

Micro-ground Coffee Powder and method for its manufacture

The present invention relates to a micro-ground coffee powder, a method for its manufacture and its use in an instant coffee product. Micro-ground coffee powders are known in the art and are very fine particle size distributions of coffee, much finer than those used for café-
5 brewing of coffee beverages or soluble powder production (i.e. bulk coffee extractions). Instead they are used as an additive in instant coffee products to improve the flavour and organoleptic experience when a coffee beverage is reconstituted from a mostly soluble coffee powder. The present invention focuses particularly on an improved low energy milling
10 technique for obtaining a micro-ground coffee powder which contributes a particularly desirable organoleptic property to the final beverage.

There are a number of instant coffee products available on the market which seek to more accurately simulate the coffee beverages produced in coffee shops from roasted coffee
15 beans. In order to provide an improved organoleptic experience, these instant coffee products are typically formed of spray- or freeze-dried instant coffee, together with finely ground roasted coffee particles. These particles simulate the fine material which is included in authentic coffee beverages during a café extraction process and provide an improved depth of flavour. In a café-style coffee beverage production this fine material in the beverage
20 is typically only the smallest “fines” from the coffee grind which have passed through the filter.

One example of a soluble coffee product containing micro-ground coffee material is Millicano®. Millicano® coffee is prepared by mixing an aqueous coffee extract with finely
25 ground roasted coffee particles. This mixture is then freeze-dried to provide an instant coffee containing the fine particles. The particles typically have a particle size (D90) of less than 60 microns and are prepared by jet milling. Jet milling is expensive, energy intensive and can potentially cause a loss of aroma due to the expression of oils from the coffee during grinding. A Millicano® coffee may be manufactured as described in GB2482032.

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Other approaches to milling include cryo-milling, but this also has a high capex and energy consumption. The cold temperatures involved preserve the aroma of the coffee but add system complexity and operating costs.

35 There are also other products on the market which simply add a finely ground roasted coffee to pre-manufactured instant coffee particles. Such products suffer from a number of

disadvantages including unwanted separation and settling during storage and, typically, use larger particles which lead to grit and sedimentation.

5 US20160295876A1 was a previous attempt to overcome the disadvantages of jet-milling discussed herein to obtain a suitable micro-ground coffee additive. However, such roller grinding approaches typically struggle to achieve a sufficiently small final particle size and the micro-ground coffee-containing products can be found to be gritty.

10 KR1020120048145A discussed the addition of micro-ground coffee to soluble coffee products.

15 JP2008072901A discloses the use of an impact grinder to obtain a finely ground roasted coffee having a diameter of less than 20 μm . The particles have a more rounded shape which is noted to improve the flavour and mouthfeel.

JP4453829B2 discloses wet-milling of coffee to achieve a fine particle size and to avoid a rough organoleptic experience. The wet-milling is performed with a range of different mill types.

20 US3697288 relates to slurry milling.

DE3110020 relates to roller grinding of coffee before an industrial extraction process.

25 WO2015/197340 relates to cryomilling of coffee to allow oil recovery and diterpene reduction.

30 Accordingly, it is desirable to provide an improved method for the manufacture of a micro-ground coffee powder and/or one which addresses problems with the prior art, or which at least provides a commercially useful alternative. In particular, there is a desire for a simpler method for producing micro-ground coffee with a lower energy consumption. There is also a desire to provide an instant coffee product with a higher amount of micro-ground coffee without a high cost and high energy consuming method.

35 Accordingly, in a first aspect the present invention provides a method for the manufacture of a micro-ground coffee powder, the method comprising:

a) providing whole or cracked roasted coffee beans having a moisture content of less than 5wt%;

b) milling the coffee beans in a vibrating rod mill to form a micro-ground coffee powder having a D90 of less than 75 µm.

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The present invention will now be further described. In the following passages different aspects of the invention are defined in more detail. Each aspect so defined may be combined with any other aspect or aspects unless clearly indicated to the contrary. In particular, any feature indicated as being preferred or advantageous may be combined with any other feature or features indicated as being preferred or advantageous. In particular, the micro-ground powder may be made by the method described herein and used accordingly in the production of the micro-ground supplemented instant coffee powders disclosed herein.

The micro-ground coffee is discussed herein in terms of the particle size distribution. As will be appreciated, any grinding process will lead to a distribution of particle sizes and this is particularly the case with coffee beans, due to the hard nature of the beans and the random fragmentation that occurs during grinding. In order to characterise the particle size distribution, the grind of the beans is discussed in terms of the D10, D50 and D90. These terms are well known in the art and can be readily determined using known apparatus and methods. The method used herein is laser diffraction using a Malvern (wet) diffraction unit in water. Ultrasonic dispersal of the sample is performed for 5 minutes before the measurement is taken. The value of D50 is the log-normal distribution mass median diameter: the average particle diameter by mass. The values of D10 and D90 are respectively the values for which 10% and 90% by mass of the particles are finer.

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The software which provides the particle size distribution (PSD) is provided with the measuring system, e.g. Malvern laser diffraction system. Further equipment and software can be used to determine sphericity, such as the Sympatec Qicpic Image Analysis machine. This includes software which can be used for characterising the PSD and also the particle shape. For the avoidance of doubt D50 is the same as Dv50, is the same as Dx50, is the same as X50, and the terms may be used synonymously in the art.

The terms “soluble coffee” and “instant coffee” are used herein. These terms are often used synonymously in the art and they refer to a solid powder product which, on addition of water, dissolve to form a coffee beverage. In the present disclosure a distinction is made between a “soluble coffee” which is one which is made substantially entirely from the soluble portions of

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a coffee extract, and an "instant coffee" which contains predominantly soluble portions of a coffee extract but also some insoluble (but dispersible) coffee material, such as the micro-ground coffee discussed herein.

- 5 The inventors were seeking an alternative way to produce a micro-ground coffee powder suitable for use as an additive in instant coffee products, i.e. ones which contain roast and ground coffee material. It has always been difficult to grind to the fine sizes that are required and it has been the case that some micro-ground is obtained by jet-milling. This is energy intensive, at least because it requires a compressor and a blower, and it also requires
- 10 significant addition of added soluble coffee to absorb oil produced by the milling. The additional volume of instant coffee increases the amount of material that needs to be handled for a given final product. There has therefore been a desire to find alternative milling techniques.
- 15 The inventors have now employed a vibrating rod mill (VRM) to mill the coffee beans. Vibrating rod mills, also known as eccentric vibrating rod mills, are a known and commercially available mill equipment. However, to date they have not been employed in the coffee industry and, in particular, not in the production of micro-ground coffee powders.
- 20 A VRM has a milling chamber which is filled with rod-like (cylindrical) milling media. The chamber has first and second flat faces and the rods are arranged between these faces, their own end-faces adjacent the first and second flat faces of the chamber, so that they substantially extend from the first to the second flat faces. This substantially limits the movement of the rods to those directions orthogonal to their axial length. In use, the
- 25 chamber is vibrated by an eccentric motor and this causes the rods to vibrate against each other. Coffee material introduced into the milling chamber gradually filters down between the vibrating rollers and is milled to a very fine size. The rods are free to move and rotate, in comparison to the rolls in a roller mill where rotation is driven and controlled. The VRM milling process is a dry-milling process. The rods are typically made of solid metal and may
- 30 have a diameter of from 1 to 5cm, preferably 2 to 3cm and preferably about 2.5cm. The length will vary depending on the device, but typical lengths are at least 30cm, with continuous VRM mills having rods of at least 1m.

- The milling in a VRM is not a wet-milling process. It is conducted under air or, optionally
- 35 under a controlled atmosphere such as under nitrogen or carbon dioxide. The milling

process may release gases such as carbon dioxide from the coffee being milled. The moisture content of the air is typically at or below ambient moisture levels.

5 Surprisingly, the inventors found that when employing a VRM to form micro-ground coffee from a lower moisture content coffee (i.e. lower than normal, now using <5wt%, especially <3wt%) any undesirable chalky mouthfeel could be avoided. It appeared that the use of lower moisture coffee led to an increased sphericity of the powder particles –ground moist coffee had flavour problems seemingly because of their low sphericity, but the more spherical powder particles obtained with milling the drier material did not. The chalkiness
10 seems to be a particular problem which arises for particles of 30-100 microns. It is desirable to have a sufficiently low D50 that these particles are minimised, but also that those larger particles which do remain are spherical. Surprisingly the inventors also found that there was very little aroma loss with the VRM approach, despite the fact that it does not require cryo-temperatures.

15 The inventors were therefore able to obtain a good tasting coffee powder for use as an additive by using a VRM. This is particularly desirable because it has a low energy consumption (about 1/4-1/8th of jet-milling approaches, depending on the size of the VRM mill) and because it can mill all the way from whole beans to micro-grind in a single step.
20 This leads to a significantly reduced energy cost and also to a simplified process.

Further benefits were found for preferred embodiments. For example, at lower moistures such as 0.5 to 3wt% and especially 1-2wt%, the sphericity was even higher than that of jet-milled coffee powders. This gave a mouthfeel at least comparable to the conventional jet-milled additive (and better than roller-milled products). The inventors also found that using
25 arabica rich blends gave a higher sphericity than for comparable robusta-rich blends.

The inventors have now found that the use of the VRM milling technique provides a microground product with a mouthfeel equivalent to jet-milled microground coffee, despite
30 that fact that the VRM product can have a coarser particle size. This seems to be a function of the improved sphericity. The fact that the VRM product has a coarser particle size without compromising the mouthfeel means that its lower energy route can be used to provide a desirable microground additive.

The present invention provides a method for the manufacture of a micro-ground coffee powder. Micro-ground coffee is a term in the art and refers to a ground coffee having a particle size distribution which is substantially all on a micron-scale, i.e. smaller than 100 µm.

- 5 The method comprises a first step of providing whole or cracked roasted coffee beans. By “cracked” it is meant that the beans have not been subjected to a prior grinding or milling step. It should be appreciated, however, that the handling, drying and roasting processes can themselves lead to some level of comminution of the beans as they strike each other of the transport/roasting equipment. The method is intended, therefore, to be applied to beans
10 which are intact or substantially intact.

- Preferably the whole or cracked roasted coffee beans comprise a majority of Arabica coffee beans, preferably at least 70wt%, more preferably at least 90wt% and most preferably 100wt% Arabica coffee beans. As mentioned above, the inventors found that the arabica
15 beans tended to give a great sphericity in the VRM and, hence, an improved mouthfeel. The balance may be Robusta coffee and, in some embodiments the whole or cracked roasted coffee beans may comprise or consist of Robusta coffee.

- The whole or cracked roasted coffee beans have a moisture content of preferably less than 5wt%, preferably less than 4wt% and most preferably less than 3wt%. Preferably the whole or cracked roasted coffee beans have a moisture content of 0.5 to 2.5wt%, preferably 1.0 to 2.0wt%. The use of low moisture contents, especially below 3wt% gave increases to the sphericity observed through VRM milling. On the other hand, having too low a moisture content gave rise to other issues, as discussed below, and are less suitable for an industrial
25 scale process. It is noted that the moisture content of coffee beans used in soluble coffee production plants is typically higher, in the region of 6-7wt%. The inventors found that the increased sphericity observed and discussed herein was particularly the case below 3wt%.

- Preferably the whole or cracked roasted coffee beans provided in step a) are obtained by the
30 roasting of green coffee beans, wherein the moisture content of the whole or cracked roasted coffee beans is controlled by a post-roasting quenching step. That is, the roasting process has a simultaneous drying effect on the beans being roasted. In order to finish the roasting process with the very hot beans (+200°C) it is conventional on an industrial scale to quickly cool the roasting beans by adding water. This avoids a fire risk and quickly drops the
35 temperature. The final moisture content of the beans can therefore be controlled by careful selection of the amount of water used in the quenching step.

In a standard roasting and quenching step for providing roasted beans for extraction, the quenching would result in a moisture content above 5wt%, such as between 6 and 8wt%. The present invention targets a lower moisture content so a reduced amount of water is employed. Working below 1wt% moisture as the quench target is possible, but it generally requires working on a smaller scale, rather than at industrial throughput levels. Low moisture approaches can also lead to static handling problems of the powder. There can also be fire risks associated with trying to target a particularly low moisture content. In general coffee moistures are kept high in standard processes, since this ensures a faster more reliable quench.

In a further step there is milling the coffee beans in a vibrating rod mill (VRM). The milling in the VRM is to form a micro-ground coffee powder having a D90 of less than 75 μm . Preferably the D90 is less than 60 μm , preferably between 30 and 60 μm . The lower the D90 the lower the impact is of larger particles on the apparent mouthfeel. Preferably the micro-ground coffee powder has a D50 of less than 30 μm , preferably 10-30 μm . The D50 reflects the mean particle size and it is desirable that the micro-grind has a low D50 for good distribution in a final product and low sediment.

Step b) may be a batch process which mills the whole or cracked coffee beans to the micro-ground coffee powder in a single milling step. The batch process allows for ready reproducible grinding results.

Preferably step b) is a continuous grinding process. In a continuous process the mill typically has an inlet at the top, proximate to a first end of the milling chamber and an outlet at the bottom, proximate to the second end of the milling chamber. During operation the roast coffee beans are fed in at the inlet and are crushed between the rods, moving between them and along their length to the outlet where the coffee powder is collected. The residency time in a continuous process represents the average time that any given part of the coffee remains in the milling chamber.

The continuous milling permits a higher throughput than batch and the machines can have a larger capacity. Surprisingly the continuous milling was found to also further improve the particle sphericity, possibly as a function of the larger mill capacity. The improved sphericity is associated with the mouthfeel benefits.

Preferably the batch milling step has a coffee weight capacity of from 0.1 to 30kg, preferably 0.2 to 20kg, preferably 3 to 15kg. Larger scale operations may be possible in the future should larger VRM mills become available, but it is felt that the cooling requirements would increase due to undesirably high levels of heat generation as the apparatus scales.

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Preferably the milling is performed for a period of at least 3 minutes, preferably at least 4 minutes, such as preferably 3-30 minutes, preferably 4-8 minutes and most preferably 5 to 7 minutes. The lower limit of 3 minutes is typically the minimum to achieve the fine grind size required. The maximum of 30 minutes represents a long time for the VRM to be engaged with a single batch. A range of 4-8 minutes represents the optimum timing before diminishing returns are observed for finer grind sizes. However, the precise timing may vary depending on the size of the VRM being employed. For a continuous milling operation, these milling times represent the average residency time of the coffee. Preferably the residency time for a continuous process is at least 5 minutes, preferably at least 10 minutes, preferably at least 15 minutes, such as from 10 to 30 minutes, more preferably 15 to 25 minutes and most preferably about 20 minutes. Precise timing will depend on the size and configuration of the VRM employed.

In a continuous mill the throughput is preferably from 20 to 150kg/hr, preferably 25 to 100kg/hr.

The temperature of the coffee is important as this helps to ensure that the product is produced as-desired. Preferably the coffee is fed into the mill at room temperature or at least at a temperature below 40°C, preferably below 30°C. It has been found that on a batch scale the roasted coffee temperature does not increase that much during milling, nonetheless it is important that the temperature is not allowed to increase and active cooling may be employed.

However, because of the energy input into the VRM mill during continuous processing, the temperature of the coffee may need to be more closely monitored (than batch) and active cooling may be desired. The inventors found that when the temperature of the coffee is allowed to increase too high, not only can there be a potential loss of volatiles but also a loss in the desirable sphericity. For a continuous process the coffee temperature during milling is preferably less than 60°C, preferably less than 56°C and most preferably less than 52°C. A typical coffee temperature during milling will be from 40°C to 60°C, preferably 45 to 56°C and most preferably 48 to 52°C. Active cooling of the mill to control the coffee temperature can

be achieved with a cooling jacket on the mill and use of cooling. Cooling can be achieved using conventional means, such as a cooling jacket around the mill with, for example, circulating glycol or cold water (such as 2-5°C). The level of cooling can be controlled with, for example, circulation speeds of the coolant.

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In another aspect there is a method for the manufacture of a soluble coffee powder comprising a micro-ground coffee powder. That is, this aspect is directed to the method in which the micro-ground is obtained as discussed herein and then put into use in a conventional way, i.e. as an additive in a soluble coffee product. Accordingly, the method comprises firstly performing the method described herein to obtain a micro-ground coffee powder, and then either (i) mixing the micro-ground coffee powder with a soluble coffee powder to form a blend of soluble coffee powder and micro-ground coffee powder; or (ii) mixing the micro-ground coffee powder with a liquid coffee extract to form a mixture and drying the mixture; thereby forming a soluble coffee powder comprising a micro-ground coffee powder.

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The first of these methods is generally a dry-mixing approach which gives rise to a dry powder having distinct, theoretically separable components of soluble coffee and roast and ground coffee. The soluble coffee may be dried by any technique, with spray-drying or freeze-drying being preferred.

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The second of these methods produces a homogeneously structured soluble coffee with the roast and ground micro-ground additive present throughout the structure of the soluble coffee granules. The liquid coffee extract may be dried by any technique, with spray-drying or freeze-drying being preferred.

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Preferably the micro-ground coffee powder forms less than 20wt%, preferably more than 1wt% and preferably from 3 to 20wt%, preferably 5 to 15wt%, and most preferably 7-13wt%, of the soluble coffee powder comprising the micro-ground coffee powder. This is a suitable range for the micro-ground coffee to provide a flavour benefit, without contributing an unduly large sediment or otherwise detracting from the product. If the levels are too low then the benefit may not be observed.

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According to a further aspect there is provided a micro-ground coffee powder consisting of roasted and ground coffee bean material and:

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- i) having a D90 of 30 to 60 µm;

ii) having a moisture content below 5wt%, preferably below 3wt% and more preferably 1-2.5wt%; and

iii) wherein a first number weighted average sphericity of a first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5µm is at least 0.7.

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This embodiment distinguishes the VRM coffee over the prior art based on a combination of different parameters. The D90 values are relatively large, far larger than those observed with jet-milling. This is characteristic of the micro-grind obtained by VRM and it is a technically important feature since it is the particles greater than 30 microns that contribute to a

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The sphericity is a key parameter measured by the Sympatec Qicpic system (although other laser diffraction systems will be able to achieve the same) which uses optical systems to determine the shape of the micro-ground. The software looks at distinct ranges of particle sizes and provides an average sphericity of the particles in that range. For the present invention the inventors have looked in particular at two ranges of particles. The first is the range of 20 to 77.5 µm which represents organoleptically discernible particles and also those particles where the VRM and roller-milling techniques has a significant number of particles. The second is 94 to 114 microns. There are fewer of these particles, but the sphericity of these particles is characteristic, particular for jet-milling.

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The inventors have looked at number weighted average sphericity which allows a meaningful value to be obtained from the values, regardless of the total number of particles present. The sphericity is given a number from 0 to 1 (or as a percentage), where 1 is a perfect sphere. In some taste-tests higher sphericity for the observed particles was found to have no adverse effect on mouthfeel, whereas a low sphericity (i.e. below the ranges claimed) was found to provide a chalky mouthfeel.

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The moisture content is discussed above and is necessary to achieve the sphericity for the given target D90 (and D50).

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Preferably the powder has a D50 less than 30 microns, preferably 10 to 30 microns. This limitation distinguishes over jet-milled micro-ground which has a lower D50 value.

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Preferably the first number weighted average sphericity of the first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5µm is at least 0.75, preferably at

least 0.8. This parameter distinguishes over roller-milled coffee which is less spherical in this size range. As the numbers increase, it also distinguishes over lower Arabica or higher moisture VRM grinds.

- 5 Preferably a second number weighted average sphericity of a second fraction of particles of the micro-ground coffee powder sized between 94 and 114 μ m is at least 0.6, preferably at least 0.65. This provides a further distinction over jet-milled coffees. These tend to have few particles in this size range, but they are then very a-spherical.

- 10 Preferably the micro-ground coffee comprises at least 70wt% Arabica coffee. Higher amounts are preferred as discussed above.

Preferably at least 50% of the volume weighted distribution of the particles is sized between 20 and 77.5 μ m.

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Preferably the micro-ground coffee powder is obtainable by the method described herein.

- According to a further aspect there is provided an instant coffee powder comprising less than 20wt%, preferably 3 to 20wt%, preferably 5-15wt%, of a micro-ground coffee powder
- 20 consisting of roasted and ground coffee bean material, based on the total weight of the instant coffee powder, and the balance soluble coffee powder,
- wherein the micro-ground coffee powder:
- i) has a D90 of 30 to 60 μ m;
- ii) has a moisture content below 5wt%, preferably below 3wt% and more preferably
- 25 1-2.5wt%; and
- iii) has a first number weighted average sphericity of a first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5 μ m of at least 0.7.

- Preferably the micro-ground coffee powder in the instant coffee powder has a D50 less than
- 30 30 microns, preferably 10 to 30 microns.

- Preferably the micro-ground coffee powder in the instant coffee powder has the first number weighted average sphericity of the first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5 μ m of at least 0.75, preferably at least 0.8.

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Preferably the micro-ground coffee powder in the instant coffee powder has a second number weighted average sphericity of a second fraction of particles of the micro-ground coffee powder sized between 94 and 114 μ m is at least 0.6.

- 5 Preferably the micro-ground coffee powder is as described further above.

Characteristic particle size distributions of micro-ground roasted coffee achieved by different techniques are set out in the table below:

	D10 (μ m)	D50 (μ m)	D90 (μ m)	% below 99.9 μ m
VRM Sample 1 (batch)	4	21	50	99.6
VRM Sample 2 (batch)	2	18	44	99.9
VRM Sample 3 (Continuous)	2	17	46	98
4 stage roller ground	5	39	106	87.9
Jet-milled	2	11	25	100.0

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There are generally two approaches to including micro-ground coffee in instant coffee products. The first approach is to use jet-milling which produces very fine particles. These can be included in the instant coffee in a large amount (10-20wt%) since they are predominantly below 30 microns in size and do not have an adverse effect on the

- 15 organoleptic experience. The second approach is to use coarser particles, such as those obtained by roller milling, but these then need to be used in a smaller amount 2-4wt%, since the larger content of particles above 30 microns has an adverse effect on the organoleptic properties.

- 20 As can be seen, the VRM approach provides the possibility of providing a micro-ground powder which has a larger D90 than jet-milled coffee but, because of the enhanced sphericity, a larger amount of the powder can nonetheless be included in the product. The high sphericity of the larger particles avoids the adverse organoleptic effects. This opens a window for providing a unique alternative instant coffee beverage product. This novel
- 25 product has a larger amount of a coarser coffee micro-grind than has previously been seen.

According to a further aspect, there is provided a method of preparing a beverage, the method comprising adding a beverage medium to the micro-ground-coffee-containing instant coffee as described herein. Preferably the beverage medium is hot water and/or milk.

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Particularly preferred embodiments of the invention are as set out below:

A method for the manufacture of a micro-ground coffee powder, the method comprising:

- 10 a) providing whole or cracked roasted coffee beans having a moisture content of less than 3wt%;
- b) milling the coffee beans in a vibrating rod mill to form a micro-ground coffee powder having a D90 of less than 75 µm.

A micro-ground coffee powder consisting of roasted and ground coffee bean material and:

- 15 i) having a D90 of 30 to 60 µm;
- ii) having a moisture content 3wt% and more preferably 1-2.5wt%; and
- iii) wherein a first number weighted average sphericity of a first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5µm is at least 0.7.

- 20 An instant coffee powder comprising 5-15wt%, of a micro-ground coffee powder consisting of roasted and ground coffee bean material, based on the total weight of the instant coffee powder, and the balance soluble coffee powder,

wherein the micro-ground coffee powder:

- i) has a D90 of 30 to 60 µm;
- 25 ii) has a moisture content below 3wt% and more preferably 1-2.5wt%; and
- iii) has a first number weighted average sphericity of a first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5µm of at least 0.7.

Figures

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The invention will now be described in relation to the following non-limiting figures, in which:

Figure 1 shows the process steps of an exemplary micro-grind preparation process.

- 35 Figure 2 shows a cross-sectional drawing of the end of a VRM.

Figure 3 is a graph showing how the observed grind size distribution changes during VRM milling with moisture. This is based on Malvern laser diffraction in water.

Figure 4 is a graph investigating the effect of longer milling times in the VRM. This is based on Malvern laser diffraction in water.

Figure 5 is a graph exploring the particle size distribution for different techniques. This is based on Sympatec Qicpic image analysis in water.

Figure 6 is a graph looking at how the moisture content affects the sphericity at each particle size. This is based on Sympatec Qicpic image analysis in water.

Figure 7 is a graph looking at how the particle shape changes as a number weight average over the sphericity parameters disclosed herein. This is based on Sympatec Qicpic image analysis in water.

Figure 8 is a graph looking at how the particle shape changes as a number weight average over the sphericity parameters disclosed herein. This shows the ranges over which the sphericity is measured for the particle sizes. This is based on Sympatec Qicpic image analysis in water.

Figure 1 shows an exemplary micro-grind preparation process 1. As shown in Figure 1, the system is provided with a source of roasted whole coffee beans 5. The coffee beans 5 are divided into a minority portion 10 for forming micro-ground coffee powder 60 and a majority portion 20 for extraction to form a liquid coffee extract 25.

The majority portion 20 of the whole coffee beans 5 is passed to a roller mill 30 for grinding. Typical grind sizes are 2-3mm. The ground coffee 35 obtained from the roller mill 30 are passed to an extraction system 40, where hot water 45 is used to extract soluble material from the ground coffee 35 and to form a liquid coffee extract 25.

The minority portion 10 of the whole coffee beans 5 is passed to the VRM 55 where it is ground to provide a micro-ground coffee powder 60. This may be stored before further process steps, if required. The micro-ground coffee powder 60 is then dosed in a dosing step 65 into water or a further liquid coffee extract and thoroughly mixed in a mixer 70 to provide a suspension 75.

The suspension 75 is then mixed in a mixer 50 with the liquid coffee extract 25 and the mixture 80 is passed to a dryer 85 to form the final micro-ground-containing instant coffee product 90.

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In contrast, a jet-milling process would require a pre-crushing step to be performed as jet-milling is not suitable for milling whole beans. Similarly, roller milling can require multiple milling steps whereas the present method can complete the milling with a single stage. Jet-milling of coffee to a micro-ground size also requires: a blower, a compressor and a source of spray-dried soluble coffee powder.

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Figure 2 shows a cross-sectional view of the end of a VRM mill 100. The VRM mill 100 has a grinding chamber 105 which is filled with rods 110. These rods 110 all have substantially the same cross-section (and material and mass) and are stacked on top of each other within the chamber 105. The chamber 105 is supported on sprung supports 115 and there is an eccentrically configured motor (not shown) which provides vibrations through the whole structure. This causes the rods 110 to vibrate relative to each other. As a consequence, coffee (not shown) loaded onto the rods 110 is caused to pass between and be crushed between pairs of adjacent rods 110. This crushes the coffee to the desired final size.

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At the end of a batch, the chamber 105 can be inverted and opened in order to dispense the material. The chamber 105 does not need to be fully emptied, since left over coffee can be retained for the next batch cycle. The chamber 105 can be substantially full of the rods 110, since they do not need to move much to have the desired vibrational milling effect.

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The use of rods 110 over other possible milling media (e.g. balls) is advantageous for a number of reasons. Firstly, they are easier to use continuously as the coffee can be readily removed from the chamber 105. In addition, the voids between rods are smaller than between balls, so there is a lower amount of larger particulate matter remaining. It is also considered that the rod-milling approach has something akin to a roller milling effect on the coffee, such that the form and nature of the particle size distribution obtained matches that which is commonly used in the coffee industry.

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The VRM mill 100 can be configured with a number of variables:

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1. batch size (g) – this is generally a function of the mill size;

2. frequency (Hz) – this is generally a function of the mill, but the size can be selected to achieve a desired energy consumption. Values of 40 to 60 are typical.
3. residency time – this is discussed in more detail above.
4. cooling temperature – preferably the mill is kept around room temperature such as 10-25°C to ensure that there is no aroma loss.

If the VRM mill 100 is set up in a continuous mode, then the variables may include:

1. loading weight (g) – this is generally a function of the mill size;
2. frequency (Hz) – this is generally a function of the mill, but the size can be selected to achieve a desired energy consumption. Values of 40 to 60 are typical.
3. residency time – this is discussed in more detail above.
4. cooling temperature – preferably the mill is kept below 75°C, preferably below 60°C, to ensure that there is no aroma loss.

Examples

The invention will now be described further in relation to the following non-limiting examples.

Particle size measurements were taken using a Malvern Laser diffraction system in water, the Malvern 300. Particle shape measurements were taken using a Sympatec Qicpic, in water. Both techniques looked at 0.5g of sample dispersed in 50ml of demineralised water after 5 minutes of ultrasonic treatment.

1. Moisture content

Moisture content for coffee beans having different moisture contents were examined in the VRM mill process. The coffee sampled was a 70% Arabica, 30% Robusta blend, roasted and quenched to moisture contents of 1.1, 2.1, 4.1 and 6.5wt%. Analysis was performed on a Malvern 3000 in water (0.5g in 50mL, 5 minutes ultrasonic treatment).

The graph in Figure 3 shows the results. The D10 values remain substantially constant. The D50 values increase slightly with increasing moisture. The D90 values increase significantly with increasing moisture content. At the same time, the higher moisture gives more particles having a particle size greater than 100 microns. The vertical dashed lines show different moisture regions.

2. Milling time

The effect of the milling time on the particle distribution was investigated and the results are shown in Figure 4 (Malvern laser diffraction in water). As can be seen, 300s represents a point beyond which the returns diminish and substantially all the particles are all smaller than 100 μm . In particular, this is the point at which the D90 value reaches an acceptable level. The dashed vertical lines are to highlight different milling extents.

Milling times for continuous milling systems seem to broadly correlate well with the suitable times for batch systems, although optimal residency times may be longer for continuous milling systems.

3. Particle size distribution

Figure 5 (Malvern laser diffraction in water) shows how the VRM approach produced a broadly similar peak to jet milling, but with a larger D50. The roller grinder peak has a much larger distribution of particles. The effect of increasing moisture can also be seen for the VRM distributions, as the higher moisture leads to a broadening of the right-hand side of the main peak – representing a larger number of larger particles remaining (particularly above 100 μm). VRM test #36 is a VRM milled Arabica sample.

4. Sphericity

Figure 6 shows how the sphericity of the particles varies as a function of milling technique and the particle size. Here it can be seen that jet milling has a high sphericity for its smaller particles, but the larger particles, especially those above 50 microns which are critical for the observed mouthfeel (below 30 microns the particles are undetectable), the sphericity is worse than for the other techniques. The roller milling gives reasonable sphericity across the range, but there are many more larger particles. This graph shows that the sphericity on VRM decreases with increasing moisture and also that a 100% Arabica grind is better than for a Robusta blend. Indeed, the best consistent sphericity is observed across the graph for the 100% Arabica, 2wt% moisture grind.

5. Sphericity of fractions

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The following chart assesses the sphericity of different blends and the observed values achieved for each sample. As can be seen, VRM gives the highest sphericity across the range of detectable particle sizes:

	20 μm	24 μm	29 μm	35.5 μm	43 μm	52.5 μm	64 μm	77.5 μm	20-77.5 μm	52.5-77.5 μm
VRM Arabica 2wt% (batch)	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.77	0.66
VRM Arabica 2wt% (batch)	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.78	0.65
VRM 70% Robusta 1.1% moisture (batch)	0.78	0.77	0.76	0.73	0.69	0.67	0.65	0.65	0.71	0.64
VRM 70% Robusta 2.1% moisture (batch)	0.79	0.78	0.76	0.74	0.71	0.685	0.68	0.665	0.73	0.64
VRM 70% Robusta 4.1% moisture (batch)	0.78	0.765	0.75	0.72	0.68	0.665	0.645	0.635	0.71	0.62
VRM 70% Robusta 6.5% moisture (batch)	0.76	0.75	0.73	0.71	0.67	0.64	0.62	0.62	0.69	0.61
Jet mill (comparative)	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.72	0.60
VRM (continuous)	0.86	0.86	0.85	0.84	0.81	0.79	0.76	0.74	0.84	0.77

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Unless otherwise stated, all percentages herein are by weight.

The term "comprising" is intended to be inclusive and mean that there may be additional elements other than the listed elements. The term "consisting of" is intended to mean that no other elements may be present other than those listed. The term "consisting essentially of" is intended to mean that no other elements may be present other than those listed unless the other elements do not materially affect the basic and novel characteristics of the invention.

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Although preferred embodiments of the invention have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the scope of the invention or of the appended claims.

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Claims:

1. A method for the manufacture of a micro-ground coffee powder, the method comprising:
 - 5 a) providing whole or cracked roasted coffee beans having a moisture content of less than 5wt%;
 - b) milling the coffee beans in a vibrating rod mill to form a micro-ground coffee powder having a D90 of less than 75 μm .
- 10 2. The method according to claim 1, wherein the whole or cracked roasted coffee beans have a moisture content of less than 4wt%, preferably less than 3wt%, and more preferably 0.5 to 2.5wt%, preferably 1 to 2wt%.
3. The method according to claim 1 or claim 2, wherein the whole or cracked roasted
15 coffee beans provided in step a) are obtained by the roasting of green coffee beans, wherein the moisture content of the whole or cracked roasted coffee beans is controlled by a post-roasting quenching step.
4. The method according to any preceding claim, wherein the whole or cracked roasted
20 coffee beans comprise a majority of Arabica coffee beans, preferably at least 70wt%, more preferably at least 90wt% and most preferably 100wt% Arabica coffee beans.
5. The method according to any preceding claim, wherein the micro-ground coffee
25 powder has a D50 of 10-30 μm .
6. The method according to any preceding claim, wherein the D90 is less than 60 μm , preferably between 30 and 60 μm .
7. The method according to any preceding claim, wherein step b) is a batch or
30 continuous process which mills the whole or cracked coffee beans to the micro-ground coffee powder in a single milling step.
8. The method according to claim 7, wherein the batch milling step has a coffee weight capacity of from 0.2 to 20kg, preferably 3 to 15kg, or wherein the continuous milling step has
35 a throughput of 20 to 150kg/hr, preferably 25 to 100kg/hr.

9. The method according to any preceding claim, wherein the milling is a batch process performed for a period of 3-30 minutes, preferably 4-8 minutes, more preferably 5-7 minutes, or a continuous process performed for a period of 3-30 minutes, preferably 15-30 minutes, more preferably 15-25 minutes.

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10. A method for the manufacture of an instant coffee powder comprising a micro-ground coffee powder, the method comprising:

a) performing the method according to any preceding claim to obtain a micro-ground coffee powder; and

10 b1) mixing the micro-ground coffee powder with a soluble coffee powder to form a blend of soluble coffee powder and micro-ground coffee powder; or

b2) mixing the micro-ground coffee powder with a liquid coffee extract to form a mixture and drying the mixture to form an instant coffee powder comprising a micro-ground coffee powder.

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11. The method according to claim 10, wherein the micro-ground coffee powder forms from 3 to 20wt%, preferably 5 to 15wt%, of the soluble coffee powder comprising the micro-ground coffee powder.

20 12. A micro-ground coffee powder consisting of roasted and ground coffee bean material and:

i) having a D90 of 30 to 60 μm ;

ii) having a moisture content below 5wt%, preferably below 3wt% and more preferably 1-2.5wt%; and

25 iii) wherein a first number weighted average sphericity of a first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5 μm is at least 0.7.

13. The micro-ground coffee powder according to claim 12, wherein:

a) wherein the powder has a D50 less than 30 microns, preferably 10 to 30 microns;

30 and/or

b) wherein the first number weighted average sphericity of the first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5 μm is at least 0.75, preferably at least 0.8; and/or

35 c) wherein a second number weighted average sphericity of a second fraction of particles of the micro-ground coffee powder sized between 94 and 114 μm is at least 0.6.

14. The micro-ground coffee powder according to claim 12 or claim 13, comprising at least 70wt% Arabica coffee.

15. The micro-ground coffee powder according to any of claims 12 to 14, which is
5 obtainable by the method of any of claims 1 to 11.

16. An instant coffee powder comprising 3 to 20wt%, preferably 5-15wt%, of a micro-ground coffee powder consisting of roasted and ground coffee bean material, based on the total weight of the instant coffee powder, and the balance soluble coffee powder,
10 wherein the micro-ground coffee powder:
i) has a D90 of 30 to 60 μm ;
ii) has a moisture content below 5wt%, preferably below 3wt% and more preferably 1-2.5wt%; and
iii) has a first number weighted average sphericity of a first fraction of particles of the
15 micro-ground coffee powder sized between 20 and 77.5 μm of at least 0.7.

17. The instant coffee powder according to claim 16, wherein the micro-ground coffee powder:
a) has a D50 less than 30 microns, preferably 10 to 30 microns; and/or
20 b) has the first number weighted average sphericity of the first fraction of particles of the micro-ground coffee powder sized between 20 and 77.5 μm of at least 0.75, preferably at least 0.8; and/or
c) has a second number weighted average sphericity of a second fraction of particles of the micro-ground coffee powder sized between 94 and 114 μm is at least 0.6.

25 18. The instant coffee powder according to claim 16 or claim 17, wherein the micro-ground coffee powder is according to any of claims 12 to 15.