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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Rice Milling

I, Truman Benjamin WAYNE, of 2405 Norfolk Street, Houston 6, Texas, United States of America, a citizen of the United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for the treatment of brown rice and is divided out the specification of my copending Application No. 37409/63. (Serial No. 1066946).

It is common practice to prepare brown rice for further milling by cleaning dirt, straw and other debris from rough, or paddy, rice which is then sent to stone hullers where hulls are removed, together with some loosely adhering bran. The hulled, brown rice is then commonly milled in a machine comprising a horizontal cylindrical shell having perforations there-through. The machine has a rapidly revolving inner rotor with a ribbed surface which rubs the brown rice against the outer cylindrical shell to ~~abrade~~ bran from the endosperm.

The surface-grinding operation is normally carried out under retention time and feed-rate conditions selected to produce a desired degree of removal of the outer bran layers from the rice kernels. The milling process is rather severe, and breaks a substantial proportion of the whole rice grains into two or more fragments by a combination of factors such as impact, mechanical and thermal stresses, and generated heat. Breakage results in economic loss, since broken rice has a lower market value than whole rice grains.

According to the present invention there is provided a process for the treatment of brown rice comprising the steps of mixing a liquid bran-softening agent, as herein defined, with brown rice in a quantity, and for a time, sufficient to soften bran on the rice kernels; and milling bran from the rice in the presence of the bran-softening agent.

A preferred temperature range for carrying

[Price 4s. 6d.]

out the bran-layer softening is from 32°C to 60°C.

Softening the bran on the exterior of the kernels of brown rice reduces the degree of abrasion necessary to remove bran from the kernels, reduces kernel breakage, reduces the increase in temperature in the milling process to some extent and permits more flexible operation.

The brown rice starting material may be hulled and cleaned rough or paddy rice, or rough or paddy rice which has been parboiled and dried prior to removal of the hulls. Either source of brown rice is satisfactory although that derived from rough or paddy rice yields a better product than that derived from brown rice which has been sufficiently parboiled to drive much of the bran layer into the endosperm.

Any non-toxic or easily removable liquid material which has the property of wetting, dissolving, penetrating into, becoming miscible with and attacking the complex structure of oils, proteins and carbohydrates present in layers of bran on kernels of the rice may be used as the bran-softening agent, with the exception of water. The starchy kernels of the rice are so easily affected by either pure water or water containing such small proportions of salts as are normally present in domestic water supplies that it is impractical to soften bran on rice with water to an extent substantially improving ease of milling without causing moisture checking of the rice, and thus increasing the breakage of rice kernels during the milling process.

The term "liquid bran-softening agent" is used in this specification in a special restricted sense to exclude water but to include non-polar liquid materials, such as highly refined mineral oils; predominantly non-polar materials such as higher fatty acids; and glycerol, glycol and polyglycol esters of higher fatty acids; dually polar-non-polar organic materials having a hydrophobic and a hydrophilic group in the

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5 molecule, such as soaps, sugar alcohol esters of higher fatty acids, amido compounds of higher fatty acids, glycols having three or more carbon atoms in the molecule, and polyglycols; aqueous solutions of alkaline materials which have a saponifying effect on fatty components and a solubilizing effect on certain protein constituents of the bran, such as hydroxides and carbonates of ammonia and the alkali metals; 10 aqueous solutions of neutral salts which attack and render soluble certain proteins of the bran layer, such as chlorides and sulfates of ammonia and the alkali metals; and dilute solutions of acids or mixtures of acids, which are non-toxic in the small proportions present but are effective to attack and solubilize proteins, such as hydrochloric, sulfuric, phosphoric and citric acids.

20 Bran-coat softening may be used in combination with solvent extractive milling which is described in more detail in the specification of my copending application (Serial No. 1066946) No. 37409/63 from which the present specification is divided.

25 When milling in the presence of a solvent effective to extract fatty components from the bran and germ, the bran-softening agents may be materials which are soluble in the solvent or which are capable of being emulsified into the solvent in contradistinction to being truly soluble therein, such as aqueous solutions mentioned above. These materials usually tend to selectively wet and to be absorbed by the bran coating.

35 Such solutions or suspensions however should be limited in the quantity used to proportions insufficient to penetrate through the bran coating and thereby to wet, swell or discolor the endosperm so that the water-wettable or water-soluble softening agent and the water in which it is dissolved or suspended will be absorbed in the bran layer to the substantial exclusion of absorption below the aleurone layer.

45 The ammonium compounds are especially desirable since they may be easily and completely removed by heat in subsequent finishing steps or may be partitioned in a solvent system, when this is used, with the high molecular anion dissolving in the solvent and the ammonium radical remaining in the water containing bran settlings from which it is later volatilized when bran is recovered, desolventized and dried.

55 The glycerol esters of higher fatty acids may be used in the form of edible vegetable oils, such as rice oil, maize oil, or cottonseed oil, if desired. When extractive milling, as described below, is used, recycled rice oil or a solution of rice oil in a suitable solvent is a very satisfactory softening agent, and is preferred because it is readily available at substantially no cost.

65 In general, the bran-layer softening agent should be used in proportions of about 0.25

to 5.0 weight per cent, based on the weight of the brown rice. These quantities apply to the total liquid bran-softening agent, including any medium in which a bran-softener is dissolved in order to obtain proper distribution and wetting of the rice. When an undiluted mineral oil or vegetable oil is used, the quantity of oil required is in the range from about 0.25 to 1.0 per cent; while from 2.0 to 5.0 per cent of a solution of the same oil in a suitable solvent may be desirable, according to the degree of dilution. Thus, for recycled rice oil, this range of 2.0 to 5.0 per cent would apply to the oil plus residual solvent content.

For strong alkalis, such as sodium and potassium compounds, it is practical to add from 2 to 5 weight per cent of an aqueous solution containing about 1 per cent of the particular reagent. For example, about 2 to 5 weight per cent of commercial aqua-ammonia should be used; for ammonium carbonates, about 2 to 5 weight per cent of an aqueous solution containing up to 20 per cent of ammonium carbonate since this material volatilizes easily in finishing steps; for salts, acids and surface-active agents, from 2 to 5 per cent of aqueous suspensions of solutions containing from 0.1 to 20 per cent of the particular reagent depending on the nature of the reagent are desirable. While larger proportions could be used, nothing is gained thereby and excessive amounts of residues may be left in the product which, although not harmful, may impart objectionable tastes. In any case, there is no need for drying or other removal of the bran-softening agent prior to a milling step; and milling is performed in the presence of the bran-softening agent.

After the milling step, various combinations of finishing steps may be used as desired. For example, when extraction of fatty components is combined with the milling step, at least a major part of the bran may be separated from the rice during the milling step; and the separated bran may be passed directly to a bran-drying step. Milled rice containing some bran may be simultaneously passed to conventional rice-milling units, such as second break hullers, and pearling cones, or may be transported by a stream of air or other gas, such as a warm flue gas mixture, to a cyclone separator collector. One cyclone of this type has a roughened inner surface, and a stationary central cylinder is disposed in an upper part of the interior of the cyclone. This cylinder is formed from wire screen and provides an annular space between the cylinder and wall of the cyclone into which the air-borne rice and bran are introduced. The rice and bran swirl in the annular space; the rice is polished; and the heavier rice is withdrawn from the bottom of the cyclone while bran is carried upward through a central part of the cyclone by reverse flow of gas and is carried to any conventional collecting and drying steps desired.

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Alternatively, when milling is conducted without addition of a solvent effective to remove fatty components from the bran and germ, rice and separated bran may be withdrawn from the mill together. The mixture of rice and bran is then introduced immediately into a solvent extractor, which may be of the moving basket type or other conventional type; and fatty components and colouring matter are extracted from the unseparated rice and bran by a solvent. After extraction, the solvent is separated from the rice and bran and is passed to a suitable solvent-recovery system where a rice-oil product is separated from the solvent and solvent is recycled. After extraction, the rice and bran are subjected to air separation, screening or other separation steps; and the rice after separation from bran may be subjected to polishing steps or any type of finishing step desired.

When milling in the presence of a solvent effective to extract fatty components from the bran and germ, it is often desirable to use a series of extraction steps, only one of which is extraction during the milling operation. For example, in one practical application of this process, brown rice after the dehulling operation is treated with a softening agent in quantity to soften and loosen the bran coating on the rice kernels. The softening agent in this case advantageously may be recycled rice oil or rice oil containing a solvent. Bran is milled from the rice kernels in the presence of the softening agent and a stream of solvent containing dissolved rice oil is passed through the mill in contact with the rice.

Solvent containing fatty components of rice is hereinafter referred to as "miscella."

In a practical application of the process, bran on the brown rice is softened as described above and is milled in the presence of the softening agent and a stream of solvent passing through the mill in contact with the rice. Rice is fed into the mill at a selected rate and a selected back pressure is applied upon rice passing through the mill to give the desired degree of abrasion required for any particular degree of bran removal.

In this application the stream of solvent passed through the mill is strong miscella containing oil extracted from the bran and germ in later extraction steps. The flow of solvent and rice is preferably, although not necessarily, countercurrent, throughout the operation. Bran is abraded from the rice in the mill by rubbing the rice against a screen having openings there-through and by friction of the grains against each other, and the stream of strong miscella flows not only through the rice but along the outside of the screen and carries away bran passing through the screen. A large proportion of the bran is thus separated from the rice in the mill.

When it is desired that the degree of milling accomplished in the mill be reduced to leave

a part of the bran layers on the rice, the current of strong miscella passed through the mill in contact with the rice will soften the bran layers sufficiently to permit the required degree of milling without undue breakage of kernels; the strong miscella in this case serving both as bran-softening agent and as solvent, as the strong miscella is relatively rich in rice oil at this stage of the extraction process. Retention of a part of the inner bran layers including the aleurone layer increases the protein and mineral contents of the milled rice.

It will thus be seen that preliminary softening of the bran layers may be used in combination with a great variety of later steps, in every case obtaining the advantages of reduced abrasion necessary to separate bran from the kernels, reduced breakage of kernels and more flexible operation in the milling step. Thus, the softened bran may be milled without addition of solvent, the rice and bran may be separated and finished by conventional methods, and the above advantages obtained. The rice and bran from the milling step without separation may be immediately extracted with a solvent effective to extract fatty components from the bran and germ and additional advantages are obtained in that a rice oil of high quality may be obtained which has good colour and low acidity due to inhibition of enzyme actions. Improved rice products are also obtained in that the rice and bran are substantially fat free, have good keeping quality, are sterile and free from insects and insect eggs. The rice has good cooking qualities, colour, taste, and physical appearance. Rice oil recovered from the solvent is light in colour, low in acidity and is easily refined to an edible oil.

The above advantages are attained in enhanced degree when milling is conducted in the presence of a solvent wherein the solvent performs the function of extraction and removal of fats and colouring matter from the bran and germ of the rice simultaneously with the milling operation, maintains the bran in a wet and increasingly soft condition during the milling operation, acts as a flushing medium for washing separated bran from the rice, and washes openings in screens and other parts of the apparatus free from bran, and acts as a coolant during the milling operation, thus effectively preventing build-up of temperature due to friction and preventing heat checking of the rice.

Examples of processes according to the invention are hereinafter particularly described with reference to the accompanying drawings in which:—

Figs. 1 and 2 show a first embodiment of suitable apparatus;

Figs. 3 and 4 show a second embodiment;

Fig. 5 shows a further embodiment incorporating the apparatus of Figs. 1 and 2; and

Fig. 6 shows another embodiment of suitable apparatus.

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In the embodiment of apparatus shown in Figs. 1 and 2, the reference number 1 designates generally an assembly consisting of three substantially similar units of a horizontal milling apparatus together with a tandem variable speed drive. The three units are arranged in series and each has an inlet 2, an outlet 3, a cylindrical housing 4, a perforated cylindrical metal member, or screen, 5, laterally spaced from the housing, and a central rotor 6 within the screen.

Each unit in the series is substantially identical with the exception that the hand of short helically arranged flights 7 on the horizontal rotor 6 in the central unit is opposite that of the flights on the two other units. A helical ribbon 8 is arranged between the housing and the screen and is attached to the housing at a selected spacing from the housing to support the screen 5 rigidly at a selected distance from the housing and to provide a helical path for liquid flowing through the unit between the screen and housing.

The housings are equipped with piping connections 16, 17, 18 and 19 for liquid so that a stream of solvent and/or bran-coat softener can be sent through the unit, either concurrently or countercurrently to the movement of rice therethrough.

The screen 5 preferably is fabricated of a perforated metal or heavy wire mesh cloth which has perforations or open meshes of area too small to allow a rice grain to pass through. The screen, due to the openings, presents a roughened surface, suitable to abrade bran from the rice and through which the stream of liquid will pass freely. The texture of the perforated or wire cloth surface may be varied to suit the degree of milling in each successive unit. Thus, the first unit may make a coarse cut into the bran layer and the others may make successive finer cuts which tend to polish the milled rice grains. Rectangular or oblong openings are preferred since openings of this shape reduce breakage of rice kernels due to a pointed end of a kernel becoming caught in an opening.

The helical flights 7 preferably overlap each other by one half of the arc on the surface of the rotor covered by a corresponding flight in a succeeding group of flights. The rotor 6 is supported in bearings 9 and 10 at the ends thereof and is driven by any suitable drive illustrated as a series of sprockets and chains driven by a motor 11 through a reducing gear assembly 12. Each of the units is provided with an inlet 2 arranged to introduce rice upon the surface of the rotor 6 between the rotor and perforated screen 5. A means for exerting back pressure on the rice is provided and may take a number of forms. For instance, the pitch of the helical flights 7 on the last unit of the series may be somewhat smaller than the pitch in preceding units or the pitch may be gradually decreased from that of the first unit through

the second unit to the third unit. Too much decrease in pitch however should be avoided as this would cause the mill to jam. Alternatively the pitch of helical flights 7 may be the same on all rotors and the drive may be arranged to drive a succeeding unit at lesser speed. Variable speed sheaves 13 and 14 and a V-belt 15 illustrate one type of variable drive of this type. In any case, the helical flights of a succeeding unit and the drive means cooperate to exert a selected degree of back pressure on rice in a preceding unit.

This apparatus is particularly useful when solvent extractive milling is used. Solvent together with bran-coat softening agent is introduced into a unit of the series and may be passed therethrough either concurrently or countercurrently to the direction of flow of the rice in the mill. It is preferred that solvent be introduced into each of the units successively and passed in countercurrent flow through all units. The arrangement illustrated is effective to pass solvent and bran-coat softener in countercurrent flow through each of the mills consecutively, and then on to succeeding steps for separation of bran, further extraction of the rice and bran, and recovery of solvent and bran-coat softener, and separation of rice oil as described both above and hereinbelow.

Another type of milling device is shown in Figs. 3 and 4. In Fig. 3 the reference number 20 shows a hopper superimposed on a milling section designated generally as 21, which discharges by means of a chute 22 into a helicoid screw conveyor 24. This screw conveyor consists of an outer tubular casing 23, a helicoid screw 25, a discharge chute 26, a drive means illustrated as a sprocket 27 driven by a motor 28 through a reducing gear 28a. The mill is driven by a suitable drive means, illustrated as a variable speed motor 29 arranged to drive a central frusto-conical rotor 30 through a reducing gear 29a and drive shaft 34. This rotor is located concentrically within a frusto-conical perforated screen 31 which may be formed of perforated metal or a suitable wire screen.

The rotor has spiral flights 32 upon its surface arranged so that when the motor is driven the spiral flights oppose passage of rice downward through the mill and direct the rice strongly outwardly against the inside of the perforated screen. Rice is fed downward within the perforated screen outside the rotor and leaves through an opening 33 surrounding the central drive shaft 34. The frusto-conical rotor 30 also is provided, on its base, with a number of scraper ribs 35 (best shown in Fig. 4) which at the periphery of the cone coincide with the lower end of spiral flights 32. These scraper ribs rotate at substantially the same clearances over a horizontal screen 36 as that between the rotor and the perforated screen 31 so that they tend to sweep rice from the bottom of the screen into the central opening 33. It is preferred that the frusto-conical rotor

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be adjustable vertically upon the drive shaft 34 by means of set screws 34a or other adjustable means. Considerable vertical movement is required to effect small changes in the width of the annulus between the perforated screen 31 and the rotor 30 and the set screws thus form a convenient means of accurately adjusting this annulus to the type of grain being milled.

10 A means for passing a current of liquid solvent through a housing 37 and screen 31 into contact with rice in an annular space between rotor 30 and screen 31 is provided, and is illustrated as a pump 38 connected to withdraw clarified miscella from an upper part of a settling tank 39 through a filter 40 and to introduce the withdrawn miscella through line 41 into the interior of the housing 37.

20 Recycled miscella after passing in counter-current flow to rice in the mill is withdrawn through filter 42 and line 43 to settling tank 39. Alternatively, a connection to line 43 may be made through the pipe connection 43a, illustrated as plugged, and the miscella returned to settling tank 39 from this point. Recycle is thus provided and a side stream may be taken off through line 44 and passed to a solvent recovery system arranged to separate oil, and any excess water that may be present, from the solvent or to any extraction step in the process where it may be useful.

30 A slurry of concentrated miscella and bran is withdrawn from the bottom of settling tank 39 and passed by lines 45, 46 and 46a to wash a mixture of rice and bran issuing from the mill in a lower part of the helicoid screw conveyor 24. A side stream of this slurry also is passed through line 46 into an upper part of hopper 20 to serve as bran softening agent.

40 A second side stream of the concentrated miscella carrying bran in suspension is passed by line 47 to bran separation and solvent recovery or to any other extraction desired. The maximum concentration of oil in the strong miscella is preferably maintained at not more than 10% by weight oil so that it has good extractive properties.

50 Bran passing through openings in screen 31 settles in housing 37 and passes through the openings 48 in a horizontal plate 49 in the mill so that rice and bran are withdrawn from the mill without separation and enter the screw conveyor 24. A weaker miscella from a later extraction step, or fresh solvent from the solvent recovery system is introduced into an upper part of conveyor 24 by line 50 so that the mixture of rice and bran withdrawn from the mill receives a two-stage countercurrent washing in conveyor 24. It is to be understood that the screw conveyor 24, extends upward for a sufficient distance, indicated by a break in the drawing, that the line 50 connects with the conveyor at a point somewhat above the level of filter 42 so that solvent introduced through line 50 will flow downward through

the conveyor. The rice and bran are then passed through discharge chute 26 to any extraction, separation and finishing steps desired.

70 The level of miscella in conveyor 24 is controlled by valve 51 in drain pipe 52 in which is inserted strainer 53 which contains a coarse perforated screen which is capable of holding back the rice but allows the solvent and finer bran particles to flow into settling tank 39.

75 Fig. 5 shows another arrangement for carrying out the process of the invention. A feed hopper 51a is arranged to discharge brown rice into a mixing conveyor 52a into which a liquid bran-softening agent is introduced in desired proportion through a line 53¹ or 53a. From the conveyor 52a the rice containing bran-softening agent is discharged into a ribbon mixer 54 and after thorough mixing therein is passed into a mill designated generally as A and which preferably is constructed as described under Fig. 1 as illustrated, or according to Fig. 3 above.

90 From the outlet of mill A rice containing residual bran is passed into an elevator 55 and is there washed while passing through the elevator by a miscella of moderate strength entering by line 56. The rice and bran mixture then passes into a separator-extractor tank 57, having motor driven agitator paddles 58 and 58a, and which is fed with weak miscella introduced from line 61 into a discharge elevator 60 and screw feeder 63. Flow of rice is thus countercurrent to the flow of liquid in the elevator, screw feeder and separator tank 57.

100 The heavier rice sinks through the liquid and is withdrawn by the screw feeder 63 and discharged therefrom into the elevator 60.

105 Bran suspended in the miscella is withdrawn through a screen 59 and line 64 and passed to a settling tank 65 from which a slurry of bran and miscella is passed to a second settling tank 66. A slurry of bran in strong miscella is withdrawn from tank 66 and passed to a filter 67, illustrated as of rotary type, and is washed on the filter first with a weaker miscella carried by line 68 and finally by an almost fresh solvent carried by line 69. These washing operations leave the bran substantially oil free and it is then passed to a bran drier by means of an elevator 70. The bran drier may be of any type desired, although that illustrated is of rotating tray type. From the bran drier bran is withdrawn through discharge spout 71 into elevator 72 and is passed to any bagging or finishing steps desired.

120 Rice free from bran is discharged by elevator 60 into an inclined screw conveyor 73 and is there subjected to a final washing by fresh solvent from the solvent-recovery system entering by lines 74 and 74a. Washed rice is delivered by conveyor 73 to surge tank 90, and thence to a desolventizer 92. This desolventizer may be of any type desired as, for example, a rotary tumbler arranged to tumble rice in a current of superheated solvent vapour and/or

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warm inert gas. From the desolventizer rice is withdrawn at 93 and may be sent to storage, bagging operations or to any finishing steps desired. Clarified strong miscella from an upper middle part of settling tank 66 is withdrawn by pump 78 and is introduced into the mill A by lines 79 and 80, thus providing solvent for extraction during the milling step. The oil content of the strong miscella is maintained sufficiently low that it has good extractive properties by continual withdrawal of strong miscella from the bottom of settling tank 66 and the introduction of weaker miscella from tank 65.

Vapours from all apparatus illustrated are sent to a solvent-recovery system indicated at 76 and strong miscella from the filter-receiving tank 75 is sent by line 77 to this system. The solvent-recovery system may be of any type desired so long as it provides for the separation of rice oil from solvent and the separation of any excess water that may be present in the system. The solvent recovery system indicated at 76 includes means for condensation of solvent vapours received through lines 82, 83 and 84 and means for separating solvent from rice oil received through line 77 and means for separating excess water from the solvent and to discharge water as indicated at line 85. The solvent and oil recovery system is not illustrated in detail since it is merely an arrangement of apparatus known per se and in itself forms no part of this invention. A container 86 is connected to receive fresh purified solvent from the solvent-recovery system and to return the fresh solvent to the extraction system through line 74. A container 87 and pump 81 also are connected to receive rice oil from the recovery system and may be connected to line 53a by valved line 88 for recycle of rice oil as bran-softening agent to mixing conveyor 52a. Alternatively, rice oil containing residual solvent may be withdrawn from the solvent-recovery system by line 89 and recycled to line 53a. Valved line 88a is provided for pumping rice oil to storage.

In the embodiment illustrated in Fig. 6 rice from holding tank F1 which has undergone softening treatment in preceding apparatus previously described for Figs. 3 and 5 is delivered together with bran-coat softener by means of screw-feeder 110 and/or 110a into the corresponding combination solvent extraction and milling apparatus G1 and/or G2. If the combination solvent extraction and milling apparatus e.g., G1 and G2 are operated in parallel, both screw feeders are operated. If operated in series, only screw-feeder 110a is operated. The helicoid screw flight in the operative screw feeder 110 effectively seals off the flow of rice into apparatus G1 and also prevents loss of solvent vapours from the extraction and milling apparatus. A screw feeder 110b receives the material from G2 and conveys it to above

the flap gate 111a which determines whether milled rice and bran from apparatus G2 shall flow directly to inclined conveyor H1 through chute 111c, and thus are products of single stage milling, or whether the milled products from apparatus G2 will be diverted through chute 111b to apparatus G1 to receive a second stage milling. These procedures may roughly be compared to "first break" and "second break" milling in the conventional dry milling process.

The construction and operational features of combination solvent extraction and milling apparatus G1 and G2 are identical, in which, 112 is an outer metal shell which serves as a housing for the apparatus, 113 is an inclined hopper bottom of perforated metal or wire screen construction, 115 is a feed screw which delivers rice from the hopper area formed by shell 112 and inclined bottom 113, 116 is a perforated metal or wire screen stator in which ribbed rotor 117 revolves. The stator and rotor are either cylindrical or frusto-conical shaped, and the ribs on the rotor may either be arranged vertically or diagonally with reference to the vertical dimension of the rotor, and are positioned 45° to 90° apart around the circumference of the rotor. The aperture between the rotor and perforated stator is adjustable by raising or lowering the position of the rotor on its shaft in any suitable manner, while maintaining the stator in fixed position. It is, of course, possible to employ an apparatus in which the position of the rotor is fixed and that of the stator may be varied upward or downward to vary the clearance between them within a range of between one quarter and three quarters of one inch. Closer clearances will tend to increase the milling action but will limit the throughput, whereas the reverse is true where wider clearances are employed.

The discharge from pump 18a is piped so that by closing valve V5 and opening valve V6, the weak miscella from tank compartment 17a may be used in the primary extraction stage. Also, by opening valve V7 when valve V5 remains closed the weak miscella from pump 128 may be sent through pipe 20a to an intermediate extraction stage in a conventional moving basket extractor.

Concurrently with the introduction of unmilled brown rice, or partially milled rice where series milling employing two combination solvent extraction and milling apparatus is practised, a solvent capable of extracting fats and colouring matters from the bran layers and millings therefrom is introduced through pipe 134. The solvent may be fresh solvent from the solvent recovery and oil recovery steps previously described, but is usually under multiple extraction procedure a weak miscella withdrawn from a chamber 17a in a lower part of a conventional moving basket extractor. Bran-coat softening agent may be introduced either with



the rice or with the solvent; or if the solvent is a weak miscella it will also act as a softening agent.

In the instance weak miscella from pump 18 is delivered through pipe 134 to apparatus G1 and/or G2 through valves V3 and/or V4 respectively, to inlet connection 114 or 114c and circulates countercurrently upwards through the descending column of rice and millings between rotor 117 and stator 116 and discharges through outlet connection 114a or 114b. Rotor 117 is driven at r.p.m. speeds selected over a substantial range by a motor and speed reducer drive 120. Smaller apparatus will require higher r.p.m. than larger apparatus to obtain equivalent milling and product throughput for any given clearance between stator and rotor, as it is largely a matter of rim speed expressed in feet per second. However, excessive rim speeds above the actual milling requirements will result in excessive breakage of rice grains. Applicant's speed range expressed as r.p.m. may vary from about 600 r.p.m. for 18 inch average diameter rotor down to 200 r.p.m. for a 60 inch average diameter rotor where a high degree of milling is desired. Slower speeds are used where undermilling is desired. If higher pressures are applied within the stator-rotor aperture by higher grain levels in hoppers and chutes above the rotor, or if positive feed-in is provided, the above stated speeds may be further reduced. In general, the use of solvent extraction simultaneously with milling in the presence of a bran-coat softening agent, increases the ease of bran layer removal, and satisfactory milling may be accomplished at lower speeds and under lower pressures against the milling screen than with conventional dry milling procedures. The same is true where bran layer softening agents are employed without simultaneous solvent extraction in the milling apparatus, but to a lesser extent.

Whether the flow of solvent through the milling apparatus is concurrent or countercurrent is not critical if further extraction steps in other apparatus will follow. Thus, the flow from pipe 134 may be introduced through connection 114a and exit through connection 114 instead of in the reverse direction.

The mixture of milled rice and bran layer millings falls into lower hopper 118 where it is conveyed out of the apparatus by screw conveyor 119 and enters inclined screw conveyor H1 through chute 121. The solids are conveyed upwards by the screw 131 and discharged into screw feeder J1, and from thence into an upper part of a conventional moving basket extractor as indicated at 15, whereas the solvent containing extracted oils and colouring matters drains continuously to miscella settling tank 11 through rotary strainer 122 and pipe 123. Pipe 123a and valve V1 may also serve as means of draining oil-containing solvent to tank 11, but normally are used only

for drainage of the system.

The weak miscella derived as above described, passes through miscella settling tank 11 where most of its bran is settled out and removed through a sludge valve V2 which may be either manually operated or automatically operated by a sludge density controller (not shown). If intermittently operated, pump 132, of a positive displacement diaphragm type, should be co-ordinated to operate only when valve V2 is open and admits sludge to pipe 130. The sludge discharged by pump 132 enters pipe 133 and discharges into inclined screw conveyor H1 at a point slightly above the liquid level in the system. The weak miscella drains out and the drained sludge joins the milled rice and bran mixture which discharges into screw conveyor J1. The main volume of weak miscella goes down the centre baffle, shown dotted at the right of 11, rises through the staggered baffles, shown dotted at the left of 11, and exits through filter 125 and pipe 126 into miscella surge tank 127. Pump 128 then sends the weak miscella through pipe 129 to line 20a from which it is supplied to moving basket type extractor. It is then employed in the intermediate extraction step which is conducted in the concurrent flow pattern previously described. The strong miscella produced in this second stage extraction collects in chamber 17b and is then sent to the oil and solvent recovery system previously described, and the milled rice and bran mixture then undergoes the final extraction and rinsing stages as the baskets ascend in countercurrent flow to the fresh solvent stream above chamber 17a. The extracted solids then are discharged to a screw conveyor similar to conveyor 23 of Fig. 3 and enter a desolventizer similar to the desolventizer 92 of Fig. 5 and proceed throughout the remaining steps as previously described.

The processes so far particularly described employ extractive milling as well as the use of a bran-softening agent.

When the bran on the rice is softened by a liquid bran-softening agent as herein described, and milled from the kernels of the rice without simultaneous solvent extraction, conventional equipment may be used in the milling step, or the milling apparatus 1 of Fig. 1, or 21 of Fig. 3, may be modified to be effective in such milling. For example, instead of separate housing 4 surrounding each unit as shown in Fig. 1, a single housing surrounding all three units may be used so that all bran passing through opening in screens 5 will fall into the bottom of the single housing. From this location the bran may be withdrawn and dried in conventional manner, while rice containing residual bran is discharged from the mill to any conventional drying and separating steps desired, or to extraction equipment such as that illustrated at 57 in Fig. 5.

The special mill of Figs. 3 and 4 also may

solvent



be easily modified for dry milling by omitting the solvent circulation system and admitting air under pressure through pipe nozzle 43a to blow the bran out of the mill. In this case, bran and rice containing a liquid bran-softening agent is fed from any suitable source such as ribbon mixer 54 in Fig. 5 into the milling section 21 of Fig. 3. Rice and bran are withdrawn at 22 and may be passed to conventional drying and separation steps, or may be introduced into extraction equipment, as for example a moving basket extractor, or the extractor 57 of Fig. 5, and therein extracted with a solvent immediately after milling and before separation.

Equivalents of equipment shown in the process are contemplated. For example, other versions of horizontal and vertical milling machines may be employed. Likewise, instead of conducting secondary extraction and bran solids recovery steps in screw conveyors and rotary filters, multiple extraction steps may be conducted in a series of settlers, in bowl-type centrifuges, or by combining settlers with centrifuges. Instead of a rotary tray desolventizer for bran, rotary drum or fluidized solids systems may be employed. Rice may be desolventized in a moving bed in a vertical column or in a fluidized solids system instead of the rotary drum shown in Fig. 5.

WHAT I CLAIM IS:—

1. A process for the treatment of brown rice comprising the steps of mixing a liquid bran-softening agent, as hereinbefore defined, with brown rice in a quantity, and for a time, sufficient to soften bran on the rice kernels; and milling bran from the rice in the presence of the bran-softening agent.

2. A process according to Claim 1, comprising mixing with the brown rice from 0.25 to 5% of liquid bran-softening agent, based on the weight of the brown rice; and holding the resulting mixture for a time sufficient for bran on the rice kernels to become softened and loosened prior to the milling step.

3. A process for the treatment of brown rice comprising the steps of intimately mixing with brown rice a liquid bran-softening agent, as hereinbefore defined, in an amount of more than 0.25% of the weight of the rice; holding the rice sufficiently long, for the bran-softening agent to soften the bran layers but insufficient for the bran-softening agent to substantially affect the underlying endosperm of the rice; and milling the rice in the presence of the bran-softening agent and under sufficient pressure on the rice to mechanically remove the bran layer.

4. A process according to claim 2 or Claim 3, wherein rice and liquid bran-softening agent are maintained at a temperature in the range from about 32°C to 60°C during the holding period.

5. A process according to any preceding claim, further comprising the steps of with-

drawing bran and rice from the milling step to an extraction step without separation of bran from rice; extracting mixed bran and rice with a solvent effective to extract fatty components and colouring matters from bran and germ; separating solvent from the rice-bran mixture and separating rice from bran.

6. A process according to Claim 5, wherein bran is washed from the mixture of bran and rice withdrawn from the milling step by solvent in an extraction step, subsequent to milling.

7. A process according to Claim 6, wherein a substantial proportion of bran is separated from the milled rice and bran mixture during the solvent extraction subsequent to milling; rice mixed with residual bran is separately withdrawn from the solvent extraction step; the extracted bran on the one hand and milled rice and residual bran mixture on the other hand are separately recovered from the solvent; and rice oil is recovered from the solvent.

8. A process according to Claim 1 or Claim 2 or any claim dependent on Claim 1 or Claim 2, wherein the liquid bran-softening agent is non-aqueous.

9. A process according to Claim 8, wherein the non-aqueous bran-softening agent is selected from the group consisting of non-toxic oils; glycerol, glycol and polyglycol esters of fatty acids; soaps; sugar alcohol esters of higher fatty acids; amido compounds of higher fatty acids; glycols having three or more carbon atoms in the molecule; and polyglycols.

10. A process according to Claim 9, wherein the non-aqueous bran-softening agent is a vegetable oil.

11. A process according to Claim 10, wherein the vegetable oil is rice oil.

12. A process according to any preceding claim, wherein at least part of the liquid bran-softening agent is extracted from the bran and milled rice with an organic solvent; the solvent is separated from bran and milled rice, and the bran-softening agent is recovered from the solvent.

13. A process according to any of Claims 5, 6, 7, or 12, wherein residual solvent is evaporated from the bran and from the milled rice.

14. A process according to any of Claims 1 to 7 or any of Claims 12 or 13 as dependent on any of Claims 1 to 7, wherein the liquid bran-softening agent is selected from the group consisting of aqueous solutions of hydroxides and carbonates of ammonia and the alkali metals; aqueous solutions of neutral salts; dilute aqueous solutions of hydrochloric, sulphuric, phosphoric, and citric acids, and mixtures thereof.

15. A process for the treatment of brown rice substantially as hereinbefore described with reference to the accompanying drawings.

16. Rice freed from bran, resulting from a process for the treatment of brown rice according to any preceding claim.



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TREGEAR, THIEMANN & BLEACH

Chartered Patent Agents,

Melbourne House,

Aldwych,

London, W.C.2.

Agents for the Applicant. *Al.*

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