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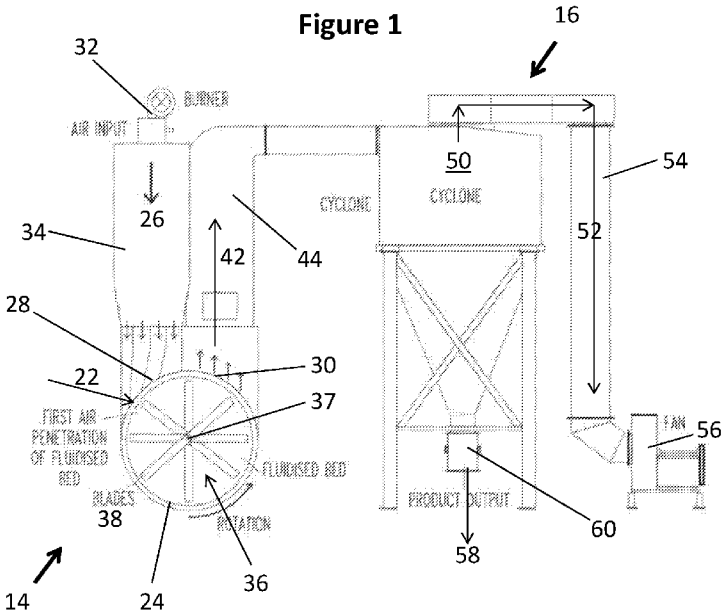
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(54) Title: DRYING PROCESS

Figure 1



(57) Abstract: A process for drying a solids-bearing fluid is disclosed. The process comprises passing a heated gas through a drying stage, whereby the heated gas passes into an initial zone of a milling stage that is located within the drying stage and, in which milling stage, solids in the solids-bearing fluid are milled so as to reduce the size thereof. The process 5 also comprises feeding the solids-bearing fluid into the initial zone of the milling stage and shredding solids in the solids-bearing fluid in the initial zone. The process further comprises drawing the heated gas together with the shredded solids further through the milling stage, whereby the shredded solids are progressively dried and milled, and such that heated gas bearing a dried, milled solids material leaves the drying stage.

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DRYING PROCESS

TECHNICAL FIELD

This disclosure relates to a process for drying a solids-bearing fluid. The solids in the fluid may comprise organic matter from plants, animals and/or humans. A liquid component of the fluid may comprise water. While the process is disclosed in this context, variations allow for the drying of solids in non-aqueous-based fluids.

BACKGROUND ART

The art is replete with processes and apparatus for drying solids-bearing fluid streams, such as organic solids-bearing, aqueous-based fluid streams. For example, WO2016122132 relates to a drying mill for the drying of soybean waste, in which the waste is fed into the unit through an inlet and is pulverized therein via a plurality of rotating blades. CN102519230 discloses a solid fuel drier for the drying of grains of varying sizes. JP2014190621 discloses a fluidization drying device for drying of a mixed organic waste, which is dried within the fluidized-drying device.

The above references to the background art do not constitute an admission that the art forms part of the common general knowledge of a person of ordinary skill in the art. The above references are also not intended to limit the application of the process as disclosed herein.

SUMMARY

Disclosed herein is a process for drying a solids-bearing fluid. The solids in the fluid may comprise organic matter from plants, animals and/or humans (e.g. waste matter), although the process is not limited to the drying of organic matter. A liquid component of the fluid may comprise water, although again, the process is not limited to the drying of aqueous-based fluids, and may be employed to drive off organic liquids from solid matter.

The process as disclosed herein comprises passing a heated gas through a drying stage. In the drying stage the heated gas passes into an initial zone of a milling stage that is

located within the drying stage. In the milling stage solids in the solids-bearing fluid are milled so as to reduce the size thereof.

The process also comprises feeding the solids-bearing fluid into the initial zone of the milling stage and shredding solids in the solids-bearing fluid in the initial zone.

The process further comprises drawing the heated gas together with the shredded solids further through the milling stage. The shredded solids can be progressively dried and milled, such that heated gas bearing a dried, milled solids material (product) is able to leave the drying stage.

In the process as disclosed herein, the solids in the fluid are shredded, dried and milled, all in the drying stage. Further, the process as disclosed herein is able to produce a dried, milled solids product in a rapid manner. The drying stage of the process can be operated to cause "flash" evaporation of liquid in the solids-bearing fluid, which can enhance drying rate and reduce residence time in the drying stage. The process also differs from prior art teachings, wherein organic waste typically requires pre-processing (e.g. shredding) prior to drying.

In one embodiment, the solids-bearing fluid may be directly fed in a generally lateral direction into the initial zone with respect to a flow direction of the heated gas through the initial zone. Thus, the solids are immediately shredded as they move transversely through the heated gas, disrupting gas flow, dispersing liquid and causing turbulence and eddies, etc. All of this can enhance drying and flash evaporation of liquid from the solids-bearing fluid.

In one embodiment, the heated gas and the solids may be drawn through the drying stage by applying at least a partial vacuum thereto. For example, said at least partial vacuum may be applied to the drying stage at an outlet thereof. The at least partial vacuum may be applied by a vacuum generation apparatus, such as a fan or compressor arranged downstream from and remote to the drying stage outlet. The employment of an at least partial vacuum can enhance the passage of solids from the initial zone of the milling stage, through to drying and milling in a remainder of the milling stage. The employment of an at least partial vacuum can also be used to draw the heated gas and solids stream into a separation stage.

In one embodiment, the milling in the milling stage may be such as to cause the solids in the solids-bearing fluid to form a fluidised bed. The fluidised bed may flow within the drying stage towards an outlet thereof. For example, in a vessel for the drying stage, the fluidised bed may form around the side wall(s) of the vessel, and solids may generally move therein and there-along towards the outlet, being progressively dried and milled along the way.

In one embodiment, after the drying stage, the dried, milled solids material may be separated from the heated gas in a separation stage (e.g. by a gas-solids separation apparatus). The separation stage may, for example, comprise a gas-solids separator such as a cyclone, although the use of other gas-solids separation apparatus is possible. Whilst a cyclone is optimal, other gas-solids separators that may be employed include filters, electrostatic separators, etc.

In one embodiment, and prior to the drying stage, the solids-bearing fluid may be subjected to a pre-treatment stage. The pre-treatment stage may be employed to optimise the characteristics of the solids-bearing fluid prior to it being introduced into the initial zone of the milling stage. The pre-treatment stage may also be employed to enhance one or more of shredding, drying and milling in the drying stage.

In one embodiment, the pre-treatment stage may be operated to pre-heat the solids-bearing fluid – e.g. to an optimal temperature for the drying stage, such as a temperature somewhere between 60°C -70°C (e.g. about 65°C). This pre-heating can help to reduce the load on the drying stage.

In one embodiment, depending on the solids material in the fluid, the pre-treatment stage may initially break down solids in the solids-bearing fluid in some way. For example, by agitation, maceration, etc. This can help to improve shredding of the solids in the initial zone of the milling stage.

In one embodiment, the pre-treatment stage may include removal of liquid (e.g. to reduce the drying load), or addition of liquid (e.g. to improve flowability or to enable injection of fluid, etc). Pre-treatment may include blending in of other (e.g. organic) solids material. Pre-treatment may include removal or addition of fats and oils; etc.

In one embodiment, the pre-treatment may employ one or more apparatus such as: a heating vessel to pre-heat the solids-bearing fluid; an agitation vessel to break down solids in the solids-bearing fluid (e.g. stirred tank, vibrational or ultrasonically treated vessel, etc); a solids-liquid separator such as a settling vessel, a decanter, a thickener, a filtration or membrane apparatus, etc to at least partially remove liquid (such as water when the fluid is an aqueous fluid) and/or fats (when present in the solids/fluid) and/or oils (when present in the solids/fluid).

In one embodiment, the heated gas may comprise one or both of: combustion gases resulting from the burning of a fuel; and a gas (e.g. air) that has been indirectly heated (e.g. in a heat exchanger). In other words, hot combustion gases may be fed directly fed into the drying stage. The hot combustion gases may first be filtered, etc before being fed into the drying stage, whereas an indirectly heated gas may require no such treatment. When the fuel for the heated gas comprises e.g. natural gas, the heated gas may have a temperature in the range of 300°C - 500°C, more typically around 400°C.

In one embodiment, the drying stage may be effected in a drier that is arranged to have the heated gas passed therethrough from a drier inlet to a drier outlet. The drier may take the form of a vessel such as a cylindrical vessel. The vessel can have an inlet located at or adjacent to one end of the vessel, and an outlet located at or adjacent to an opposite end of the vessel.

In one embodiment, the milling stage may comprise a milling mechanism (e.g. rotary mill) that is located within the drier and through which the heated gas passes. The milling mechanism may be configured to operate as a grinder, pulveriser, crusher, comminuter, etc. The milling mechanism may extend for a substantial length of the drier or may extend for a discrete (intermediate) region thereof (e.g. inset from each of the drier (vessel) inlet end and outlet end). The initial zone may be defined by a discrete region of the milling mechanism located at or inset from the drier (vessel) inlet end.

In one embodiment, one or more feed inlets may be arranged at the drier to deliver the solids-bearing fluid to that part of the milling mechanism located in the initial zone. The delivery direction of fluid can be generally lateral with respect to the flow direction of heated gas from the drier inlet to the drier outlet. The one or more feed inlets may

comprise one or more ports arranged at a side wall of the drier adjacent to the milling mechanism. Alternatively or additionally, the one or more ports may be arranged within the milling mechanism itself.

The one or more feed inlets can typically be separate to the heated gas inlet of the drier and the heated gas outlet of the drier, and can typically be located immediately adjacent to the initial zone. Thus, shredding of the solids can commence as soon as the solids-bearing fluid leaves the one or more feed inlets. This can again contribute to the rapid, flash evaporation of liquid present in the solids-bearing fluid to enhance drying rate as well as to reduce drier residence time.

In one embodiment, the solids-bearing fluid may be delivered to the one or more feed inlets by a feed displacement mechanism. Depending on the consistency of the fluid, the feed displacement mechanism may take the form of a screw-feeder (e.g. for a thick or viscous fluid), a piston-type injector (e.g. for a more liquid, less viscous fluid), a pump, etc.

In one embodiment, the milling mechanism may comprise a rotary mill that has a rotating shaft extending longitudinally in the drier. The shaft can be provided with a plurality of blades that extend radially therefrom. The blades can be located (e.g. evenly) about the shaft. The blades can also be located spaced out along a longitudinal axis of the shaft. The profile and configuration of the blades can be varied to suit the nature of the solids-bearing fluid to be dried and milled in the drier. For example, thicker, heavier blades can be employed for a thicker, more viscous fluid, and thinner blades for a thinner, more liquid, less viscous fluid.

In one embodiment, the rotating shaft may comprise a central feed passage, with one or more of the feed inlets (e.g. one or more ports) formed in the shaft and communicating with the central feed passage to release the solids-bearing fluid directly into the milling zone.

In one embodiment, when the shaft is rotated within the drier, the blades can be arranged to mill, into smaller particle sizes, solids within the solids-bearing fluid. For example, the blades can first shred and later grind the solids.

In one embodiment, the blades can impart a centrifugal force to the solids such that they may be displaced towards side wall(s) of the drier. This can cause a solids bed to form at the side wall(s) of the drier, which bed may be fluidised in operation of the milling mechanism. In other words, the drier may be configured to function as a fluidised bed drier.

In one embodiment, an initial section of the blades may define the initial zone of the milling stage in which the solids are shredded. An intermediate section of the blades may define a drying zone of the milling stage in which the shredded solids continue to be milled and dried. A final section of the blades may define a grinding zone of the milling stage in which the drying solids are further milled and dried. The blades can be configured to e.g. perform one or more of: grinding, pulverising, comminuting, crushing, etc of the solids, such as in the grinding zone of the milling stage

In one embodiment, the solids-bearing fluid may take the form of a slurry of solids dispersed in a liquid. For example, the slurry may comprise organic solids suspended in an aqueous fluid whereby, in the drier, liquid such as water is removed from the solids-bearing fluid as a vapour.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described by way of example only, with reference to the accompanying drawings in which:

Fig. 1 shows a front view of an embodiment of apparatus for the process;

Fig. 2 shows a side, partly sectioned view of the apparatus shown in Fig. 1;

Fig. 3 shows a flow diagram for an embodiment of a process as disclosed herein;

Figs. 4 & 6 show photomicrographs of particles produced by a conventional prior art drying process (150x and 10 x magnification respectively);

Figs. 5 & 7 show photomicrographs of particles produced by the drying process as disclosed herein (150x and 10 x magnification respectively).

DETAILED DESCRIPTION

In the following detailed description, reference is made to accompanying drawings which form a part of the detailed description. The illustrative embodiments described in the detailed description, depicted in the drawings and defined in the claims, are not intended to be limiting. Other embodiments may be utilised and other changes may be made without departing from the spirit or scope of the subject matter presented. It will be readily understood that the aspects of the present disclosure, as generally described herein and illustrated in the drawings can be arranged, substituted, combined, separated and designed in a wide variety of different configurations, all of which are contemplated in this disclosure.

Disclosed herein is a process for drying a solids-bearing fluid. In the present detailed description, the process will be described with reference to the drying of an aqueous slurry comprising organic matter. The organic matter may either comprise waste organic material, or organic material to be dried for later use. The drying can extend the shelflife of such organic material. The drying and milling may be such as to turn the waste matter into a useable (e.g. comestible) material. The organic matter may be derived from animals, plants, and/or humans (e.g. whole fish or fish waste; plant or crop waste; sewerage; etc). It should also be understood that the process may be used for drying solids in non-aqueous-based fluids, and may be employed to e.g. drive off organic liquids from solid matter.

Reference will now be made to the process flow diagram shown in Figure 3. Individual components of the process will, at the same time, be described with reference to Figures 1 & 2.

Referring to Figure 3, a flow sheet for a process 10 for drying of a solids-bearing liquid stream 20 (e.g. an aqueous slurry that comprises organic matter) is depicted. The process 10 comprises a number of stages, namely, a pre-treatment stage 12, a drying & milling stage 14, a solids separation stage 16 and a solids handling stage 18. Each of these stages will now be described in turn, with reference to Figures 1 to 3.

Pre-treatment Stage 12

In the process 10, the pre-treatment stage 12 is located prior to the drying stage 14. In pre-treatment stage 12 a solids-bearing liquid stream 20 (which may also be formed in stage 12 e.g. from organic matter) is pre-treated so as to optimise its characteristics prior to the stream 20 being introduced into the drying stage 14.

For example, in the pre-treatment stage 12 the stream 20 can be pre-heated in e.g. a heating vessel (e.g. stirred tank reactor) to an optimal temperature for the drying stage 14. Suitable temperatures somewhere in the range of 60°C -70°C, typically about 65°C, have been observed to help reduce the load on the drying stage 14.

The pre-treatment stage 12 can also comprise an agitation vessel (e.g. a stirred tank, vibrational or ultrasonically treated vessel, etc) in which the solids in stream 20 are broken down in a preliminary step (e.g. by agitation, maceration, etc). This can help to improve/enhance shredding of the solids when milled within the drying stage 14.

In the pre-treatment stage 12 liquid (e.g. water) can be removed to reduce the drying load. Pre-treatment stage 12 can also be employed remove (or add) fats and oils; etc. The pre-treatment stage 12 can comprise a solids-liquid separator such as a settling vessel, a decanter, a thickener, a filtration or membrane apparatus, etc. For some fluids, liquid (e.g. water) may need to be added to e.g. improve flowability or to enable injection of the fluid into the drier, etc. Pre-treatment stage 12 can also provide for the blending in of other (e.g. organic) solids material, such as to provide a mixed solids material. The resultant pre-treated fluid stream 22 may have a moisture/liquid content as high as 70 wt. %.

Drying Stage 14

The drying stage 14 comprises a cylindrical drying vessel 24 for receiving the pre-treated fluid stream 22, and through which a heated gas stream 26 is passed, from a vessel inlet 28 to a vessel outlet 30. The vessel inlet 28 is located adjacent to a first end of the drying vessel 24, extending laterally into the vessel through a side wall thereof to deliver the heated gas stream 26 into the vessel. The vessel outlet 30 is located adjacent to an opposite end of the vessel, extending laterally out from the side wall of the vessel to receive a dried solids product therethrough. The vessel outlet 30 can be provided

with a regulator or valve (e.g. flap-valve) to regulate the outflow of dried, milled solids in a heated gas stream.

In the embodiment of Figures 1 & 2, the heated gas stream 26 is produced by burning air in a burner 32, and feeding the resultant combustion gases 26 through a plenum 34, directly into the vessel inlet 28. These hot combustion gases can be filtered, etc before being fed into the drying vessel 24. Alternatively, an indirectly heated gas (e.g. air) that is passed through a heat exchanger can be fed into the drying vessel 24.

The fuel for the burner 30 typically comprises natural gas, which can produce heated combustion gases 26 having a temperature in the range of 300°C - 500°C, more typically around 400°C.

The drying vessel 24 is of a type that comprises a milling mechanism in the form of a rotary mill 36 located therein. Whilst the rotary mill 36 can be configured to operate as a pulveriser, crusher or comminuter, typically it is configured to grind the solids present in the fluid stream 22 so as to reduce the particle/grain size thereof.

In the embodiment of Figures 1 & 2, the rotary mill 36 extends for a substantial length of the drying vessel 24. In a variation, it may extend for a discrete (intermediate) length, so as to be inset from each of the drying vessel inlet and outlet ends.

The rotary mill 36 comprises a motor-driven rotating shaft 37 that extends longitudinally in the drying vessel 24. The shaft 37 is provided with a plurality of blades 38 that extend radially therefrom. The blades are spaced evenly about the shaft. The blades are also spaced out evenly along a longitudinal axis of the shaft. The profile and configuration of the blades is varied to suit the nature of the solids present in the fluid stream 22. For example, thicker, heavier blades are employed for a thicker, more viscous fluid, and thinner blades are employed for a thinner, more liquid, less viscous fluid. In the embodiment depicted the blades are formed from a rectangular cross-sectioned bar (e.g. of stainless steel).

The shaft 37 can be rotated at speeds in the range of 700-1500 rpm, depending on the solids material to be dried and milled.

An initial "solids shredding" zone is defined by a discrete region of the rotary mill 36 that is located adjacent to the drying vessel inlet end. In drying stage 14, the solids-containing fluid stream 22 is fed into the solids shredding zone whereupon the blades function to shred the wet solids material, breaking it down into a smaller particle/granular size range. This exposes more of the solids surface to the heated combustion gases, resulting in a rapid (i.e. "flash") evaporation of the liquid (water) therefrom.

Adjacent to the solids shredding zone, the rotary mill 36 can define an intermediate drying zone (i.e. a further discrete section of the blades 38) in which the shredded solids continue to be dried and being to be grinded. Adjacent to the intermediate drying zone, the rotary mill 36 can define a final grinding zone (i.e. a yet further discrete section of the blades) in which the progressively drying solids are further milled (grinded) and further dried.

The rotating shaft 37 and blades 38 impart a centrifugal force to the shredded solids, displacing them towards a side wall of the drying vessel 24 to define a fluidised bed thereat (dotted lines 39). Thus, the drying vessel 24 functions as a fluidised bed drier.

As explained in greater detail below, a partial vacuum is applied to the drying vessel 24 via the vessel outlet 30. The partial vacuum is applied to the drying vessel 24 by a vacuum generation apparatus, such as a fan 56 or compressor arranged downstream from and remote to the vessel outlet 30. This partial vacuum causes the heated combustion gases 26 to be drawn through the drying vessel 24, from its inlet 28 to the outlet 30. This in turn causes the shredded solids material to be drawn from the solids shredding zone, moving further through the drying vessel 24, along with the heated combustion gases 26. As the shredded solids move further through the rotary mill, the solids are progressively dried and milled (grinded by the blades 38) until an optimal particle size range and moisture content (e.g. around 10 wt.%) is reached, such that heated gas bearing a dried, milled solids material (product) is able to leave the drying stage.

Thus, in drying stage 14, the solids in the fluid stream 22 are able to be shredded, dried and milled, all within the one drying vessel 24 (i.e. the process provides for single-stage

processing). Further, this is able to occur in a rapid manner (i.e. less than 10 sec, and optimally around 5 sec). The drying stage 14 can be operated at a temperature (~400°C) and partial vacuum that causes "flash" evaporation of liquid in the solids-bearing fluid, which can enhance drying rate and reduce residence time in the drying stage. The drying stage 14 also differs from prior art organic waste treatment processes which typically require pre-processing (e.g. shredding) prior to drying.

In drying stage 14, the fluid stream 22 is directly fed in a generally lateral direction into the solids shredding zone (i.e. with respect to the flow direction of the heated gas through this zone). The solids in stream 22 are immediately shredded as they move transversely through the heated gas. This serves to disrupt gas flow, disperse liquid and cause turbulence and eddies, etc in this part of the drying vessel 24, all of which enhance drying and flash evaporation.

In the drying vessel 24, the fluid stream 22 is directly fed into the solids shredding zone via a number of feed ports 40 that are defined in the side wall of the drying vessel 24. The ports tend to be located immediately adjacent to the solids shredding zone. Feeding of the fluid stream 22 to and from the ports 40 is controlled by a feed displacement mechanism. Depending on the consistency of the fluid stream 22 (i.e. solids size and type, viscosity, rheology, etc), the feed displacement mechanism takes the form of a screw-feeder (e.g. for a thick or viscous fluid), or a piston-type injector (e.g. for a more liquid, less viscous fluid), or a pump, etc.

Feed ports can also (or alternatively) be provided in the rotary mill 36. In this regard, the rotating shaft 37 can be provided with a central feed passage, and the feed ports can be formed in the shaft to communicate with the central feed passage to release the fluid stream 22 directly into the solids shredding zone.

Exiting from the drying vessel 24 of drying stage 14 is a dried, milled solids material product stream 42, along with the heated gas comprising gas vapour (e.g. water vapour). The dry product stream 42 is drawn through the vessel outlet 30 and passes into an exhaust plenum 44. Exhaust plenum 44 transfers the dry product stream 42 to the solids separation stage 16.

Solids Separation Stage 16

In solids separation stage 16 the dry product stream 42 comprising a milled solids material is separated from the heated gas and gas vapour in a gas-solids separation apparatus. In the embodiment of Figures 1 & 2, the gas-solids separator is a cyclone 50, although the use of other gas-solids separation apparatus is possible, such as filters or electrostatic separators, etc.

The dry product stream 42 flows into the cyclone 50, whereupon the separated gas overflow stream 52 flows via ducting 54 to a fan 56. The fan 56 supplies the partial vacuum to the drying stage 14 via the drying vessel outlet 30. The partial vacuum is used to draw the heated gas and gas vapour and dried solids stream into the cyclone 50. A separated dried solids underflow stream 58 is removed via the cyclone outlet 60.

Solids Handling Stage 18

In the solids handling stage 18 the separated dried solids that is removed via the cyclone outlet 60 is stored and/or packaged into suitable containers for storage and transportation. Such storage may be vacuum-tight to increase shelflife.

As mentioned above, the separated dried solids can have a moisture content as low as around 10 wt. %. In addition, an optimal fat content can be retained in the dried solids so as to help promote product shelflife. A typical product shelflife of around 2 years or greater is envisaged.

The process as disclosed herein can be used to generate a protein-based product (e.g. feed for livestock, fisheries, etc or food for human consumption from a (waste) protein material (e.g. fish and crustacean waste, shells and oyster waste, animal by-products, grains, fruit and vegetables or other bio-matter). The process as disclosed herein can be used to transform lower quality foodstuffs into comestible foodstuffs. The process as disclosed herein can also be used to render an otherwise toxic waste material (e.g. human or animal sewage) benign or safe for disposal.

The process as disclosed herein has been used to successfully create a meal with salmon fish waste (such as guts and heads), and well as to successfully create an apple-meal food product. Many other waste protein materials can be successfully treated (i.e. dried and milled) by the present process to transform them into comestible foodstuffs.

EXAMPLES

Non-limiting examples will now be described. Example 1 outlines applications of the process, and Examples 2 and 3 provide specific experimental applications of the process.

Example 1

Specific applications of the process were investigated using a typically high-fat content, proteinaceous waste product supplied by a poultry producer. The purpose of the investigation was to determine if a commercially attractive, proteinaceous meal product for animal feed applications could be produced from a combination of food waste and grain. Various blends 1-4 of waste poultry and grain were tested.

The typical nutritional analysis of the finished product meals as produced by the process as outlined above were analysed for both commercial viability and reproducibility. The results are set out in Table 1 below.

Table 1

Blend	Protein (%)	Moisture (%)	Crude Fat (%)	Ash (%)
1	22.99	4.82	11.7	7.19
2	35.41	9.34	21.1	9.00
3	32.15	10.22	22.0	7.42
4	36.50	14.20	24.1	10.28

The results indicated that a suitable proteinaceous meal product for animal feed applications was able to be produced.

Example 2

This experimental example was conducted to demonstrate the effect of processing parameters, including feed type, feed speed, feed weight and temperature on the viability of the process, and the quality of the resulting meal product. The results are set out in Table 2 below.

Table 2

Trial	Feed	Input rate	Weight (kg)	Temperature (°C)	Residence time (s)	Operation
1	fish	slow	25	220	5-6	OK
2	fish	slow	30	250	5-6	OK
3	fish	fast	25	220	5-6	OK
4	chicken	slow	25	220	5-6	NO
5	chicken	slow	25	300	5-6	OK
6	fish	fast	30	220	5-6	OK
7	Fish	fast	25	220	5-6	OK
8	chicken + grain	fast	25 + 5	300	5-6	OK

Example 3

This experimental example was conducted to demonstrate the advantages of the present process over a prior art drying process, in terms of nutritional value to the consuming animal. Batches of salmon feed were processed via both the present process and a conventional prior art drying method, with the morphology of the resulting product compared. It was observed that the cell structure of proteinaceous material had a direct impact on the digestibility of the material by consuming animals.

The conventional, prior art 'drum dried' process yielded particles exhibiting closed cell spherical structures, as shown in Figure 4. This morphology was considered indicative of poor surface lipid bonding and reduced bioavailability to the consuming animal. In contrast, particles produced by the present process exhibited an open cell structure, typical of processing under vacuum, as shown in Figure 5. Strong surface lipid complexing is apparent in Figure 5.

In examining the cross section of larger 'sinking' particles of product (i.e. able to sink in water) from both the conventional 'drum dried' process (Figure 6) and the present process (Figure 7), similar morphological distinctions are observed. As shown in Figure 6, the particles produced by the conventional process exhibited an internal closed cell structure, indicative of poor lipid absorption capacity. Additionally, a crumbling structure was observed, indicating reduced mechanical strength. In contrast, as shown in Figure 7, particles yielded under the present process exhibited an open cell internal structure, with numerous pockets available for lipid entrainment and functional protein binding. Enhanced mechanical strength over particles from the conventional process was also observed.

Thus, in considering both surface and internal morphologies, the cell structure of proteinaceous material that had been flash dehydrated by the present process appeared more conducive to lipid absorption by the consuming animal, than that produced by a conventional 'drum dried' process.

Variations and modifications may be made to the process previously described without departing from the spirit or ambit of the disclosure.

In the claims which follow and in the preceding summary except where the context requires otherwise due to express language or necessary implication, the word "comprising" is used in the sense of "including", that is, the features as above may be associated with further features in various embodiments.

CLAIMS

1. A process for drying a solids-bearing fluid, the process comprising:

passing a heated gas through a drying stage, whereby the heated gas passes into an initial zone of a milling stage that is located within the drying stage and, in which milling stage, solids in the solids-bearing fluid are milled so as to reduce the size thereof;

feeding the solids-bearing fluid into the initial zone of the milling stage and shredding solids in the solids-bearing fluid in the initial zone;

drawing the heated gas together with the shredded solids further through the milling stage, whereby the shredded solids are progressively dried and milled, and such that heated gas bearing a dried, milled solids material leaves the drying stage.

2. A process according to claim 1, wherein the solids-bearing fluid is directly fed in a generally lateral direction into the initial zone with respect to a flow direction of the heated gas through the initial zone.

3. A process according to claim 1 or 2, wherein the heated gas and the solids are drawn through the drying stage by applying at least a partial vacuum thereto.

4. A process according to claim 3, wherein said at least partial vacuum is applied with respect to an outlet of the drying stage, and through which outlet the heated gas bearing the dried, milled solids material leaves the drying stage.

5. A process according to claim 3 or 4, wherein said at least partial vacuum is applied by a fan or compressor arranged downstream from and remote to the drying stage.

6. A process according to any one of the preceding claims, wherein after the drying stage, the dried, milled solids material is separated from the heated gas in a separation stage.

7. A process according to claim 6, wherein the separation stage comprises a gas-solids separator such as cyclonic separation.

8. A process according to any one of the preceding claims, wherein, prior to the drying stage, the solids-bearing fluid is subjected to a pre-treatment stage.

9. A process according to claim 8, wherein the pre-treatment stage is employed to perform one or more of: pre-heating of the solids-bearing fluid; breakdown of solids in the fluid; at least partial removal from or addition to the solids-bearing fluid of one or more of: liquid (such as water when the fluid is an aqueous fluid); and/or fats (when present); and/or oils (when present).

10. A process according to any one of the preceding claims, wherein the heated gas comprises one or both of: combustion gases resulting from the burning of a fuel; and a gas that has been indirectly heated.

11. A process according to any one of the preceding claims, wherein the drying stage comprises a drier that houses a milling mechanism in the milling stage thereof, and wherein one or more feed inlets are arranged at the drier to deliver the solids-bearing fluid to that part of the milling mechanism located in the initial zone.

12. A process according to claim 11, wherein the one or more feed inlets comprise:

one or more ports arranged at a side wall of the drier adjacent to the milling zone; and/or

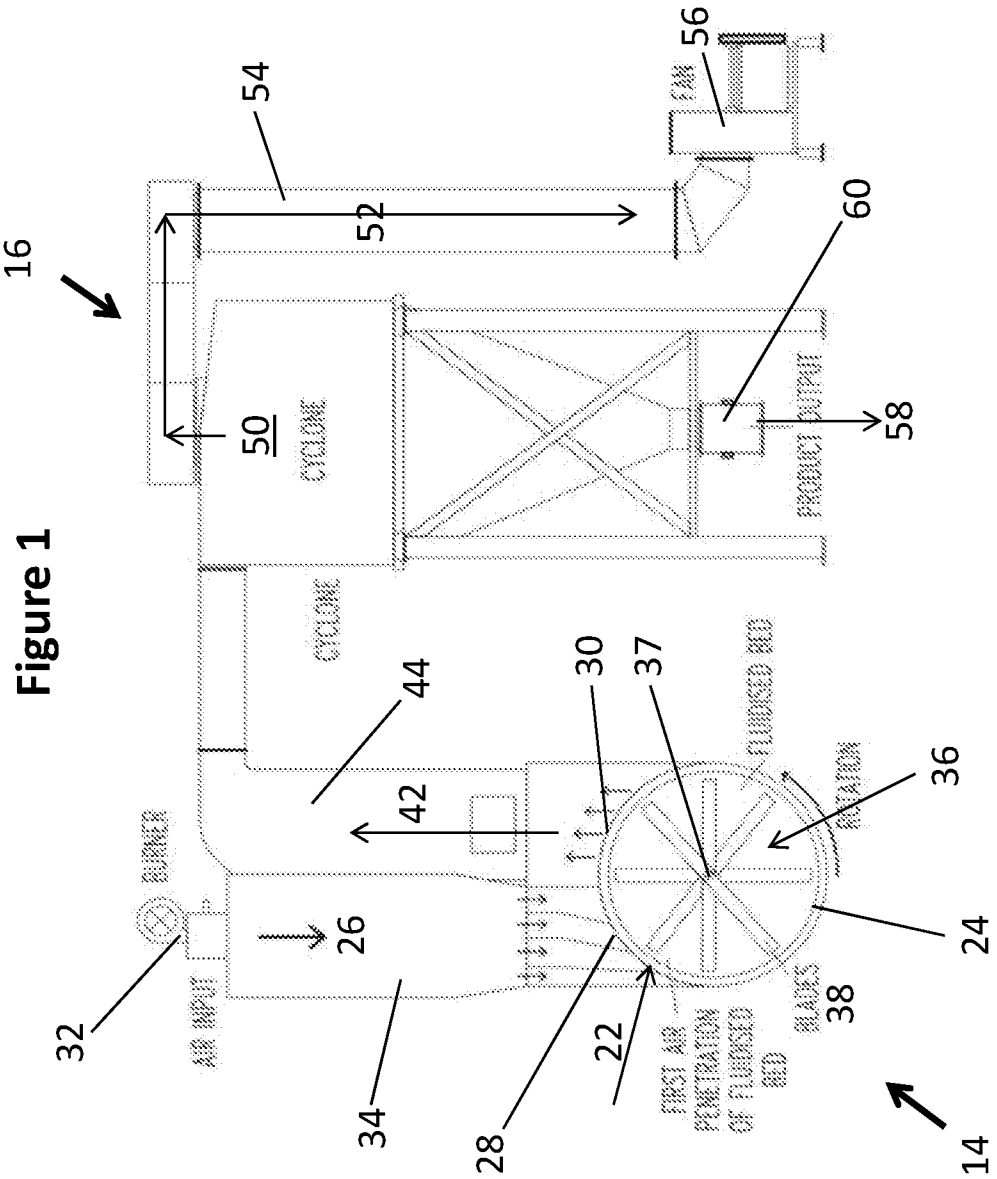
one or more ports arranged within the milling mechanism.

13. A process according to claim 11 or 12, wherein the milling mechanism comprises a rotary mill that has a rotating shaft extending longitudinally in the drier, the shaft having a plurality of blades extending radially from, about and along a shaft longitudinal axis such that, when the shaft is rotated, the blades are arranged to mill, into smaller particle sizes, solids within the solids-bearing fluid, and so as to impart a centrifugal force to the solids to be displaced towards side wall(s) of the drier.

14. A process according to claim 13, wherein an initial section of the blades defines the initial zone of the milling stage in which the solids are shredded, an intermediate section of the blades defines a drying zone of the milling stage in which the shredded

solids continue to dry; and a final section of the blades defines a grinding zone of the milling stage in which the drying solids are further milled and dried.

Figure 1


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CYCLONE
PRODUCT OUTPUT
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CYCLONE
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FLUIDISED BED
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BURNER
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AIR INPUT
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FIRST AIR PENETRATION OF FLUIDISED BED
BLADES
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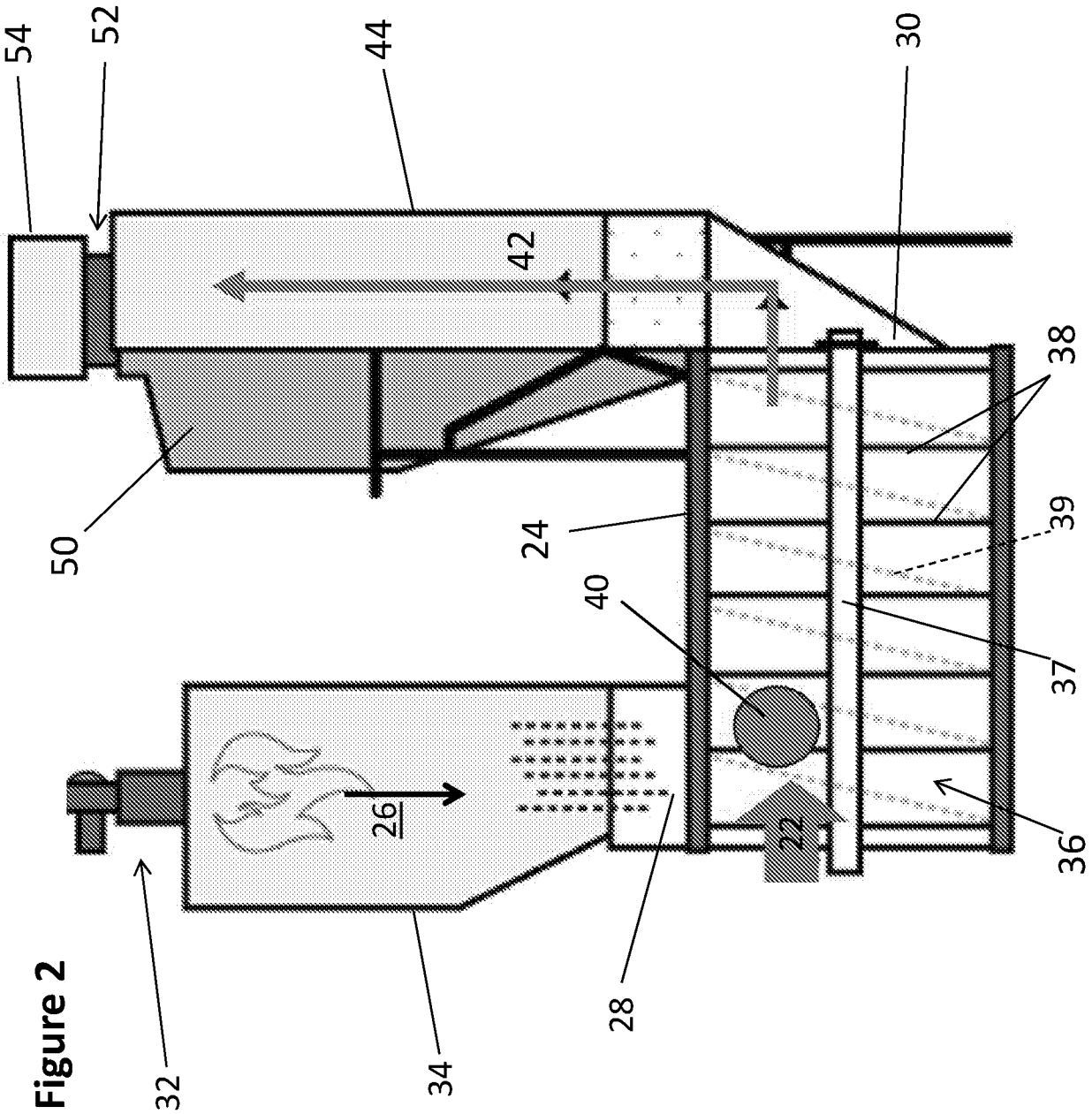


Figure 2

Figure 3

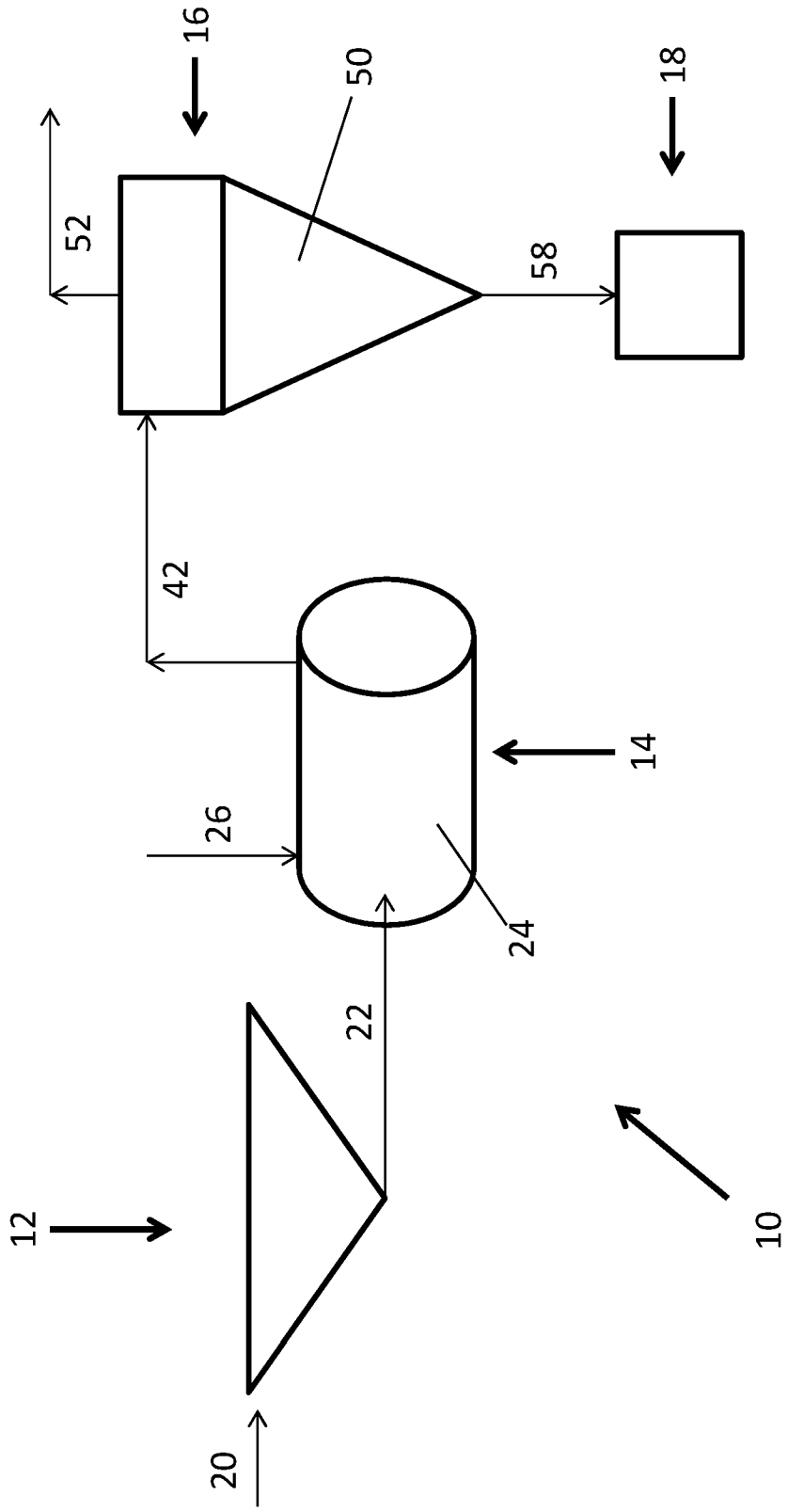


Figure 5

Dried meal particle produced by present process from salmon feed stock (150X magnification)

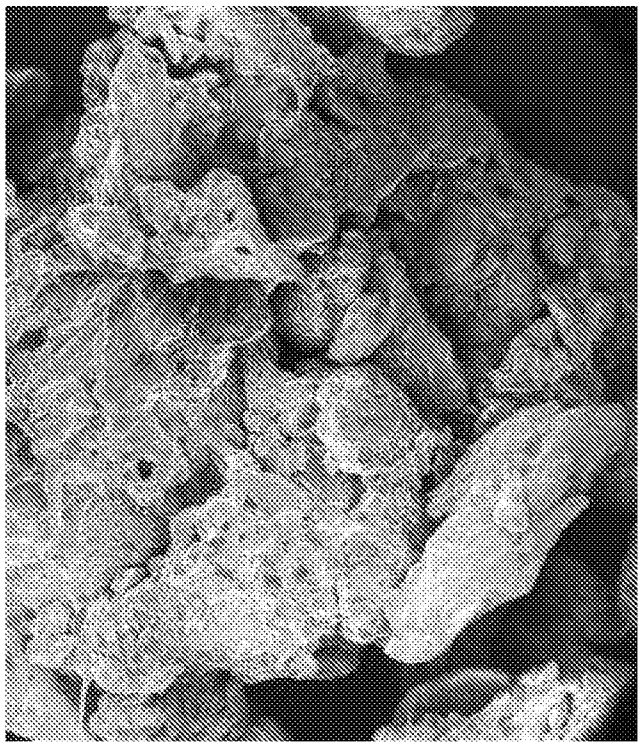


Figure 4

Conventionally dried meal particle produced from salmon feed stock (150X magnification)

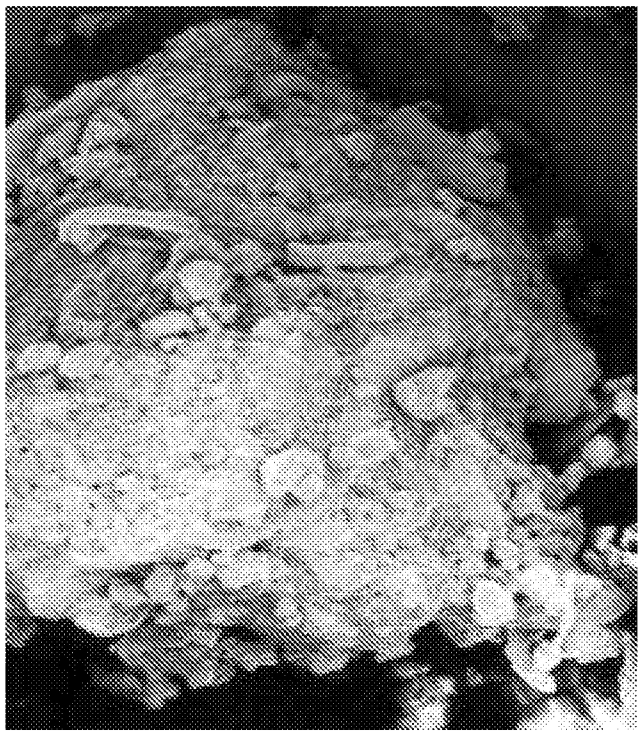


Figure 7

Cross-section of dried sinking meal pellet produced by present process from salmon feed stock (10X magnification)

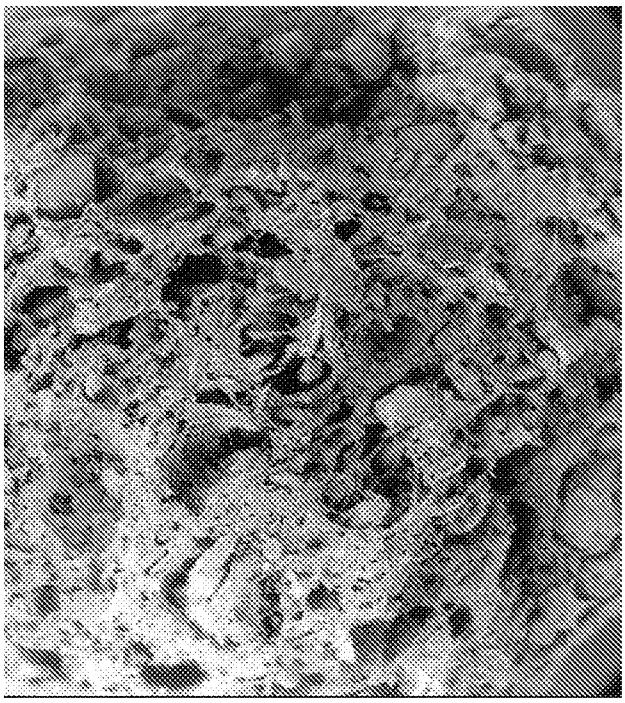
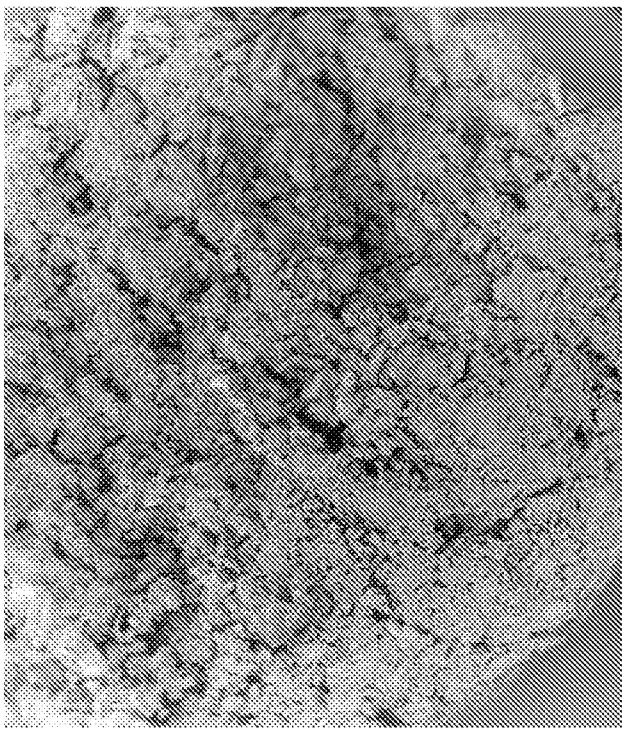


Figure 6

Cross-section of conventionally dried sinking meal pellet produced from salmon feed stock (10X magnification)



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2017/050235

A. CLASSIFICATION OF SUBJECT MATTER

F26B 1/00 (2006.01) F26B 21/00 (2006.01) F26B 23/00 (2006.01) B01D 45/12 (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

PATENW in EPOQUE INTERNAL: IPCs & CPCs: F26B1/LOW, F26B23/LOW, F26B7/LOW, F26B21/LOW, B01D45/LOW, B04C/LOW, B02C/LOW, F26B3/02/LOW; key words: Dry, Heat, Mill, Shred, Gas, Solid, Fluid, Vacuum and similar terms;

Applicant and Inventors name searched in AusPat and internal databases (PAMS Nose and INTESS) by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

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Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2017	30 May 2017
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Santosh Gupta AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262837947

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2017/050235**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0567560 B1 (BONTECH ENGINEERING A/S) 23 August 1995 Figs. 1-3; page 1, lines 24-30; page 2, lines 11-56; page 5, lines 16-33; page 9, lines 16-24	1-14
X	US 2016/0169581 A1 (KOTYK ENERGY AG) 16 June 2016 Abstract; All Figs.; paragraphs [0026], [0028], [0041], [0070], [0077], [0088], [0096], [0124], [0133]-[0135], [0186]-[0187]	1-12
A	US 7020980 B1 (ADAMS ET AL.) 04 April 2006 Abstract; all claims	1-14

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2017/050235**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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		US 7140122 B1	28 Nov 2006

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.