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SORGHUM GRAIN DEGERMINATION PROCESS
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7 Claims

ABSTRACT OF THE DISCLOSURE

Degerminating sorghum grains by compressing the grains with pressure sufficient to release the germ portion from the grain but insufficient to cause breakage of the germ and then separating the germ from the grains.

The present invention relates to an improved method of degerminating sorghum grains. More specifically, the instant invention is concerned with degerminating sorghum grains by a specific germ release step. The escape of germ from the remainder of the constituents of the sorghum grains is effected by compressing the sorghum grains with pressure sufficient to fracture the grain but insufficient to cause breakage of the germ. The germs are then separated from the ruptured grains, preferably by liberating the germ from the remainder of the grain by a slurry agitation technique. In a specific embodiment, prior to the germ-release step, the grains are dehulled.

A typical sorghum grain consists of endosperm which contains essentially all of the starch in the grain, germ which contains substantially all of the easily removable oil, and a thin outer covering called the pericarp or hull. A cementing layer holds the germ firmly to the endosperm and causes difficult separation of the germ from endosperm.

Conventionally, degermination of sorghum grain is usually carried out after steeping the grains for relatively long periods of time in sulfurous acid, that is, an aqueous solution of sulfur dioxide or in a dilute base such as sodium hydroxide. This process known as wet milling is essentially concluded by releasing the germ from the remainder of the grain by attrition in an appropriate mill. Such mills usually include rotating knobs or teeth which tear apart the steeped grain. In the wet milling process, the grain must be steeped for a time ranging from about 30 to about 50 hours to effect clean germ separation. Insufficient steeping causes a great proportion of germs to become shattered in the attrition mill. However, if the grain is steeped for an appropriate amount of time, satisfactory germ release is obtained in the process. That is, during the prolonged steeping, the internal structures connecting germ and adjacent endosperm are so weakened that endosperm is essentially brushed away from the germ surface during milling.

The prolonged, but necessary, steeping of grain as an initial step in the wet milling procedure presents a number of serious drawbacks. For example, such extended soaking period generally requires large inventories of grain and water, and to be economically feasible would necessarily require extremely large storage bins which would take up much valuable plant space. This in turn does not allow one to efficiently process a number of different sources of sorghum grain as needed over short periods of time. Again, it has been noted that the long steep time tends to gradually extract from the germ structure a number of useful substances such as minerals, proteins, sugars, vitamins, etc. The useful materials must be subsequently recovered in a separate step, which again makes the overall process less attractive economically.

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Also, the prolonged steeping tends somewhat to contribute a distasteful flavor and aroma to the germ. Furthermore, grain steeped over a relatively long interval of time becomes essentially void of indigenous antioxidants and rapidly becomes rancid when stored dry at room temperature for any extended period. With specific regard to a prolonged soak in alkaline solution, it has been noted that in addition to loss of valuable products through extraction, spoilage and putrefaction tend to take place.

While dry milling avoids the above outlined disadvantages imposed by prolonged steeping exposure to aqueous sulfur dioxide and other solutions, this process is not even roughly quantitative. Moreover, well known methods of degerminating cereal grains by dry milling techniques require excessive amounts of equipment. Again, even in the dry milling procedure, tempering or conditioning of the grain must usually be carried out to adjust moisture.

It would therefore be a distinct advance in the art of degerminating grain sorghum if a method were found which would do away with the step of steeping. This would avoid the disadvantages just discussed above. Moreover, if the germ could somehow be quickly and efficiently separated from the remainder of the sorghum grain without resort to intricate special equipment, such a process would find ready acceptance. Lastly, if the discovered method resulted in a separated germ component which yielded oil of a character at least equal to or even superior to that realized from conventional methods, such degermination process would be exceedingly attractive.

It, therefore, becomes an object of the invention to provide a highly efficient method for milling sorghum grain whereby the germ therefrom is isolated in a state of relatively high purity, essentially free of hulls and endosperm.

Another object of the invention is to recover, from sorghum grain, germ in a form most nearly approximating its native state, which germ contains protein, sugars, vitamins, minerals, antioxidants, etc. Such germ would be highly nutritious, have excellent flavor, and would strongly resist oxidation in storage.

Yet another object of the invention is to obtain excellent yields of high quality germ, uncontaminated with undesirable flavors added as an incident to traditional steeping.

A further object of the invention is to provide a simple yet efficient way of degerminating grain sorghum while maintaining the germ in its integral form. Other objects will appear hereinafter.

In accordance with the invention, an improved method of degerminating sorghum grains has been discovered. This process broadly comprises the steps of compressing the grains with pressure sufficient to release the germ portions from the grains but insufficient to cause breakage of the germs. The germs are then freed from the degerminated grain portion by forming an aqueous slurry of crushed endosperm and partly adherent whole germ and agitating the slurry mass. This tends to complete germ separation from endosperm. In a greatly preferred embodiment, the grains are dehulled prior to degermination. This results in simpler and more efficient germ separation.

The most essential step in the invention involves subjecting the grains to a pressure source of the type generally described above. This step may be accomplished by exerting the proper pressure by means of suitable apparatus now available. Any mechanical operation may be utilized which obtains a preliminary partial separation of germ from endosperm. The surfaces contacting the kernels in pressure relationship may be composed of any rigid or

partially elastic material. Pressure is applied which is just sufficient to rupture the endosperm. When pressure is properly applied, the germ no longer tightly adheres to the endosperm and can be easily removed, free of endosperm and pericarp such as by the slurry agitation method.

The following has been presented by way of explanation of the phenomenon of germ release as carried out in the instant invention. Such explanation is only intended as a theory of what is believed to occur, and the invention is not to be limited thereto. It is believed that compression of the grain causes the endosperm to flow laterally and partially break free of the germ. This movement results in a shearing action along the sloping face of the germ, which action ruptures the cementing layer and thus frees the germ from the endosperm.

While the following discussion of degermination is made with respect to subjecting the grains to pressure rollers, such explanation is merely meant to be illustrative of this step. Other modes of degermination may also be practiced, such as for example, crushing the grains by means of a press, etc.

In the preferred practice of the invention, the grains are degerminated by passing them between a pair of counter-rotating cylinders of rigid, semi-rigid or elastic material. In one embodiment, a pair of smooth steel rolls is utilized which are set for a gap at the nip to apply pressure to both largest and smallest grains being processed. The gap may vary from about 0.02 to about 0.08 inch, and more often from about 0.045 to about 0.065 inch. Thus, a typical roller mill apparatus utilized in the instant invention may be so designed that the distance between the rolls is not rigidly set, but is allowed to increase or decrease depending upon the size of the grain passing between the rolls. This may be achieved by utilization of relatively weak tension springs, whereby the gap is automatically adjusted when contacting grains of varying sizes, and so that germ release is obtained with minimal germ damage. The grains when fed into the nip between the rolls are crushed to the required degree as they are pulled between the cylinders.

The roller mills themselves may be operated whereby the roll surfaces are smooth or roughened. Again the opposing rolls may be rotated at different or the same speeds. It is preferred to utilize rolls presenting a smooth face which are operating at the same peripheral speed.

In still another embodiment, the gap between the rolls is set at a fixed distance. The grains to be degerminated may be sorted as to size and the gap set to accommodate that lot of grain being processed. Likewise, the gap may be adjusted to accommodate smaller or larger sized lots. In an alternate method of germ release, the entire lot of grain may be passed through a series of rolls set at successively narrower gaps so that the thicker grains will be flattened in the first rolls, the smaller grains being flattened under the second pair of rolls set at a closer gap and so on. In this embodiment, a plurality of pairs of rolls set at progressively decreasing gaps may be utilized, with the number of pairs of roller mills being dependent upon the desire of the processor.

In still another modification of the invention, the hulls of the grains may be freed at any time prior to degermination. Any properly equipped conventional dehulling machine may be used for this purpose. Generally, the grains are subjected to some type of mild friction or attrition which releases the hulls without fracturing the grains or setting free a substantial portion of the starch contained therein. Usually, such step is accomplished by placing the grains in water and mildly agitating the resulting slurry. One suitable device generally comprises an agitation tank having an impeller covered with some soft material such as, for example, rubber. Likewise any hard or sharp leading edges or other structures within the tank such as splash boards should be covered with soft material in order to minimize the fracturing of the grain.

It should be emphasized that the method of the invention can be carried out with or without a separate step of hull removal prior to or subsequent to grain crushing. When the degermination step is practiced upon intact grains, the hull is usually split lengthwise in several places under the applied pressure, is thereby loosened from the face of the germ of the grains and can be separated in a subsequent conventional step. However, since it is difficult to separate hull from germ once the grain has been cracked, it is greatly preferred to effect dehulling as an initial step in the invention.

As mentioned above, subsequent to the compression step, the crushed grains are treated to more completely free germ from adhering pieces of hull and endosperm. This may be accomplished by any conventional dehulling process as generally described above. For example, the crushed grains may be taken up in a liquid such as water and gently agitated in suspension for several minutes. The lighter hulls will generally float to the top of the suspension, and can be removed simply by skimming them off the top. The heavier components are then taken off the bottom of the vessel.

All that remains in the process is to completely separate the germs from other grain components. Again, this may be accomplished in a wide variety of ways. For example one may take advantage of fact of lower density of the germs resulting from their higher oil content which causes them to be selectively floated on a number of media. One conventional technique is to utilize a starch slurry of about 10 to 20 Baumé. The crushed grains are added to the starch, the lighter germ floats to the top and is easily and conveniently removed from other grain components, such as by skimming the germ off the top of the slurry.

It has been found that the germ released in the above described process is more stable to fatty oxidation and yields oils of improved flavor, color and refining characteristics. Other advantages of the process are also quite apparent. For example, less operational space is required for an equivalent grind rate, and capital expenditure for steeping equipment for degermination is obviated. Lastly, due to the versatility of the process, one need maintain only small grain inventories.

The following examples illustrate typical modes of operation of the instant invention. It is understood, of course, that these examples are merely illustrative, and that the invention is not to be limited thereto.

Example I

A 450-gram sample of commercial white waxy milo was dehulled in a blender, the blade of which was covered with rubber tubing. Approximately 100-grams of grain was placed in a blender bowl with 200-ml. water and the machine was operated 2.5 minutes at 3400 r.p.m. Free hulls were separated from dehulled kernels by gently agitating the slurry and screening the hulls from the grain. The water was poured from the grain, and the wet, decorticated grain was passed through a roller mill having 6-inch smooth rolls and a mill gap of 0.050 inch. The cracked grain was transferred to a blender having smooth cylindrical metal blades and agitated 15 seconds with two parts of water per part grain at approximately 2250 r.p.m. The mixture of endosperm particles and germs were placed in a germ separator, a 14° Baumé starch slurry prepared from commercial corn starch and free germs removed by flotation. The heavier cracked grain was removed from the slurry and then further treated to free additional germ. Specifically, the grain was blended an additional 15 seconds at 2700 r.p.m. to free more tightly attached germs, and these germs were separated by the same procedure as employed above. This was followed by successive attritions at 3200 r.p.m., 3400 r.p.m. and 4000 r.p.m., with removal of free germ after each agitation. Yields and compositions of milling fractions are given in Table I below.

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TABLE I

Fraction	Yield ¹	Starch ²	Protein ²	Oil ²
Hulls, on 150 mesh.....	4.06	22.6	5.8	³ 10.11
Germ.....	11.97	29.9	18.6	27.73
Endosperm.....	72.13	75.3	11.5	0.85
Solubles and other.....	11.84			

¹ Proportion of whole kernel as percent, dry basis.² Percent of fraction on a dry basis.³ A little more than 80% of this is wax.

In the above run, the germ fraction contained more than 80% of the total oil. From calculations, it appeared that the method outlined above gave quantitative or, at least, near quantitative yields of germ.

Example II

425 grams of a different lot of commercial white waxy milo was dehulled in water as described in Example I and passed through a roller mill with a clearance of 0.065 inch at the nip. The fractured grain was agitated 90 seconds at 2500 r.p.m. in two parts of water per part of grain. The germ was then removed utilizing a 14° Baumé starch slurry. The endosperm was thereafter steeped for starch release. The yields and compositions of fractions are reported in Table II below.

TABLE II

Fraction	Yield	Starch	Protein	Oil
Hulls, on 150 mesh.....	4.77	11.7	4.87	4.58
Germ.....	7.24	14.0	20.41	30.63
Sum of Fractions From Wet Milled				
Endosperm.....	73.25			
Solubles and other.....	15.91			

The germ fraction contained about 55% of the total hexane soluble material. This demonstrates that satisfactory yields of high purity germ can be obtained with just a single agitation step. Maximum yield is, of course, realized with multiple agitations.

Example III

The procedure of Example I was repeated with the exception that commercial red milo grain was processed in this instance. Results are tabulated in Table III below.

TABLE III

Fraction	Yield	Starch	Protein	Oil
Hulls, on 30 mesh.....	2.95	26.41	5.46	3.37
Hulls, on 150 mesh.....	1.05	74.72	5.36	0.37
Germ.....	10.16	22.47	19.21	24.10
Endosperm.....	73.41	80.85	13.94	0.59
Solubles and other.....	12.43			

In the germ release step, the grains may be either in a wetted or dry state. However, for best results it is preferred that the grain be wetted prior to their release under pressure. Improved results are obtained in terms of

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more efficient germ release, improved yields, and better through-put with employment of roller mills or similar devices acting upon the wet grains.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

The invention is hereby claimed as follows:

1. An improved method of degerminating sorghum grains which comprises the steps of compressing said grains with pressure sufficient to release the germ portion from said grains, but insufficient to cause breaking of said germs, and separating said germs from the degerminated grains.

2. The method of claim 1 wherein said grains are dehulled prior to said compression step.

3. The method of claim 2 wherein said dehulling step is effected by preparing a liquid suspension of hulled grains, agitating said suspension to free the hulls from the grains and separating said hulls from the dehulled grains.

4. The method of claim 1 wherein said compression step is carried out by passing said grains between at least one pair of rolls.

5. The method of claim 4 wherein said compression step is carried out by passing said grains between at least two pairs of rolls having progressively decreasing gap distances.

6. The method of claim 5 wherein each of said rolls is rotating at the same peripheral speed, and presents a smooth surface to said grains.

7. An improved method of degerminating sorghum grains which comprises the steps of dehulling said grains by preparing a liquid suspension of hulled grain, agitating said suspension to free the hulls from the grain and separating said hulls from the dehulled grain, compressing said dehulled grain with pressure sufficient to release the germ portion from said grains but insufficient to cause breakage of said germs, and separating said germs from the degerminated grains by taking up said germs and degerminated grains in liquid to form a suspension thereof, agitating said suspension to completely free said germs from said grains and separating said germs from said grains.

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