Title of the Invention: **Dry ice-assisted mechanical extration process**
Abstract Title: **Dry ice assisted mechanical extraction process**

A process for mechanical extraction of oil from oil-bearing, particulate materials is described. The materials are firstly mixed with solid carbon dioxide and then introduced into a screw press. The oily extract and the press cake are then collected and may undergo further processing. The particulate material may comprise crushed nuts and/or seeds. The solid CO₂ may take the form of carbon dioxide snow. A pre-pressing step of cracking and dehulling the nuts and/or seeds can also be performed. The temperature of the pressing process may be maintained below 31°C. The oil thus produced may be further refined using EDTA. The used CO₂ may be collected.
DRY ICE-ASSISTED MECHANICAL EXTRACTION PROCESS

FIELD OF THE INVENTION

The process relates to the low-temperature, mechanical extraction of oil from oil-bearing materials whereby the low temperature is maintained by mixing the oil-bearing material with solid carbon dioxide.

BACKGROUND OF THE INVENTION

Extracting vegetable oil from oil-bearing materials such as nuts, seeds, cereal seed germs or beans has been practiced in oil mills for centuries. In these mills, the material is first of all comminuted to open the cells and enable the oil to flow freely, whereafter the comminuted material is pressed. This produces press oil and a press cake, which cake still contains appreciable amounts of oil. Consequently, solvent extraction processes have been developed and introduced to increase the oil yield by recuperating the oil present in the press cake which processes are also used to extract oil-bearing material with a low, say < 20 weight %, oil content such as for example soya beans. Since soya beans are processed on a large scale, the solvent extraction plants profit from an economy of scale; for low-tonnage products such as speciality or gourmet oils, increasing the oil yield by solvent extraction is often not economic.

Accordingly, two kinds of crude oil are produced from oilseeds like sunflower seed and rapeseed: press oil and extraction oil, and their relative amounts can be adjusted by controlling the residual oil content of the press cake. A low oil content in the press cake has the advantage that less oil is left to be extracted which means that less solvent is required to extract this residual oil and that therefore less solvent has to be evaporated which constitutes an energy saving. On the other hand, attaining a low residual oil content in the press cake is costly in that it requires more electrical energy during screw pressing and since the capacity of a screw press also diminishes when a low residual oil content is aimed for, more presses are needed which increases investment and maintenance costs.
In general, the quality of the press oil is superior to that of the extraction oil. It contains less phosphatides and the phosphatides present in the press oil also tend to have a lower content of non-hydratable phosphatides. However, when a low residual oil content of the press cake is aimed for, the increased energy requirement leads to a temperature increase of the material being processed and this may cause a deterioration of the press oil quality.

In order to increase the oil yield during pressing, solvent assisted mechanical processes have been developed. US 5,290,959 discloses a method of extracting soluble materials from a material to be extracted which comprises: contacting the material to be extracted with an extracting fluid at an elevated pressure within a defined space; forming a fluid mixture of said extracting fluid and extract from said material to be extracted in said defined space; separating said fluid mixture from the residue of said material to be extracted; and discharging said fluid mixture as a mass from said defined space; and simultaneously reducing the volume of said defined space at a rate sufficient to maintain said elevated pressure as said fluid mixture is discharged from said defined space, the extracting fluid being preferably carbon dioxide, nitrogen, nitrous oxide, freons, argon, and low molecular weight hydrocarbons, ethanol, isopropanol and propylene glycol. For the separation of many materials, the use of CO₂ at supercritical conditions is preferred and in fact, all the examples involving the use of CO₂ exemplify the use of supercritical conditions.

US 5,939,571 discloses a device for the production of oils or other extractable substances by pressing and extracting a raw material of plant origin containing oleiferous or extractable substances in the presence of a liquid and/or supercritical extraction agent, said device comprising: an inlet for said raw material; a pressing body wherein a movable press screw is provided; means for introducing said extraction agent into said pressing body; a discharge outlet for said raw material pressed; said movable press screw is a single press screw arranged in said pressing body for transporting said raw material from said inlet into said pressing body and therefrom to said discharge outlet while pressing said raw material under simultaneous introduction of said extraction agent into said raw material subjected to pressing; and said pressing body is proof-sealed against its surroundings by means of a jacket. This device may
comprise means for introducing said extraction agent into the pressing body through outlets where through a liquid extraction agent may be introduced under pressure into said raw material present in said pressing body.

US 2006/0283799A discloses a method for pressing a liquid extract from material to be pressed, comprising conveying the material to be pressed with a screw press along a pressing route and applying pressure to the material and treating the material to be pressed is treated with at least one extracting agent, removing the extracting agent from the pressed material together with the extract, further comprising supplying the extracting agent to the material to be pressed in amounts that are at most twice a weight of the extract contained in the material to be pressed. US 2006/0283799A also disclosed that it was found that it was not necessary to dissolve the extract in the extracting agent and to remove it from the pressed material in this dissolved state, but rather that excellent extraction rates can be achieved if the extract is merely diluted with the extracting agent, or if the extracting agent is dissolved in the extract. The amounts of extracting agents that are required in prior-art processes, which generally far exceed ten times the weight of the extract to be recovered, can be greatly reduced in this way. The only extracting agent mentioned in US 2006/0283799A is carbon dioxide. It is supplied as a liquid from an intermediate storage tank that is kept under a pressure of for instance 65 bar and at a temperature of 22°C. Before being fed into the press, the liquid may be cooled to for instance 15 to 18°C but in the screw press, the pressure increase causes the temperature to increase to 32 to 50°C, causing the liquid carbon dioxide to become supercritical.

WO 2006/099412 discloses a defatted biomass having less than 6% or even 5% residual oil and a Protein Dispersibility Index, PDI, of greater than 60%, the defatted biomass product being produced by a process comprising: a) feeding a raw biomass product to a compression zone of a screw press extraction unit; b) compressing the raw biomass in the screw press to form a cake plug that is essentially impermeable to fluids; c) relieving the pressure on the cake plug to make it permeable to fluids; d) injecting solvent into the extraction unit at a point where the pressure on the cake plug has been relieved, creating a mixture of solvent and biomass; and e) compressing the
mixture to form a second cake plug and to push solvent and oil from the biomass, the residual oil preferably being less than 5% and the solvent preferably partially vaporizing within the mixture and the solvent preferably being carbon dioxide. WO 2006/099412A further discloses that processes in accordance with the invention may use "organic" solvents such as carbon dioxide and alcohols, organic solvent being defined in the extraction industry, and for the purposes of this application, as nontoxic alcohols and gases, as opposed to hydrocarbons such as hexane that are frequently used in solvent extraction of oils from biomass, although only the use of liquid carbon dioxide is exemplified. Although WO 2006/099412A discloses that a higher oil quality may be recovered due to low extraction temperatures [i.e. within the range of -20°F to 200°F (-28.9 to 93.3°C), it does not specify how the low temperatures are maintained and the cake discharge temperatures reported in Example 1 are 110 to 130°F (43.3 to 54.4°C) at the outside of the cake and 180 to 210°F (82.2 to 98.9°C) inside the cake.

US 7,686,648 discloses a method of producing an organic defatted cake and an oil, the method comprising; a) dehulling a whole bean or whole grain feedstock to provide an oil bearing biomass from which the hulls have been removed; b) feeding the oil bearing biomass to a continuous screw press extractor; c) compressing the biomass in the screw press extractor to form a cake plug that is essentially impermeable to fluids; d) relieving the pressure on the biomass in the screw press extractor; e) feeding an organic solvent to the screw press extractor and into the biomass; f) compressing the biomass in the screw press extractor to extract oil and solvent from the biomass to create the organic defatted cake having a residual oil content of less than 6%; g) separating the extracted oil and solvent from the defatted biomass; and h) recovering the extracted oil having an average of less than 50 parts per million phosphorous.

WO 2007/038503A discloses an apparatus comprising: a) a screw press having a shaft and cage; b) an injector for injecting fluid into the press, the injector having a mechanical limiter that opens to allow fluid through the injector when a fluid supply pressure to the injector exceeds a first threshold level and closes when the fluid supply pressure to the injector is below a second
threshold level. The apparatus allows a fluid such as carbon dioxide that is at near-supercritical conditions to be injected into an extraction press on a controllable basis.

US 6,641,847 discloses an isolated cranberry seed oil produced by a method comprising, physically disrupting cranberry seeds under conditions that reduce the temperature and exposure to oxygen of the seeds relative to the temperature and exposure to oxygen which would occur in the absence of such conditions, such temperature reduction being preferably realised by mixing the cranberry seeds with dry ice or liquid nitrogen whereupon the mixture is sent to a hammer mill; adding to the seeds an organic solvent to produce an extract/solvent mixture; and removing the solvent portion of the extract/solvent mixture thereby producing isolated cranberry seed oil substantially free of solvent. No screw process is required in this process, since the oil is extracted from the seeds by using a solvent such as hexane.

US 2002/0174780A1 discloses a method of extracting oil from a natural material, the method comprising the steps of (i) providing a screw press having a screw, a motor to rotate the screw, a barrel within which the screw rotates, and having first and second ends, a feed port at the first end of the barrel for feeding into the barrel material to be pressed, an exit port at the second end of the barrel for pressed material to exit the barrel, and perforations in the barrel therebetween for expressing oil; (ii) feeding into the barrel the natural material to be pressed while the screw rotates; (iii) simultaneously with or subsequently to step (ii), feeding a gas or latent gas, e.g. carbon dioxide, into the barrel thereby to dissolve in oil in the natural material; and (iv) recovering oil which is expressed through the perforations. The effect is brought about by gas dissolving in the oil. The mass of gas required is typically less, often much less, than the mass of natural product. A characteristic of this process is that the compressed gas is injected under pressure into a press, the injection point being located at about halfway along the length of the barrel of the press.

Most of the above processes and extraction devices have in common that they aim at extracting oil from oil-bearing material by injecting a solvent such as carbon dioxide in gaseous or liquid state into a screw press. This solvent dissolves in the oil and thereby increases its volume and reduces its viscosity.
Both factors favour low residual oil content when said material is passed through the cage where liquid can leave the material. However, the processes and extraction devices of the prior art operate at elevated temperature and thereby cause the carbon dioxide used as extraction solvent to be in a supercritical state where solubilities are often too low to be of practical use.

**OBJECT OF THE INVENTION**

It is therefore an object of the invention to provide a low-temperature, mechanical extraction process that can be used to extract triglyceride oil of improved quality from oil-bearing materials.

**SUMMARY OF THE INVENTION**

In general one skilled in the art would expect that mixing of solids would be less efficient than the mixing of a solid with a liquid. Therefore, despite the lower pressures involved upon mixing seeds with solid carbon dioxide, prior art processes have opted for mixing seeds with liquid carbon dioxide. However, it has surprisingly been found that the object of the invention can be better realised by a process for the mechanical extraction of oil-bearing, particulate materials in which the oil-bearing material is mixed with solid carbon dioxide, then the mixture of material and solid carbon dioxide is introduced in a screw press and then separately collecting the oily extract and the press cake resulting from the screw pressing process.

The present invention concerns the extraction of oil-bearing particulate materials by introducing these materials into a screw press and separately collecting the oily extract and the press cake and in particular the mixing of solid carbon dioxide with these oil-bearing particulate materials prior to their introduction into the screw press.

In a first aspect of the present invention a process is provided for mechanical extraction of oil-bearing, particulate materials by introducing said materials in a screw press and separately collecting the oily extract and the press cake, characterised in that the oil-bearing material is mixed with solid carbon dioxide before it is introduced into said screw press.
The present invention also has the advantage that the quality of the oil and meal produced is improved over that produced using liquid carbon dioxide.

Particular and preferred aspects of the invention are set out in the accompanying independent and dependent claims. Features from the dependent claims may be combined with features of the independent claims and with features of other dependent claims as appropriate and not merely as explicitly set out in the claims.

Although there has been constant improvement, change and evolution of devices in this field, the present concepts are believed to represent substantial new and novel improvements, including departures from prior practices, resulting in the provision of more efficient, stable and reliable devices of this nature.

The above and other characteristics, features and advantages of the present invention will become apparent from the following detailed description.

This description is given for the sake of example only, without limiting the scope of the invention.

**DETAILED DESCRIPTION OF THE INVENTION**

The terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequence, either temporally, spatially, in ranking or in any other manner. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

It is to be noticed that the term “comprising”, used in the claims, should not be interpreted as being restricted to the means listed thereafter; it does not exclude other elements or steps. It is thus to be interpreted as specifying the presence of the stated features, integers, steps or components as referred to, but does not preclude the presence or addition of one or more other features, integers, steps or components, or groups thereof. Thus, the scope of the expression “a device comprising means A and B” should not be limited to
devices consisting only of components A and B. It means that with respect to the present invention, the only relevant components of the device are A and B.

Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment, but may. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to one of ordinary skill in the art from this disclosure, in one or more embodiments.

Similarly it should be appreciated that in the description of exemplary embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims following the detailed description are hereby expressly incorporated into this detailed description, with each claim standing on its own as a separate embodiment of this invention.

Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

In the description provided herein, numerous specific details are set forth. However, it is understood that embodiments of the invention may be practiced without these specific details. In other instances, well-known methods, structures and techniques have not been shown in detail in order not to obscure an understanding of this description.
The following terms are provided solely to aid in the understanding of the invention.

Definitions

The term “mechanical extraction process”, as used in disclosing the present invention, means that force is applied to a material so that its volume is decreased with the result that liquid components in that material are squeezed out.

The term “carbon dioxide snow”, as used in disclosing the present invention, means solid carbon dioxide, formed by rapid evaporation of liquid carbon dioxide. Carbon dioxide snow can, for example, be produced by releasing the pressure from liquid carbon dioxide.

The term “dry ice”, as used in disclosing the present invention, means solid carbon dioxide, which is commercially available in different forms e.g. blocks, slabs and pellets.

The invention will now be described by a detailed description of several embodiments of the invention. It is clear that other embodiments of the invention can be configured according to the knowledge of persons skilled in the art without departing from the true spirit or technical teaching of the invention, the invention being limited only by the terms of the appended claims.

It is to be understood that although preferred embodiments, specific constructions and configurations, as well as materials, have been discussed herein for devices according to the present invention, various changes or modifications in form and detail may be made without departing from the scope and spirit of this invention. Steps may be added or deleted to methods described within the scope of the present invention.

Process for mechanical extraction of oil-bearing, particulate materials

Although the process according to the invention can be used to extract oil from a wide range of oil bearing materials, it has special advantages for
speciality or gourmet oils, which are typically produced on such a small scale
that it does not justify the use of a solvent extraction facility. Examples of such
oils are: tree nut oils such as walnut oil or hazelnut oil; oils having a high \( \gamma \)-
linolenic acid content such as evening primrose oil, borage oil or blackcurrant
seed oil; oils with a high \( \alpha \)-linolenic acid content such as flax oil, perilla oil and
camelina seed oil; stone fruit oils like almond oil, plum stone oil or apricot stone
oil; germ oils like wheat germ oil, oat germ oil or barley oil; minor seed oils with
special taste such as niger seed oil, teeseed oil, tobacco seed oil, pumpkin
seed oil, parsley seed oil, carrot seed oil. Some commercially available berry
oils like wild blueberry oil, cloudberry oil, lingonberry oil and sea buckthorn oil
are already produced by supercritical fluid extraction and these oils can greatly
profit from the process according to the invention.

The nuts and seeds are preferably cracked and dehulled before being
extracted by the process according to the invention. This decreases the volume
to be processed and since oil retention is near proportional to this volume, its
decrease improves oil yield. Cracking nuts and separating the broken shells
from the meats is a labour-intensive process since it has to be done by hand but
this has also the advantage that low-quality and mouldy nuts can be removed at
the same time. The oil yield can also be improved by a mechanical opening of
the cells of the oil-bearing material. The screw press will cause some opening of
cells but a prior standard flaking process employing smooth cylindrical rolls is
more effective in this respect.

In the process according to the invention, the oil-bearing material is then
mixed with solid carbon dioxide. It has been found that mixing solid carbon
dioxide with oil-bearing material causes the carbon dioxide to be much better
dispersed throughout said material than when liquid carbon dioxide is used,
especially when this liquid material has to be forced into the expeller cake
present in the screw press. Since the mixing process is continuous, it can
conveniently be carried out in an intermediate mixing vessel that is provided
with an Archimedean screw that ensures both intimate mixing of the carbon
dioxide and the oil-bearing material and its being forwarded to the feed inlet of
the screw press. This intermediate mixing vessel is preferably insulated to
minimise the vapourisation of the solid carbon dioxide.
This carbon dioxide is fed into the intermediate mixing vessel as a solid that can be produced as snow by releasing the pressure from liquid carbon dioxide but the use of dry ice pellets has been found to be more convenient. These pellets can be supplied with a length of 8 mm and a diameter of 2 mm but the process according to the invention is in no way limited to these dimensions.

According to a preferred embodiment of the first aspect of the present invention, the carbon dioxide to be mixed with the oil-bearing material is in the form of carbon dioxide snow.

According to another preferred embodiment of the first aspect of the present invention, the carbon dioxide to be mixed with the oil-bearing material is in the form of dry ice pellets.

According to another preferred embodiment of the first aspect of the present invention, the pressure is such as to avoid the presence of liquid carbon dioxide, the pressure preferably not exceeding two bar and particularly preferably in the range of 0.8 to 1.5 bar. At temperatures at or below -56.6°C solid carbon dioxide coexists with gaseous carbon dioxide.

According to another preferred embodiment of the first aspect of the present invention, liquid carbon dioxide is absent during the mixing and pressing processes.

The amount of solid carbon dioxide to be mixed with the oil-bearing material can be varied within relatively wide limits. It has been found that when less than 10% by weight calculated on the oil content of the oil-bearing material is used, it exerts little effect. On the other hand, using more than 100% by weight brings no further benefits and is therefore unnecessarily expensive. A preferred range is therefore 20% to 60% of the weight of the oil present in the oil bearing material.

According to another preferred embodiment of the first aspect of the present invention, the amount of solid carbon dioxide mixed with the oil-bearing material lies between 10 and 100% by weight of the oil contained in said oil-bearing material.

According to another preferred embodiment of the first aspect of the present invention, the amount of solid carbon dioxide mixed with the oil-bearing
material lies between 20 and 60% by weight of the oil contained in said oil-bearing material.

When the mixture of oil-bearing material and solid carbon dioxide is fed into the screw press, the latter will compress and further mix these materials. This will cause the temperature to rise and the carbon dioxide to melt and be dispersed through the oil-bearing material. Some oil will dissolve in the carbon dioxide and some carbon dioxide will dissolve in the oil but the solubilities at the prevailing conditions are such that two liquid phases will co-exist. Of course it is possible to increase the solubility of oil in carbon dioxide by adding an entrainer such as but not limited to a lower alcohol. However, this has the serious disadvantage that this entrainer has subsequently to be removed from the press oil and may also have to be recuperated from the press cake. These are expensive processes and accordingly, the use of an entrainer is not recommended. An exception can possibly be made for gaseous entrainers such as but not limited to propane. However, their use requires extensive safety precautions and concomitant expenditure.

In the process according to the invention, controlling the temperature is of paramount importance. The compression and the mechanical energy exerted by the screw press will tend to raise the temperature whereas the amount of solid carbon dioxide relative to the oil-bearing material can be used to lower the temperature. Often, a need arises to provide additional cooling and this can be realised by fitting a cooling jacket around the part of the screw barrel where compression takes place. Liquid ammonia can conveniently be used as coolant. Cooling preferably maintains the temperature below 31°C which is the critical temperature of carbon dioxide but even when this temperature is not maintained and the carbon dioxide becomes supercritical, cooling may be advantageous from both oil and meal quality point of view.

According to another preferred embodiment of the first aspect of the present invention, the temperature inside the screw press is maintained below the critical temperature of carbon dioxide with preferably at least a part of the barrel of the screw press being cooled by means of an external coolant.

According to another preferred embodiment of the first aspect of the present invention, the temperature inside the screw press is maintained below
the critical temperature of carbon dioxide, with at least part of the carbon dioxide leaving the barrel of the screw press being used to flush oxygen from between the oil-bearing, particulate material.

In the process according to the present invention, press oil leaves the cage of the screw press together with carbon dioxide, which vaporises. In a small unit, recuperation of this carbon dioxide may not be worthwhile but when a large unit is used, recuperation should certainly be contemplated. Standard recuperation techniques can be used for the purpose. Alternatively, the vaporised carbon dioxide can also be used to flush oxygen from between the oil-bearing particles prior to or during the mixing process of the seeds with dry ice and thus protect the oil therein from oxidation. This alternative is particularly suited if the protection of the oil and the cake from oxidation is specifically aimed for.

Since the oil and the carbon dioxide leave the screw press at the same time, they entrain each other which results in a lower residual oil content of the press cake. Perhaps the capillary channels formed by the carbon dioxide release facilitate the oil being expelled.

The process according to the invention can also be profitably applied in a two-stage expelling process. In this process, the oil-bearing material, the cells of which have preferably already been opened, is pre-pressed yielding a first press oil and a first press cake, which cake is then mixed with solid carbon dioxide whereupon this mixture is then treated in a second press to yield a second press oil and a press cake with reduced residual oil content.

According to another preferred embodiment of the first aspect of the present invention, the accessibility of the oil in the cells of the oil-bearing, particulate materials has been facilitated by a mechanical treatment before said material is mixed with the solid carbon dioxide, said mechanical treatment preferably comprising a pre-pressing treatment.

The press oil obtained by the process according to the invention has been found to require hardly any refining. For gourmet oils, this is particularly important since the little refining required hardly affects their taste. In general, oils obtained by the process according to the invention exhibit a low phosphatide content and a much lower colour than the same oils obtained by
other means such as high temperature pressing and solvent extraction. Often oils with an acceptable shelf life can be prepared from the press oil obtained by the process according to the invention by filtration and possibly water washing. On the other hand, some oils obtained by the process according to the invention have been found to have an unacceptably high iron content. Such oils greatly profit from being washed with an aqueous solution of ethylene diamine tetra-acetate.

According to another preferred embodiment of the first aspect of the present invention, at least part of the carbon dioxide is recuperated.

EXAMPLE

Tests were performed on a Desmet Rosedowns Minimax mechanical press using freshly produced rapeseed flakes feedstock. Dry ice (solid CO$_2$) was purchased from Clean Surface Ltd. in the form of pellets with a diameter of about 3 mm. Dry ice was added as pellets either together with the rapeseed flakes in the feed bin or via a separate vibratory feeder positioned at the inlet of the worm assembly of the press. In the first option, there was a certain contact time between the dry ice and the flakes before entering the press, while in the second option blending of the dry ice and the rapeseed flakes occurred in the press itself. Addition of 2% by weight of dry ice with respect to the weight of flakes together with the flakes in the feed bin resulted in the sublimation of a large proportion of the dry ice. 2% by weight of dry ice with respect to the weight of flakes corresponds to about 5% by weight of dry ice with respect to the weight of oil in the flakes, given that the concentration of oil in the rapeseed flakes is typically about 40% by weight. No dry ice was visibly detected in the material that entered the press so the only effect in that case was a cooling of the flakes and of the pressed material. The temperature of the oil and of the press cake decreased by about 6°C when 2% by weight of dry ice with respect to the weight of the flakes was used. Addition of 5% by weight of dry ice with respect to the weight of flakes in the feed bin was necessary to have substantial amount of dry ice entering the press. Thermal isolation of the feed bin increased the proportion of dry ice entering the press. Addition of dry ice at the inlet of the worm assembly through a vibratory feeder needed special attention due to the
bridging tendency of the dry ice pellets. Thermal isolation was necessary to secure a full control of the dosing rate. This mode of addition appeared to be the most efficient way of introducing the dry ice into the press. The appearance (colour and odour) of the cake and of the pressed oil improved for all modes of dry ice addition. Typical press parameters such as AFM (apparent fatty matter), TFM (total fatty matter), MD (milling defect) and oil yield were impacted by addition of the dry ice. For example, it was observed that oil yield improved by up to 1 % for the addition of 5% by weight of dry ice in respect of the weight of flakes.
CLAIMS

1. A process for mechanical extraction of oil-bearing, particulate materials by introducing said materials in a screw press and separately collecting the oily extract and the press cake, characterised in that the oil-bearing material is mixed with solid carbon dioxide before it is introduced into said screw press.

2. The process according to claim 1, wherein the carbon dioxide to be mixed with the oil-bearing material is in the form of carbon dioxide snow.

3. The process according to claim 1, wherein the carbon dioxide to be mixed with the oil-bearing material is in the form of dry ice pellets.

4. The process according to any one of the preceding claims, wherein the amount of solid carbon dioxide mixed with the oil-bearing material lies between 10 and 100% by weight of the oil contained in said oil-bearing material.

5. The process according to any one of the preceding claims, wherein the amount of solid carbon dioxide mixed with the oil-bearing material lies between 20 and 60% by weight of the oil contained in said oil-bearing material.

6. The process according to any one of the preceding claims, wherein the temperature inside the screw press is maintained below the critical temperature of carbon dioxide.

7. The process according to claim 6, wherein at least a part of the barrel of the screw press is cooled by means of an external coolant.

8. The process according to any one of the preceding claims, wherein the accessibility of the oil in the cells of the oil-bearing, particulate materials
has been facilitated by a mechanical treatment before said material is mixed with the solid carbon dioxide.

9. The process according to claim 8, wherein said mechanical treatment comprises a pre-pressing treatment.

10. The process according to any one of claims 6 to 9, wherein at least part of the carbon dioxide leaving the barrel of the screw press is used to flush oxygen from between the oil-bearing, particulate material.

11. The process according to any one of the preceding claims, wherein at least part of the carbon dioxide is recuperated.
Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

<table>
<thead>
<tr>
<th>Category</th>
<th>Relevant to claims</th>
<th>Identity of document and passage or figure of particular relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>1,3-5,8,9,11</td>
<td>US5169968 A (VITAMINS INC) Columns 7 and 8, in particular lines 67-16 , column 9</td>
</tr>
<tr>
<td>X</td>
<td>1,3,4,8,9,11</td>
<td>WO87/01381 A1 (VITAMINS INC) Pages 17-18 lines 26-4, page 19 lines 20-29 and page 20 lines 18-20</td>
</tr>
<tr>
<td>X</td>
<td>1,4,8 and 9</td>
<td>GB2125269 A (HUSSEIN) Page 1 lines 17-30 and 43-100</td>
</tr>
<tr>
<td>X</td>
<td>1</td>
<td>US2009/0220437 A1 (LEBER) Paragraph [0079]</td>
</tr>
</tbody>
</table>

Categories:

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC X:

Worldwide search of patent documents classified in the following areas of the IPC C11B

The following online and other databases have been used in the preparation of this search report:

WPI, EPDOC, XPESP and selected full text databases

International Classification:

<table>
<thead>
<tr>
<th>Subclass</th>
<th>Subgroup</th>
<th>Valid From</th>
</tr>
</thead>
<tbody>
<tr>
<td>C11B</td>
<td>0001/06</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>C11B</td>
<td>0001/00</td>
<td>01/01/2006</td>
</tr>
</tbody>
</table>