration unit and evaporating said concentrate by elevating the temperature of the concentrate to above 100°C.

24. The system of any one of claims 22 and 23, further comprising a discoloration unit receiving the clarified juice from said clarification unit, and a deacidification unit receiving discolored juice from said discoloration unit, before said concentration unit.

25. The system of any one of claims 22 and 23, wherein said clarification unit comprises a pH adjuster and a filtration membrane.

26. The system of any one of claims 22 to 25, further comprising a final filtration unit.

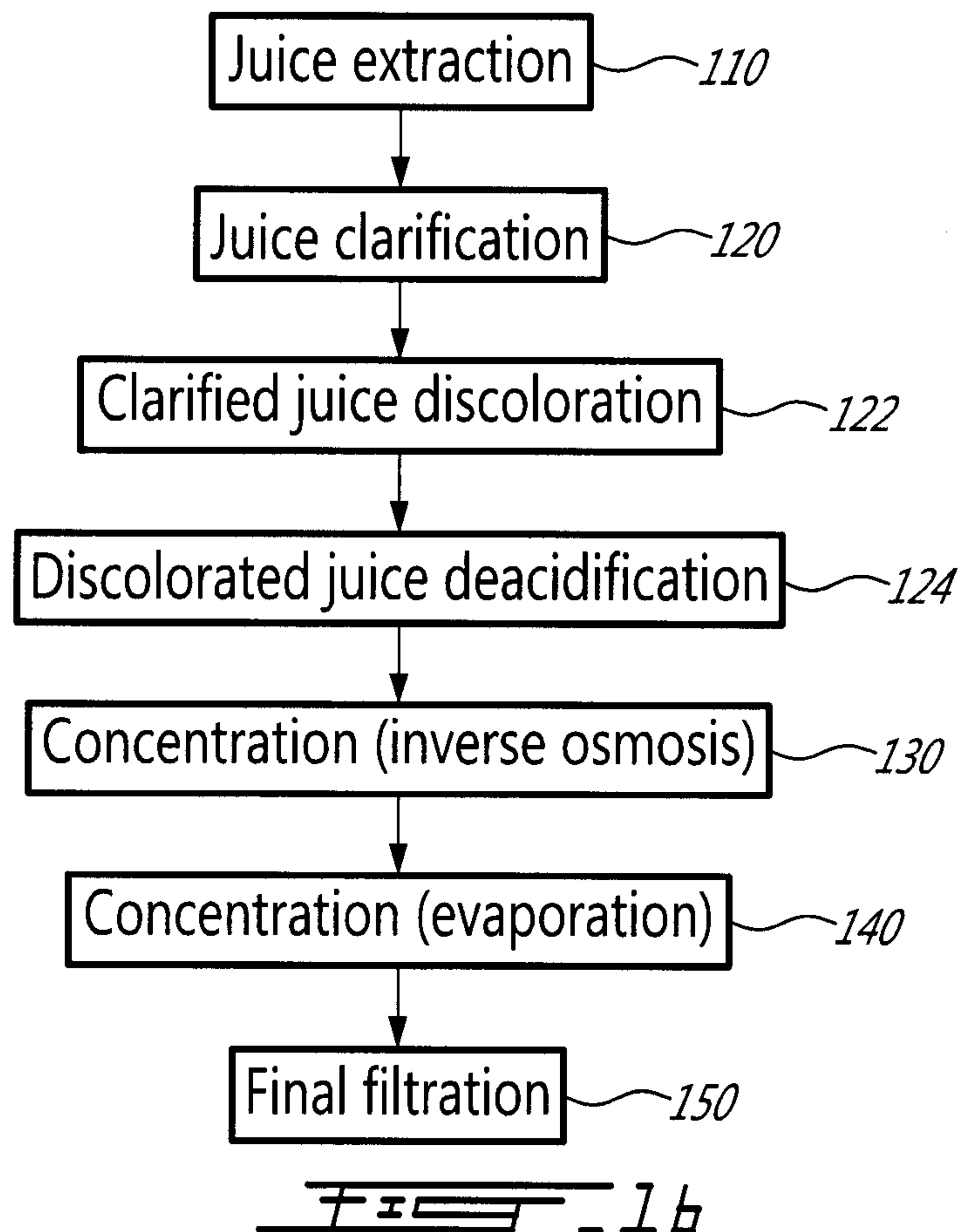
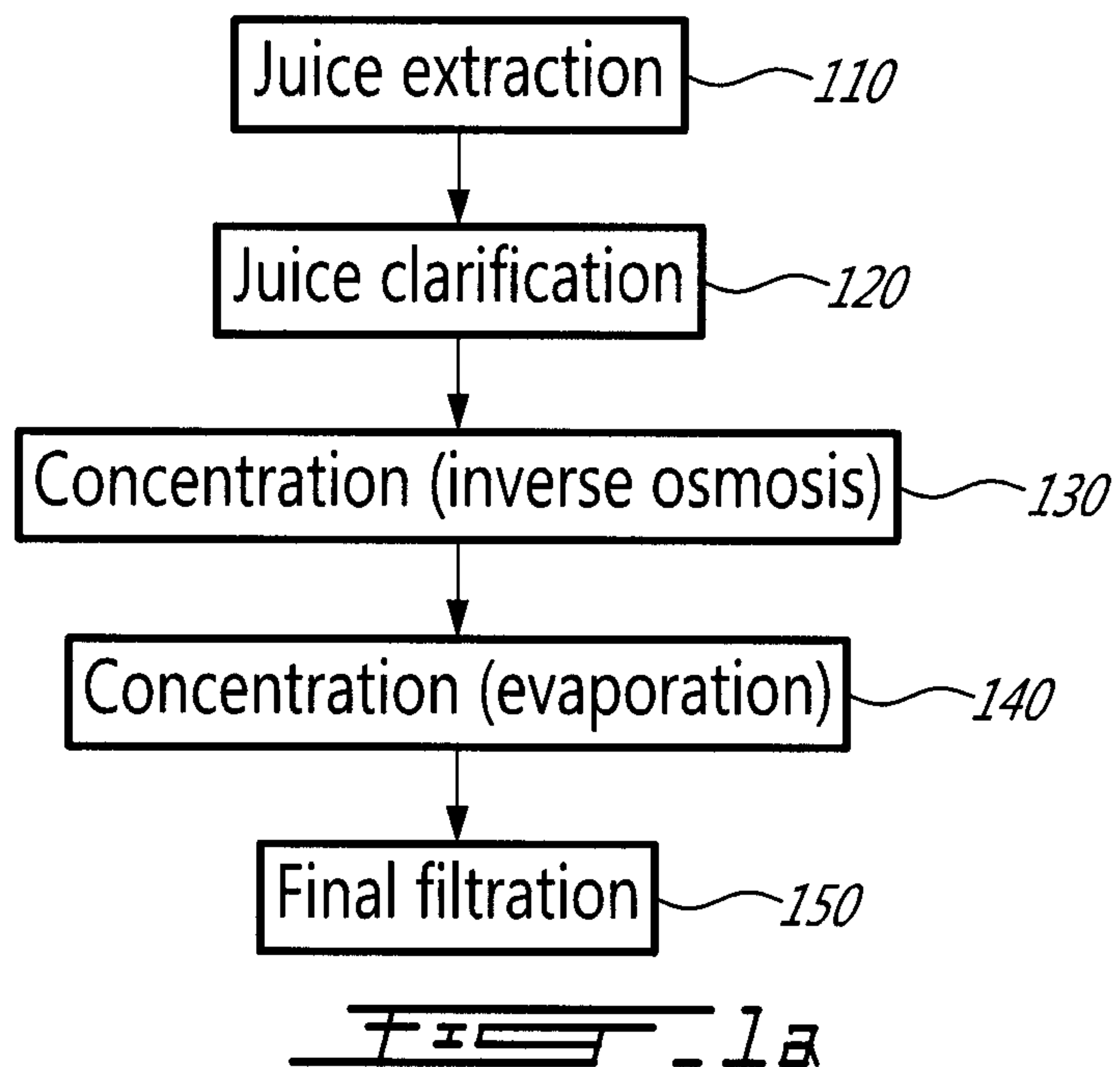
27. The system of claim 26, wherein said final filtration unit comprises sheet filters of a variable size, between about 2  $\mu\text{m}$  and about 5  $\mu\text{m}$ .

28. The system of any one of claims 22 to 27, wherein said juice extraction unit comprises a crushing unit and an extraction unit.

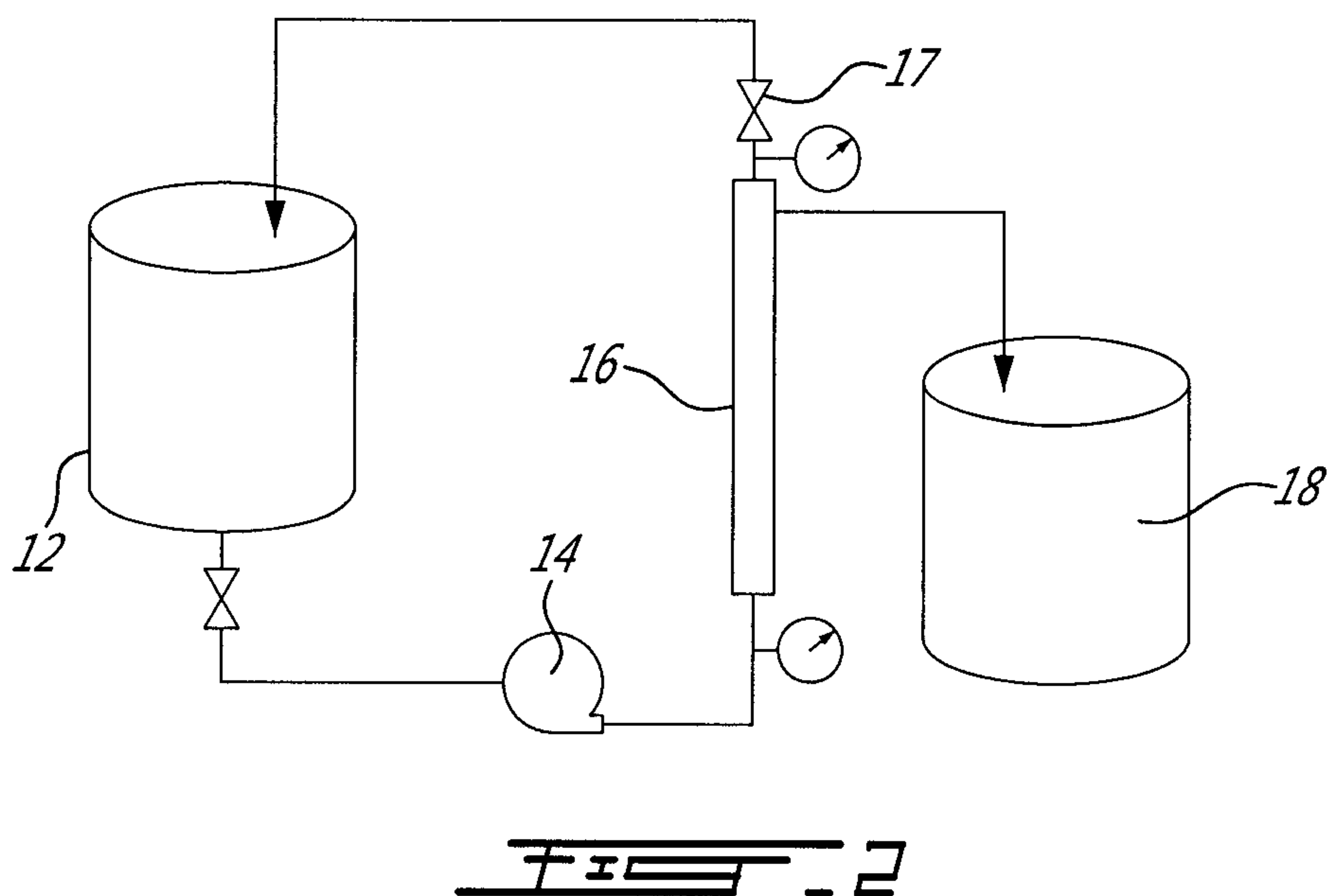
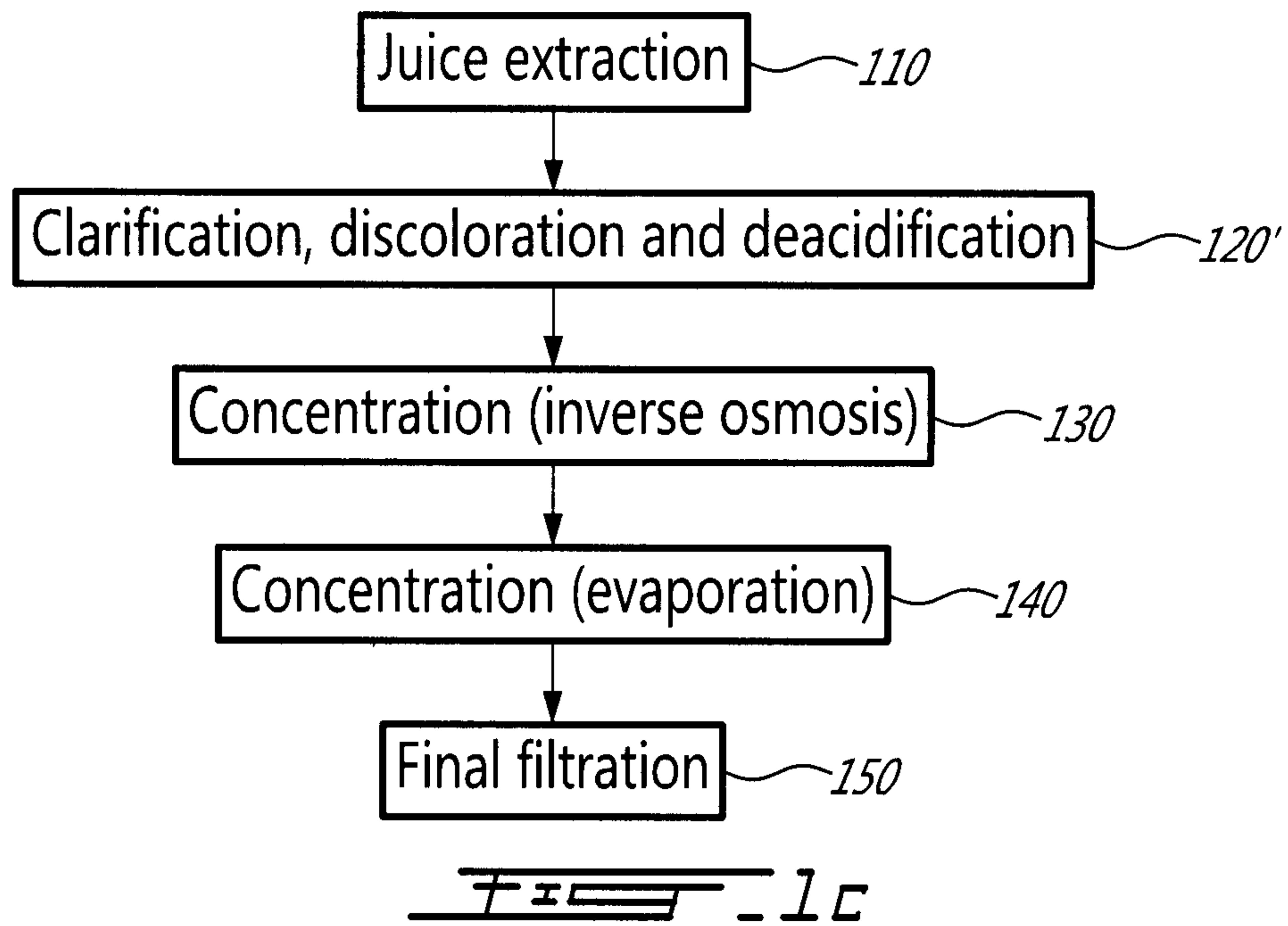
29. The system of any one of claims 22 to 27, wherein said juice extraction comprises a centrifugal juice extracting machine.

30. Apple products comprising fructose in an amount in a range between about 54 and about 66% w/w and malic acid in an amount between about 2 and 5.2% w/w, for a concentration rate of sugars comprised between about 20 and 60% w/w.

1 / 3



2 / 3



3 / 3

**Nutrition Facts****Valeur nutritive**

per 1/4 cup (60 mL) par 1/4 tasse (60 mL)

| Amount | % Daily Value        |
|--------|----------------------|
| Teneur | % valeur quotidienne |

Calories / Calories 210

|               |       |    |
|---------------|-------|----|
| Fat / Lipides | 0.7 g | 1% |
|---------------|-------|----|

|                     |       |    |
|---------------------|-------|----|
| Saturated / Saturés | 0.1 g | 1% |
| + Trans / Trans     | 0 g   |    |

|                           |      |    |
|---------------------------|------|----|
| Cholesterol / Cholestérol | 0 mg | 0% |
|---------------------------|------|----|

|                 |      |    |
|-----------------|------|----|
| Sodium / Sodium | 0 mg | 0% |
|-----------------|------|----|

|                         |      |     |
|-------------------------|------|-----|
| Carbohydrate / Glucides | 51 g | 17% |
|-------------------------|------|-----|

|                |     |    |
|----------------|-----|----|
| Fibre / Fibres | 1 g | 4% |
|----------------|-----|----|

|                 |      |  |
|-----------------|------|--|
| Sugars / Sucres | 44 g |  |
|-----------------|------|--|

|                     |     |  |
|---------------------|-----|--|
| Protein / Protéines | 0 g |  |
|---------------------|-----|--|

|                        |    |
|------------------------|----|
| Vitamin A / Vitamine A | 0% |
|------------------------|----|

|                        |    |
|------------------------|----|
| Vitamin C / Vitamine C | 2% |
|------------------------|----|

|                   |     |
|-------------------|-----|
| Calcium / Calcium | 15% |
|-------------------|-----|

|            |    |
|------------|----|
| Iron / Fer | 2% |
|------------|----|

**FIS-3**

