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(54) Benævnelse: **Fremgangsmåde til effektiv oprensning af neutrale modermælksoligosaccharider (HMO'er) fra mikrobiel fermentering**

(56) Fremdragne publikationer:
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DESCRIPTION

[0001] The present application discloses a simple process for the purification of neutral human milk oligosaccharides (HMOs) produced by microbial fermentation. The process uses a combination of a cationic ion exchanger treatment, an anionic ion exchanger treatment and electrodialysis, which allows efficient purification of large quantities of neutral HMOs at high purity. Contrary to the purification currently used in fermentative production of neutral HMOs, the presented process allows the provision of HMOs without the need of a chromatographic separation. The so purified HMOs may be obtained in solid form by spray drying, as crystalline material or as sterile filtered concentrate. The provided HMOs are free of proteins and recombinant material originating from the used recombinant microbial strains and thus very well-suited for use in food and feed applications.

[0002] Human milk represents a complex mixture of carbohydrates, fats, proteins, vitamins, minerals and trace elements. The by far most predominant fraction is represented by carbohydrates, which can be further divided into lactose and more complex oligosaccharides. Whereas lactose is used as an energy source, the complex oligosaccharides are not metabolized by the infant. The fraction of complex oligosaccharides accounts for up to 1/10 of the total carbohydrate fraction and consists of probably more than 150 different oligosaccharides. The occurrence and concentration of these complex oligosaccharides are specific to humans and thus cannot be found in large quantities in the milk of other mammals, like for example domesticated dairy animals.

[0003] The existence of these complex oligosaccharides in human milk is known already for a long time and the physiological functions of these oligosaccharides were subject to medicinal research for many decades. For some of the more abundant human milk oligosaccharides, specific functions have already been identified.

[0004] The limited supply and difficulties of obtaining pure fractions of individual human milk oligosaccharides lead to the development of chemical routes to some of these complex molecules. However, synthesis of human milk oligosaccharides by chemical synthesis, enzymatic synthesis or fermentation proofed to be challenging. At least large-scale quantities as well as qualities sufficient for food applications cannot be provided until today. In this regard, particularly chemical synthetic routes to human milk oligosaccharides (e.g. 2'-fucosyllactose; see WO 2010/115935 A1) involve several noxious chemicals, which impose the risk to contaminate the final product.

[0005] Due to the challenges involved in the chemical synthesis of human milk oligosaccharides, several enzymatic methods and fermentative approaches were developed. However, these methods - yield complex mixtures of oligosaccharides i.e. the desired product is contaminated with starting material such as lactose, biosynthetic intermediates and substrates such as individual monosaccharides and polypeptides etc.

[0006] Processes in the state of the art for purifying individual oligosaccharide products from these complex mixtures are technically complex and also uneconomical for food applications. For the purification of the disaccharides lactose or sucrose from complex mixtures such as whey or molasses, industrial scale processes have been developed which involve multiple crystallizations. The disadvantage of said methods is that they are elaborate and only lead to low yields.

[0007] For the purification of complex oligosaccharides from microbial fermentation, such as certain human milk oligosaccharides, gel-filtration chromatography is the method of choice until now. The disadvantage of gel-filtration chromatography is that it cannot be efficiently scaled up and it is unsuitable for continuous operation. Thus, gel-filtration chromatography is not economical and renders it impossible to provide certain human milk oligosaccharides - like 2'-fucosyllactose or lacto-*N*-tetraose - in reasonably amounts and quality to use them in human food.

[0008] Another problem is presented by the use of recombinant strains (recombinant bacterial or yeast strains) in the microbial fermentation, resulting in the contamination of the fermentation product with recombinant material. However, contamination with recombinant DNA or proteins is not acceptable by regulators and consumers today. Detection limits in particular for recombinant DNA molecules are very low. In case qPCR based detection is used, which is currently regarded as the gold standard for detection, even as little a single DNA molecules can be detected.

[0009] Electrodialysis (ED) represents a technique combining dialysis and electrolysis and can be used for the separation or concentration of ions in solutions based on their selective electromigration through semipermeable membranes. First industrial applications of electrodialysis dated back into the early 1960 with the demineralization of cheese whey for the use in infant formula. Further developed applications of electrodialysis include the adjustment of pH of beverages such as wines, grape must, apple juice and orange juice.

[0010] The desalination for brackish water for the production of drinking water and the demineralization of milk whey for infant food production represent the largest area of application, today.

[0011] The basic electrodialysis principle consists of an electrolytic cell composed of a pair of electrodes submerged into an electrolyte for conduction of ions connected to a direct current generator. The electrode connected to the positive pole of the direct current generator is the anode, and the electrode connected to the negative pole is called cathode. The electrolyte solution then supports the current flow, which results from the movement of negative and positive charge ions towards the anode and cathode respectively. The membranes employed in the electrodialysis are essentially sheets of porous ionexchange resins, owing negative or positive charge groups and therefore addressed as cationic or anionic membrane, respectively. The ion exchanger membranes are usually made of polystyrene carrying a suitable functional group (such as sulfonic acid or a quaternary ammonium group for cationic or anionic

membranes, respectively) cross-linked with divinylbenzene. As electrolyte, sodium chloride, or sodium acetate, sodium propionate etc. can be employed. The electodialysis stack is then assembled in such a way that the anionic and cationic membranes are parallel as in a filter press between two electrode blocks that the stream undergoing ion depletion is well separated from the stream undergoing ion enrichment (the two solutions are also referred to as diluate (undergoing ion depletion) and concentrate (undergoing ion enrichment). The heart of electrodialysis process is the membrane stack, which consists of several anion and cation-exchange membranes separated by spacers, and installed between two electrodes. By applying a direct electric current, anions and cations will migrate across the membranes towards the electrodes generating a diluate (desalted) and a concentrate stream.

[0012] Generally, the pore size of the employed membranes is rather small in order to prevent diffusion of the product from the diluate into the concentrate stream, driven by the often high concentration differences between the two streams. After separation from biomass, proteins and in particular recombinant DNA molecules (in the size of entire genomes) have to be removed quantitatively from the desired product. If at all possible the electrodialysis of such large molecules (in comparison to the molecular size of HMOs) would be rather lengthy and surely accompanied with significant losses of the desired product from the diluate into the concentrate.

[0013] Albermann C. et al. (Carbohydrate Research, 2001, vol. 334, p. 97-103) disclose the synthesis of the milk oligosaccharide 2'-fucosyllactose using recombinant bacterial enzymes.

[0014] EP 2 479 263 A1 discloses a method for producing 2'-fucosyllactose using an alpha-1,2-fucosyltransferase from *E. coli*.

[0015] WO2012/112777 discloses the purification of 2'-fucosyllactose from an E. coli fermentation broth.

[0016] Starting from this prior art, the technical problem is the provision of a novel process to provide neutral HMOs in high amounts, high purity and excellent yields.

[0017] The technical problem is solved by the process according to claim 1. The dependent claims display advantageous embodiments.

[0018] The present invention provides a process for purification of neutral human milk oligosaccharides (HMO) in a batch manner or in a continuous manner from a fermentation broth obtained by microbial fermentation wherein a purified solution containing a neutral HMO at a purity of ≥ 80 % is provided. The fermentation broth contains the neutral HMO, biomass, medium components and contaminants. The purity of the neutral HMO in the fermentation broth is <80 %.

[0019] During the process the fermentation broth is applied to the following purification steps:

1. i) Separation of biomass from the fermentation broth,
2. ii) Cationic ion exchanger treatment for the removal of positively charged material,
3. iii) Anionic ion exchanger treatment for the removal of negatively charged material,
4. iv) Electrodialysis step for the removal of charged materials,

wherein a chromatographic separation is excluded.

[0020] Contaminants that are present in the fermentation broth are e.g. other HMOs than the desired neutral HMO obtained at a purity of ≥ 80 % in the purified solution.

[0021] The applicant has discovered that with the use of electrodialysis and separation of biomass in combination with ion exchanger treatment an efficient purification of neutral HMOs from microbial fermentation can be attained, which delivers the HMO at purity suitable for food and feed applications.

[0022] One advantage of the process according to the present is that the desired neutral HMOs are obtained free from DNA and proteins from the used recombinant microbial fermentation strain. Furthermore, the obtained neutral HMO is free of recombinant material, as judged by quantitative PCR with up to 50 amplification cycles. Moreover, the product obtained from the process according to the invention is characterized by low amounts or absence of proteins.

[0023] Furthermore, the neutral HMO purification according to the invention is highly efficient with yet unknown yields of >75 % of the purified HMO (determined from cell free fermentation medium to HMO concentrate).

[0024] Thus, a hybrid process is provided comprising the steps of separation of biomass, ion exchanger and electrodialysis, and preferably further comprising an activated carbon treatment, for the efficient provision of neutral HMOs at high purity free of recombinant genetic material, endotoxins and proteins form fermentation processes using recombinant fermentation strains. With the process according to the invention, large amounts of high quality human milk oligosaccharides may be provided in a very convenient and economical way.

[0025] In a preferred embodiment of the process according to the invention, the fermentation is performed in a chemical defined minimal medium such as M9 medium (Sambrook, J. & Russell, D.W. (2001) Molecular Cloning -A Laboratory Manual. Cold Spring Harbour Laboratory Press, Cold Spring Harbor, New York) or as described in Samain *et al.,* 1999 (Samain et al., (1999) Production of O-acetylated and sulfated chitooligosaccharides by recombinant Escherichia coli strains harboring different combinations of nod genes. J. Biotechnol. 72:33-47*)* or similar salt based media able to support microbial growth.

[0026] In another preferred embodiment of the process according to the invention, the neutral HMO is purified from a fermentation broth obtained by microbial fermentation using a recombinant microorganism bacteria or yeast grown in a chemical defined medium.

[0027] In another preferred embodiment of the process according to the invention, the purity of the neutral HMO in the fermentation broth is ≤70 %, ≤60 %, ≤50 % or ≤40 % and/or the purified solution contains the neutral HMO at a purity of ≥85 %, preferably of ≥90 %.

[0028] In another preferred embodiment of the process according to the invention, the yield of the neutral HMO is >75 % and/or the purified solution is free of DNA, proteins, and/or recombinant genetic material.

[0029] According to the invention, the neutral HMO is selected from the group consisting of 2'-fucosyllactose, 3-fucosyllactose, 2',3-difucosyllactose, lacto-*N*-triose II, lacto-*N*-tetraose, lacto-*N*-neotetraose, lacto-*N*-fucopentaose I, lacto-*N*-*neo*fucopentaose, lacto-*N*-fucopentaose II, lacto-*N*-fucopentaose III, lacto-*N*-fucopentaose V, lacto-*N*-neofucopentaose V, lacto-*N*-difucohexaose I, lacto-*N*-difucohexaose II, 6'-galactosyllactose, 3'-galactosyllactose, lacto-*N*-hexaose and lacto-*N*-neohexaose.

[0030] In a particularly preferred embodiment of the process according to the invention, the neutral HMO is 2'-fucosyllactose.

[0031] In another preferred embodiment of the process according to the invention, the separation of biomass from the fermentation broth is achieved by filtration through a cross flow filter, preferably with a cut off ≤ 100 kDa, more preferably with a cut off ≤ 10 kDa.

[0032] In another preferred embodiment of the process according to the invention, at least one of the purification steps ii) to v) is repeated at least one time during the process.

[0033] In another preferred embodiment of the process according to the invention, the fermentation broth is applied at least one time to an activated carbon treatment after at least one of the purification steps i) to iv) for the adsorption of colour giving material and larger oligosaccharides to activated carbon. By applying the fermentation broth to this additional purification step, colour giving material and larger oligosaccharides can be removed from the fermentation broth.

[0034] In another preferred embodiment of the process according to the invention, the fermentation broth is concentrated after at least one of the purification steps i) to iv), preferably after purification step iv), using vacuum evaporation or reverse osmosis

1. i) to a concentration of ≥ 100 g/L, preferably ≥ 200 g/L, more preferably ≥ 300 g/L; and/or
2. ii) at a temperature of 30 °C to 50 °C, preferably 35 °C to 45 °C.

[0035] In another preferred embodiment of the process according to the invention, the purified solution is sterile filtered and/or subjected to endotoxin removal, preferably by filtration of the

purified solution through a 3 kDa filter.

[0036] In another preferred embodiment of the process according to the invention, the purified solution is concentrated to a concentration of > 1.5 M and cooled to a temperature < 25°, more preferable < 8°C, to obtain crystalline material of the neutral HMO.

[0037] In another preferred embodiment of the process according to the invention, the purified solution is spray-dried, particularly spray-dried at a concentration of the neutral HMO of 20-60 (w/v), preferably 30-50 (w/v), more preferably 35-45 (w/v), a nozzle temperature of 110-150 °C, preferably 120-140 °C, more preferably 125-135 °C and/or an exhaust temperature of 60-80 °C, preferably 65-70 °C.

[0038] The subject according to the application is intended to be explained in more detail with reference to the subsequent figures and examples without wishing to restrict said subject to the special embodiments.

[0039] Fig. 1 shows a scheme of a preferred embodiment of the process according to the present invention for the purification of 2'-fucosyllactose from a fermentation broth containing the steps: cross-flow filtration, cationic and anionic ion exchanger treatment, activated carbon treatment, concentration, electrodialysis, concentration, cationic and anionic ion exchanger treatment, activated carbon treatment and filtration with 3 kDat cut off.

[0040] Fig. 2 shows a scheme of another preferred embodiment of the process according to the present invention for the purification of 2'-fucosyllactose from a fermentation broth containing the steps: cross-flow filtration, cationic and anionic ion exchanger treatment, concentration, electrodialysis, concentration, activated carbon treatment and filtration with 3 kDat cut off.

[0041] Fig. 3 shows a scheme of another preferred embodiment of the process according to the present invention for the purification of 2'-fucosyllactose from a fermentation broth containing the steps: cross-flow filtration, cationic and anionic ion exchanger treatment, concentration, activated carbon treatment, electrodialysis, concentration, anionic exchanger treatment, activated carbon treatment and filtration with 3 kDat cut off.

Example 1: Purification of 2'-fucosyllactose from fermentation using a recombinant microbial production strain I.

[0042] A 1 m^3 microbial fermentation containing 2'-fucosyllactose at a concentration of 40 g/L was filtered through a cross flow filter with a cut off of 100 kDa (Microdyn Nadir) to obtain a cell free fermentation medium. As a fermentation medium the following medium was employed: Major medium components: glycerol 30 g/l, $NH_4H_2PO_4$ 7 g/l, K_2HPO_4 7 g/l, citrate 0,3 g/l, KOH 2 g/l, $MgSO_4 \cdot 7H_2O$ 2 g/l; trace elements: $CaCl_2 \cdot 6H_2O$ 20 mg/l, nitrilotriacetic acid 101 mg/l,

ammonium ferric citrate 56 mg/l, $MnCl_2 \cdot 4H_2O$ 9,8 mg/l, $CoCl_2 \cdot 6H_2O$ 1,6 mg/l, $CuCl_2 \cdot 2H_2O$ 1 mg/l, H_3BO_3 1,6 mg/l, $ZnSO_4 \cdot 7H_2O$ 9 mg/l, $Na_2MoO_4 \cdot 2H_2O$ 1,2 mg/l, Na_2SeO_3 1,2 mg/l; feed substances: glycerol and lactose. The cell free fermentation medium was then passed over a strong cationic ion exchanger (Lewatit S 6368 A (Lanxess) in H^+ form, size of ion exchanger bed volume was 100 l), in order to remove positive charged contaminants. The obtained solution was then set to pH 7 by the addition of a 2 M sodium hydroxide solution. The solution was then, without delay passed over an anionic ion exchanger column (bed volume of ion exachanger was 100 l) containing the strong anionic ion exchanger Lewatit S 2568 (Lanxess) in formiate ($CH_3CO_2^-$) form. The obtained solution was again neutralized to pH 7 by using hydrochloric acid (HCl). The so obtained solution was then concentrated under vacuum at 40°C to obtain a 2'-fucosyllactose solution of 200 g/l.

[0043] The concentrated 2'-fucosyllactose solution was then treated with activated carbon in order to remove color giving material such as maillard reaction products. As activated carbon 20 g Norit GAC EN per l concentrated 2'-fucosyllactose solution was used, yielding a significantly decolorized solution. The so obtained concentrated 2'-fucosyllactose solution was then electrodialysed to 0.3 mS/cm using a PC-Cell BED 1-3 electrodialysis apparatus (PC-Cell, Heusweiler, Germany) equipped with PC-Cell E200 membrane stack. Said stack contained the following membranes: cation exchange membrane CEM: PC SK and the anion exchange membrane AEM:PcAcid60 having a size exclusion limit of 60 Da. A 0.025 M sulfamic acid (amidosulfonic acid) solution was used as an electrolyte in the ED process.

[0044] Then, the obtained solution was then concentrated to obtain a 50% 2'-fucosyllactose solution. The concentrated solution was then again treated with ion exchangers, Lewatit S 6368 A (Lanxess) in Na^+ form (bed volume of the used ion exchanger was 10 l) and after neutralization with the anionic ion exchanger Lewatit S 2568 (Lanxess) in Cl^- form (bed volume of the employed ion exchanger was 10 l). The obtained 2'-fucosyllactose solution was then treated with activated carbon (Norit DX1 Ultra). For 1 l of a 50% 2'-fucosyllactose solution 40 g activated carbon was employed. The solution was then again subjected to electrodialysis until a conductivity of less than 0.3 mSi/cm was obtained.

[0045] The solution was then subjected to sterile filtration and endotoxin removal by passing the solution through a 3 kDa filter (Pall Microza ultrafiltration hollow fiber module SEP-2013, Pall Corporation, Dreieich).

[0046] Part of the obtained solution was then spray dried for analysis.

[0047] For NMR spectra recording the spray-dried product was dissolved in hexadeuterodimethyl sulfoxide (DMSO-d_6). For the proton and ^{13}C analysis the following chemical shifts were observed:

^{1}H NMR (500 MHz, DMSO-d_6) δ 6.63 (d, J = 6.5 Hz, 1H), 6.28 (d, J = 4.7 Hz, 1H), 5.21 (d, J =

2.4 Hz, 1H), 5.19 (d, *J* = 2.4 Hz, 1H), 5.01 (d, *J* = 2.2, 2H), 4.92 (d, *J* = 5.0 Hz, 1H), 4.89 (dd, *J* = 4.6, 1.3 Hz, 2H), 4.78 (d, *J* = 5.3 Hz, 1H), 4.74 (d, *J* = 5.1 Hz, 1H), 4.63 (m, 6H), 4.53 (t, d, *J* = 5.5, 1H), 4.46 (d, *J* = 5.2 Hz, 1H), 4.44 (d, *J* = 5.0 Hz, 1H), 4.38 - 4.26 (m, 5H), 4.23 (d, *J* = 0.9, 1H), 4.05 (d, *J* = 0.9, 1H), 4.00 (quin, *J* = 3.3, 1H), 3.68 - 3.60 (m, 7H), 3.59 - 3.50 (m, 13H), 3.50 - 3.37 (m, 6H), 3.24 (dt, *J* = 8.8, 2.2 Hz, 1H), 3.14 (m, 2H), 2.96 (td, *J* = 8.4, 4.7 Hz, 1H), 1.04 (d, *J* = 6.1 Hz, 3H), 1.03 (d, *J* = 6.1 Hz, 3H).

^{13}C NMR (126 MHz, DMSO-d_6) δ 100.99, 100.85, 100.35, 100.25, 96.59, 92.02, 78.13, 77.78, 77.16, 77.01, 75.27 75.05, 74.67, 73.70, 72.33, 71.62, 71.56, 70.91, 69.90, 69.64, 68.75, 68.16 , 66.33, 60.17, 59.82, 59.67, 16.37, 16.36.

[0048] Chemicals shifts were assigned and were found to be consistent with the 2'-fucosyllactose structure.

[0049] Using this protocol 2'-fucosyllactose with a purity of 95.4 % could be obtained (determined by HPLC analysis). Major contaminants were 3'-fucosyllactose (1,9%), difucosyllactose (3.3%) and lactose (0.2%). The yield of the purification was approximately 80%. Most of all no recombinant material could be determined in 10 g of freeze material using 50 cycles of qPCR. Protein amount of the obtained material as determined as < 50 µg/g freeze dried material by using a nano-bradford assay (Roth, Karlsruhe Germany). Total amount of ash was determined with 0,37%. Heavy metals were for all examine (arsenic cadmium, lead and mercury) below 0,1 µg/g material. Total ash was determined as 0,37%. Endotoxin levels were determined to be < 0,005 EU/mg 2'-fucosyllactose material.

Example 2: Purification of 2'-fucosyllactose from fermentation using a recombinant microbial production strain II.

[0050] A 1 m^3 microbial fermentation containing 2'-fucosyllactose at a concentration of 40 g/L was filtered through a cross flow filter with a cut off of 100 kDa (Microdyn Nadir) to obtain a cell free fermentation medium. As a fermentation medium the following medium was employed: Major medium components: glycerol 30 g/l, $NH_4H_2PO_4$ 7 g/l, K_2HPO_4 7 g/l, citrate 0,3 g/l, KOH 2 g/l, $MgSO_4 \cdot 7H_2O$ 2 g/l; trace elements: $CaCl_2 \cdot 6H_2O$ 20 mg/l, nitrilotriacetic acid 101 mg/l, ammonium ferric citrate 56 mg/l, $MnCl_2 \cdot 4H_2O$ 9,8 mg/l, $COCl_2 \cdot 6H_2O$ 1,6 mg/l, $CuCl_2 \cdot 2H_2O$ 1 mg/l, H_3BO_3 1,6 mg/l, $ZnSO_4 \cdot 7H_2O$ 9 mg/l, $Na_2MoO_4 \cdot 2H_2O$ 1,2 mg/l, Na_2SeO_3 1,2 mg/l; feed substances: glycerol and lactose. The cell free fermentation medium was then passed over a cationic ion exchanger (Lewatit S 6368 A (Lanxess) in H^+ form, (volume of ion exchanger bed was 100 l), in order to remove positive charged contaminants. The obtained solution was then set to pH 7 by the addition of a 2 M sodium hydroxide solution. The solution was then, without delay passed over an anionic ion exchanger column (ion exchanger bed volume used was 100 l) containing the strong anionic ion exchanger Lewatit S 2568 (Lanxess) in hydrogen carbonate

form. The obtained solution was again neutralized to pH 7. The so obtained solution was then concentrated under vacuum at 40°C to obtain a 2'-fucosyllactose solution of 200 g/l.

[0051] The concentrated 2'-fucosyllactose solution was then treated with activated carbon, using 20 g Norit GAC EN per l concentrated 2'-fucosyllactose solution. To the filtered 2'-fucosyllactose solution 40 g/l Norit DX1 Ultra activated carbon was added. The solution was then exposed to the activated carbon at 4°C for approximately 18h, after 18h the activated carbon was removed from the 2'-fucosyllactose solution by filtration. A solution with a conductivity of approx. 40 mSi/cm was obtained.

[0052] The solution was then electrodialysed to a conductivity of < 0.3 mS/cm using a PC-Cell BED 1-3 electrodialysis apparatus (PC-Cell, Heusweiler, Germany) equipped with PC-Cell E200 membrane stack. Said stack contained the following membranes: cation exchange membrane CEM: PC SK and the anion exchange membrane AEM:PcAcid60 having a size exclusion limit of 60 Da. A 0.025 M sulfamic acid (amidosulfonic acid) solution was used as an electrolyte in the ED process.

[0053] The obtained solution was then concentrated to obtain a 50% 2'-fucosyllactose solution. The obtained 2'-fucosyllactose solution was then passed over a Lewatit S 2568 (Lanxess) Cl^- form (bed volume 101) and treated with activated carbon (Norit DX1 Ultra) at 8°C for 18h. The solution was then subjected to sterile filtration and endotoxin removal by passing the solution through a 3 kDa filter (Pall Microza ultrafiltration hollow fiber module SEP-2013, Pall Corporation, Dreieich) and spray-dried using a NUBILOSA LTC-GMP spray dryer (NUBILOSA, Konstanz, Germany).

[0054] Using this protocol 2'-fucosyllactose with a purity of 93.5 % could be obtained (determined by HPLC analysis). Major contaminants were 3'-fucosyllactose (1,7%), difucosyllactose (3.4%) and lactose (0.3%). The yield of the purification was approximately 80%.

REFERENCES CITED IN THE DESCRIPTION

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Patentkrav

1. Fremgangsmåde til batchvis eller kontinuert oprensning af neutrale modermælksoligosaccharider (HMO'er) ud fra en fermenteringsbouillon, der er opnået ved mikrobiel fermentering, idet fermenteringsbouillonen indeholder et neutralt HMO, biomasse, mediets bestanddele og kontaminanter, hvor renheden af det neutrale HMO i fermenteringsbouillonen er < 80 %,
hvor fermenteringsbouillonen udsættes for følgende oprensningstrin:
i) adskillelse af biomassen fra fermenteringsbouillonen,
ii) kationisk ionbytterbehandling for at fjerne positivt ladet stof,
iii) anionisk ionbytterbehandling for at fjerne negativt ladet stof,
iv) elektrodialysetrin for at fjerne ladet stof,
hvor der tilvejebringes en oprenset løsning, som indeholder det neutrale HMO i en renhed på ≥ 80 %,
hvor det neutrale HMO er valgt fra gruppen bestående af 2'-fucosyllactose, 3-fucosyllactose, 2',3-difucosyllactose, lacto-N-triose II, lacto-N-tetraose, lacto-N-neotetraose, lacto-N-fucopentaose I, lacto-N-neofucopentaose, lacto-N-fucopentaose II, lacto-N-fucopentaose III, lacto-N-fucopentaose V, lacto-N-neofucopentaose V, lacto-N-difucohexaose I, lacto-N-difucohexaose II, 6'-galactosyllactose, 3'-galactosyllactose, lacto-N-hexaose og lacto-N-neohexaose,
hvor kromatografisk separation er udelukket.

2. Fremgangsmåde ifølge krav 1, hvor det neutrale HMO oprenses ud fra en fermenteringsbouillon, der er opnået ved mikrobiel fermentering under anvendelse af en rekombinant mikroorganisme bakterie eller gær dyrket i et kemisk defineret medium.

3. Fremgangsmåde ifølge et af kravene 1 eller 2, kendetegnet ved, at renheden af det neutrale HMO i fermenteringsbouillonen

er ≤70 %, ≤60 %, ≤50 % eller ≤40 %, og/eller den oprensede opløsning indeholder det neutrale HMO i en renhed på ≥85 %, fortrinsvis på ≥90 %.

4. Fremgangsmåde ifølge et af kravene 1 til 3, kendetegnet ved, at
i) udbyttet af det neutrale HMO er >75 %; og/eller
ii) den oprensede opløsning er fri for DNA, proteiner og/eller rekombinant genetisk materiale.

5. Fremgangsmåde ifølge et af kravene 1 til 4, kendetegnet ved, at separationen af biomasse fra fermenteringsbouillonen opnås ved filtrering gennem et tværstrømsfilter, fortrinsvis med en afskæringsværdi på ≤ 100 kDa, mere fortrinsvis med en afskæringsværdi på ≤ 10 kDa.

6. Fremgangsmåde ifølge et af kravene 1 til 5, kendetegnet ved, at mindst et af oprensningstrinnene ii) til iv) gentages mindst én gang i løbet af fremgangsmåden.

7. Fremgangsmåde ifølge et af kravene 1 til 6, kendetegnet ved, at fermenteringsbouillonen udsættes mindst én gang for en behandling med aktivt kul efter mindst et af oprensningstrinnene i) til iv) for at adsorbere farvende stof og større oligosaccharider på aktivt kul.

8. Fremgangsmåde ifølge et af kravene 1 til 7, kendetegnet ved, at fermenteringsbouillonen opkoncentreres efter mindst et af oprensningstrinnene i) til iv), fortrinsvis efter oprensningstrin iv), ved hjælp af vakuuminddampning eller omvendt osmose
i) til en koncentration på ≥ 100 g/l, fortrinsvis ≥ 200 g/l, mere fortrinsvis ≥ 300 g/l; og/eller
ii) ved en temperatur på 30 °C til 50 °C, fortrinsvis 35 °C til 45 °C.

9. Fremgangsmåde ifølge et af kravene 1 til 8, kendetegnet ved, at den oprensede opløsning sterilfiltreres og/eller

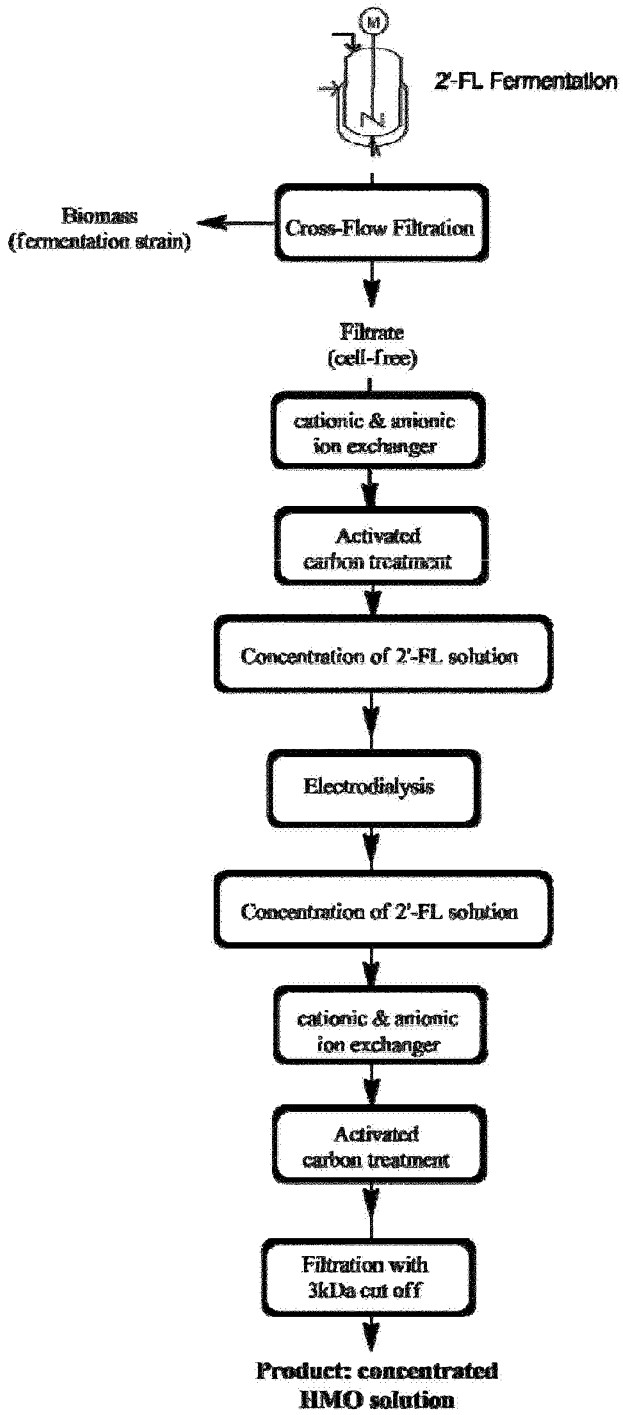
underkastes endotoksinfjernelse, fortrinsvis ved filtrering af den oprensede opløsning gennem et 3 kDa-filter.

10. Fremgangsmåde ifølge et af kravene 1 til 9, kendetegnet ved, at den oprensede opløsning opkoncentreres til en koncentration på > 1,5 M og nedkøles til en temperatur < 25 °C, mere fortrinsvis < 8 °C, for at opnå krystallinsk materiale af det neutrale HMO.

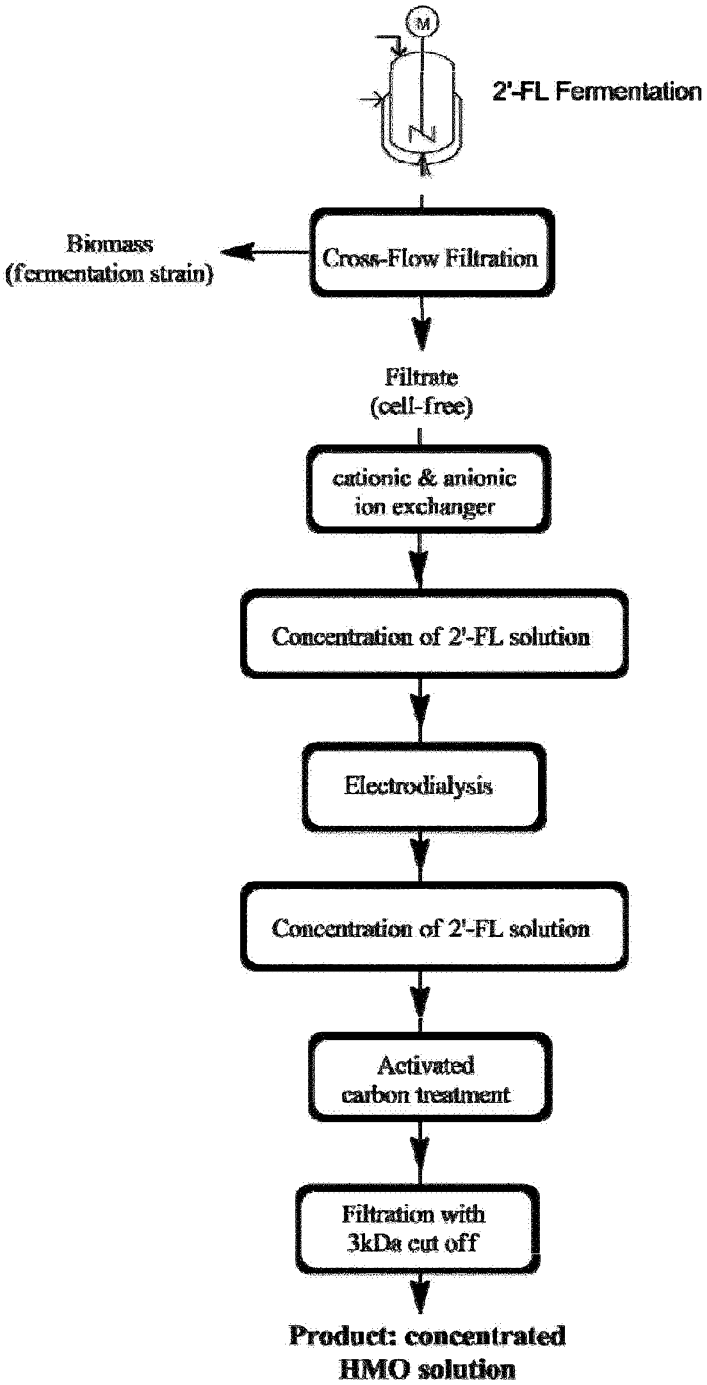
11. Fremgangsmåde ifølge et af kravene 1 til 10, kendetegnet ved, at den oprensede opløsning spraytørres, især spraytørres ved en koncentration af det neutrale HMO på 20-60 (w/v), fortrinsvis 30-50 (w/v), mere fortrinsvis 35-45 (w/v), en dysetemperatur på 110-150 °C, fortrinsvis 120-140 °C, mere fortrinsvis 125-135 °C og/eller en udgangstemperatur på 60-80 °C, fortrinsvis 65-70 °C.

DRAWINGS

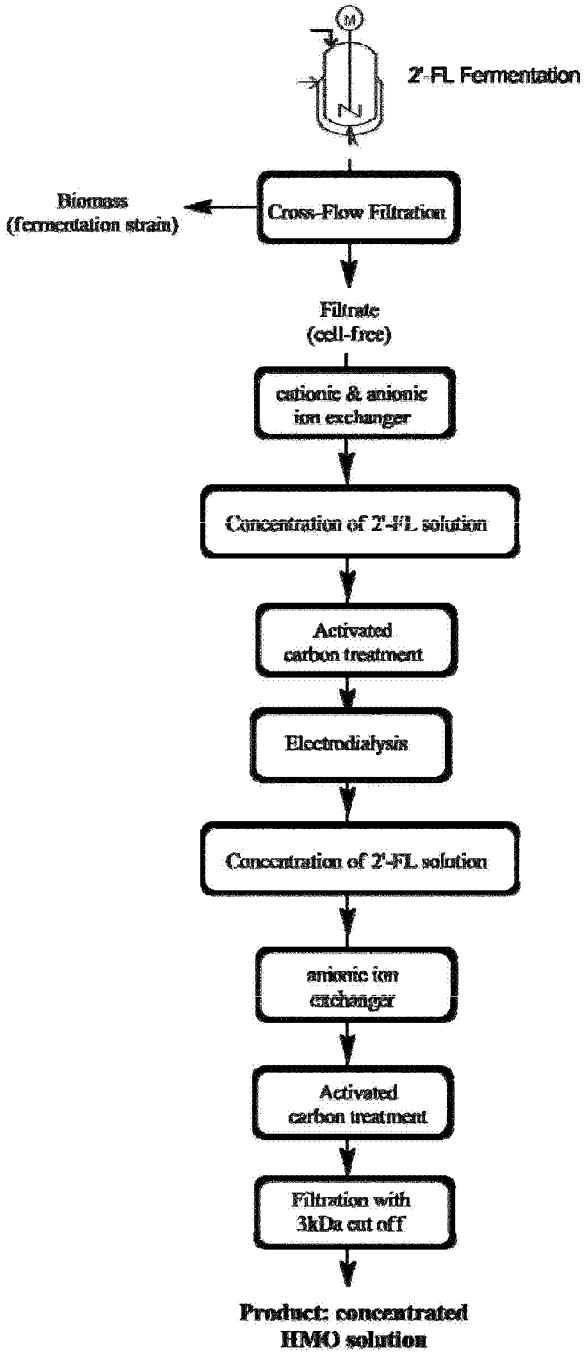
Figur 1



Figur 2


2'-FL Fermentation
Biomass
(fermentation strain)
Cross-Flow Filtration
Filtrate
(cell-free)
cationic & anionic
ion exchanger
Concentration of 2'-FL solution
Electrodialysis
Concentration of 2'-FL solution
Activated
carbon treatment
Filtration with
3kDa cut off
Product: concentrated
HMO solution

Figur 3


2'-FL Fermentation
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