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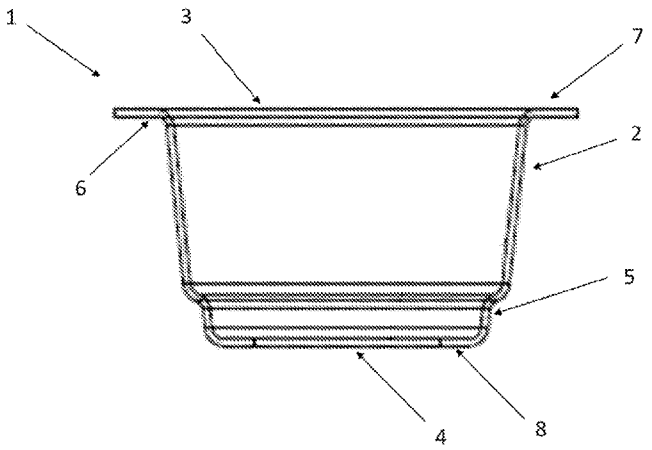


Figure 1

(57) Abstract: Biodegradable capsule (1) configured for use in a portafilter unit and capable of holding a volume of ground coffee to produce a double espresso, wherein the capsule comprises a rigid biodegradable sidewall (2) configured to fit an adapter for a portafilter unit, a biodegradable top sealing portion (3) and a biodegradable filter base (4).

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Capsule for Dispensing Coffee

The present invention generally relates to the technical field of biodegradable or compostable capsules for dispensing barista style coffee. More particularly, the present invention relates to biodegradable or compostable capsules for dispensing barista style double espresso coffees, wherein the capsule is configured for insertion into a standard portafilter. It shall be understood that the espresso, once produced, may be utilised in the production of other coffee-based drinks, such as americanos, lattes, mochas, cappuccinos, macchiatos, ristrettos, iced coffees and the like.

Specifically, the present invention relates to a biodegradable or compostable capsule which is capable of withstanding the passage of high temperature and pressure water and steam whilst simultaneously being large enough to contain a measure of ground coffee suitable for producing a double espresso.

Background

Traditionally, coffee has been produced using a standard espresso maker by a trained barista. A typical espresso is produced using around 7 g of ground coffee, making approximately a 1-1¼ oz. espresso beverage. This shot of espresso may be consumed as a beverage in its own right, or may be combined with other ingredients such as milk, cream, additional water, cocoa, and the like in order to produce other coffee based beverages, such as an americano, latte, mocha, cappuccino, macchiato, ristretto, iced coffee or the like.

A typical double espresso is produced by a trained barista using a standard espresso maker using around 14 g of coffee and produces an approximately 1½-2½ oz. espresso beverage. Again, this may be consumed as a beverage in its own right, or may be combined with other ingredients to produce other coffee-based beverages.

To produce a coffee beverage, the roasted coffee beans must first be weighed out and ground to an appropriate size.

If the coffee is ground too finely, the excess of surface area and particle size results in excessive compaction during tamping. As a result, the tamped coffee will have a higher resistance to water flow which may result in water taking 3 to 4 times as long to pass through the mass of coffee producing an over extracted, burnt and bitter coffee beverage.

If the coffee is ground too coarsely, the coffee grounds will be unable to pack together sufficiently during tamping. As a result, the tamped coffee will have a low resistance to water flow, preventing the build-up of pressure inside the espresso machine portafilter. Consequently, any steam and/or water will 'flush' through the tamped coffee too quickly resulting in a watery, bitter coffee beverage.

The ideal coffee grind may vary depending on the age and type of coffee bean used.

Correctly grinding the coffee beans may therefore be understood to be a highly skilled process requiring a fully trained barista in order to produce optimal and reproducible results.

Incorrect weighing may result in too much or too little ground coffee being loaded in the portafilter. The presence of too much ground coffee may result in a greater resistance to flow causing the coffee to be over extracted, producing a burnt and bitter tasting coffee beverage. An insufficient amount of ground coffee may result in a coffee beverage having a reduced body of flavour.

While many traditional espresso grinders feature dosing chambers which can be set to deliver 7 g units of freshly ground coffee, errors commonly occur as a result of baristas failing to correctly utilise this feature. For example where a lever must be pulled to release a 7 g unit of ground coffee, partial pulling of the lever may result in a partial release of the ground coffee resulting in an incorrectly weighed load. Since such dosing systems generally refill a dosing chamber by the same action, partial release of the coffee grounds generally

also affects the quantity of coffee grounds present in the dosing chamber. As a result, subsequent use of the dosing chamber will also result in an incorrectly weighed load.

After weighing and grinding, the ground coffee must then be loaded in a heated portafilter handle basket and appropriately levelled in order to ensure an even depth of coffee.

Coffee extraction and infusion is generally carried out at 77°C. While many traditional espresso machines are capable of maintaining brewing water at this temperature, the barista is required to control the temperature of other parts of the brewing equipment, such as the portafilter. The use of cold equipment may result in a reduction in the flavour and aroma of the coffee beverage by as much as 25%. As a result, baristas must work quickly and accurately when filling and tamping a portafilter in order to prevent cooling of the component leading to an inferior coffee beverage being produced.

Once levelled, the coffee must then be correctly tamped in the heated portafilter handle basket unit using an appropriate force and correct nutation to ensure that a suitable and even density of ground coffee is achieved such that the water flow through the ground coffee is restricted in order to provide an ideal flow rate to produce an optimal coffee beverage.

Overly harsh tamping is found to result in slow beverage production producing an over extracted, bitter coffee, while weak tamping produces a correspondingly weak and watery coffee beverage.

The tamping process is therefore understood to be a highly skilled process which may take months or years of practice in order to reliably produce optimal coffee beverages.

Once tamped, water may be passed through the tamped coffee to produce a coffee beverage. In traditional espresso machines, the volume of water passed through the ground coffee may be controlled by the machine. However the flow rate is determined only by the grind, dose and tamp of the coffee.

Consequently, it is necessary to provide a skilled barista to perform each of the steps in order to ensure that optimal and consistent coffee is produced.

The use of ground coffee also requires extensive cleaning of the espresso machine between uses and it may be time-consuming to remove each individual ground from the machine.

Since the ground coffee is degraded by moisture and oxygen content in the air, it is generally necessary to grind coffee on a regular basis prior to the brewing of each drink. Such a process may be timely, messy, and/or noisy, and may require the use of specialised grinding equipment which may also require the use of a trained user.

In order to address these issues a number of alternative means for producing coffee beverages have been developed. These means include the development of capsules, also known as cartridges, which contain a pre-weighed, pre-tamped serving of ground coffee in an individual sealed unit. Such capsules form part of a very rich and varied technological sector.

Known capsules contain between 5 to 7 g of ground coffee and may be suitable for producing a single shot of espresso, or an alternative coffee which contains a single shot of espresso, such as a standard Americano, latte, mocha, cappuccino, macchiato, ristretto, iced coffee or the like. Where a double espresso is required, generally two capsules may be used.

Since most capsules contain less ground coffee than used by a trained barista using a standard espresso maker, the coffee beverage produced from such capsules is often inferior to traditionally made coffee beverages.

Capsules commonly contain less than an optimal amount of ground coffee in order to reduce the cost of the capsule and to reduce the size of the capsule. In particular, capsules having large surface areas and large loads are less able to withstand the high pressures in the high temperature, moist environments required by espresso makers and other coffee machines.

Most commonly, the capsules are initially provided in a sealed state in order to retain the freshness of the ground coffee and are then pierced by the coffee machine during use to enable water and/or steam to flow through the capsule. Consequently, capsules are commonly designed to be used with non-standard coffee machines, wherein each brand of capsule is designed for use with a specific machine, which is configured to be of the correct size and geometry for mounting and piercing a particular capsule and for directing a flow of water and/or steam there-through. As a result, a consumer may be tied to a particular brand of capsules once a coffee machine is purchased.

Alternatively, capsules may be configured for use with a portafilter of traditional espresso making machines. Such capsules require the use of an adapter specific to each capsule. However, since traditional espresso making machines from different manufacturers may all utilise a standard-sized portafilter, such as the E98 Faema, the user may not be limited to a specific brand of capsules.

It shall be understood that a portafilter unit comprises a handle and a basket section, wherein the basket section comprises a plurality of holes which serve as the filter element of the portafilter. Some portafilter units may be in the form of a single unit where in the handle and basket sections are either integrally formed or connected during manufacture. Other portafilter units may comprise separable handle and basket units. Alternatively, the portafilter unit may comprise a handle which includes an open ring section. The ring section may be configured to house a basket and/or an adapter. Separate baskets and adapters provided by many different brands may be compatible with handles provided by other brands. For example, baskets may be provided which are configured to fit a standard portafilter handle, such as 58 mm diameter baskets.

In all instances, the preparation of hot beverages, such as coffee-based beverages, using such capsules involves the addition of a fluid, generally water and/or steam, under elevated pressures and/or temperatures, which is forced through the capsule in order to brew the beverage.

Generally, the capsules are pierced, either prior to or during use, in order to unseal the capsule and allow the passage of fluids through the capsule to produce a coffee beverage. Since fluids are introduced to the capsule through such a piercing, distribution of the fluid such as water and/or steam may not be even throughout the ground coffee.

In order to withstand the elevated temperatures, pressures and forces used during beverage production and, in particular, to withstand such temperatures and pressures in the moist atmospheres created by the presence of steam and to withstand a piercing force, most known capsules are formed of non-biodegradable and non-compostable materials such as plastics or aluminium and/or comprise non-biodegradable/non-compostable elements. Such materials are non-porous and thus retain their structural integrity during and after use.

A disadvantage of such materials is that the non-biodegradable and non-compostable materials need to be separated from the used capsule contents prior to composting or the like. Furthermore, such capsules are also commonly non-recyclable and/or contain non-recyclable components, such as plastic laminated aluminium, which may be difficult or impossible to separate after use of the capsule. Consequently, the use of such capsules causes significant waste and environmental problems, with most such capsules simply ending up in landfill.

A further disadvantage of such capsules is that they have a high carbon-footprint, that is, they are produced and supplied using energy intensive processes.

Known capsules are also costly to produce and/or require complex, individually tailored coffee machines in order to pierce and/or utilise the capsules to produce a beverage. Consequently, the cost to consumers purchasing such capsules is high.

In some cases, the piercing component may also have an associated risk of injury to consumers, and incorrect piercing of the capsule may lead to unreliable and/or inferior coffee beverage production.

There has been some development of biodegradable and/or compostable capsules, such as those disclosed in WO2016/079701. Such capsules provide the benefits of encapsulated ground coffee over loose coffee grounds without the environmental costs. However, biodegradable or compostable capsules may be structurally incapable of withstanding the harsh conditions of distribution and consumer use, which may include long periods of travel and/or storage time which may be at elevated humidity and/or temperature.

In particular, the combination of a moist atmosphere with elevated temperatures and/or pressures used during beverage production may lead to disintegration of the biodegradable and/or compostable capsules prematurely. This may lead to incorrect coffee brewing, portions of the capsule being incorporated into the resultant beverage, portions of the capsule clogging the machine during and/or after use, and difficult and/or messy removal of the capture after use.

To prevent this, biodegradable and/or compostable capsules may be designed in order to maximise the strength and integrity of the capsule. Generally this involves minimising the cross-sectional area of any materials, particularly materials that are especially weak, such as filter papers; minimising capsule weights, including capsule content weights; and providing reinforced regions of stronger materials which may be better able to support the wet ground coffee.

As such, known biodegradable capsules contain 5-7 g of ground coffee and commonly employ reinforced regions such as rigid sidewalls, rigid top and/or bottom faces, multiple layers of filter material and the like.

Other documents such as WO 2016/103104 disclose biodegradable capsules, but do not disclose large capsules capable of housing sufficient ground coffee to produce a double espresso. Furthermore, the disclosed capsules include

puncturable membranes which may be pierced to allow the flow there-through of liquid in order to produce the coffee beverage.

The piercing of capsules during use causes the capsule to be weakened, and thus it would not be expected, and nor does WO 2016/103104 disclose, that a large capsule, capable of holding a sufficient volume of ground coffee to produce a double espresso, may be sufficiently robust to not disintegrate under the elevated temperatures and pressures as well as moist conditions associated with beverage production.

Known capsules of this form therefore generally hold up to about 8 grams of coffee.

Consequently, such capsules are incapable of producing barista quality coffee, with the associated taste and aroma, and are expensive to produce. Furthermore, multiple capsules are required in order to produce a double espresso.

In order to prevent the capsule collapsing under an applied force used to pierce the capsule, biodegradable capsules may be pre-pierced in order to allow ingress and/or egress of liquids during beverage production.

Also known are flexible pouches and "easy serve espresso" (ESE) pods.

Flexible pouches, such as those disclosed in US 9371177 are prefilled textile envelopes which may be placed in a coffee machine and compressed to produce a coffee beverage.

ESE pods are prefilled textile envelopes which may be placed in a coffee machine or an adapter for an espresso machine portafilter and used to produce a coffee beverage. In order to ensure that an even distribution of ground coffee is provided across the surface area of the ESE pod, the ground coffee is highly tamped using extreme pressures in order to produce a "puck" of ground coffee. This coffee puck is then sealed inside the textile envelope ready for use.

Commonly the textile envelopes are made of biodegradable and/or compostable materials, such as plant fibres and/or paper. Unlike many capsules, the top surface of the pod contacts the coffee contained therein. Consequently, there may be a reduced risk of rupture during use since the pod surface is supported by the coffee. Larger pods, containing about 14 g of ground coffee may therefore be supplied for the production of double espressos. However, the lack of a rigid structure surrounding the ESE pod commonly results in sub-optimal coffee production.

Specifically, the absence of any protection leads to increased instances of damage to the tamped coffee structure during transportation and/or storage. Since a fluid under pressure will traverse a structure via the path of least resistance, a disrupted coffee structure may result in the water traversing less coffee than ideal. For example, water will preferentially pass round the puck and/or through fissures in the puck where possible, resulting in a weak, sub-optimal coffee beverage. To prevent this, excessive tamping forces are generally used in order to attempt to maintain the integrity of the coffee "puck". Such forces are substantially greater than would be contemplated by a traditional barista. This prevents an optimal infusion of the ground coffee into the water resulting in an inferior coffee beverage compared to a traditional barista prepared coffee beverage. For example, excessive tamping may result in an over-extracted coffee beverage having a burnt and bitter taste.

Consequently, there is a need to provide an alternative biodegradable product to be used in the production of a double espresso or double espresso-based beverage, capable of consistently producing an optimal coffee beverage without the need for excessive training of the user and the whole barista process.

There is also a need to provide such a biodegradable product which is efficient to use, is easily cleaned away, is cost-effective to produce, and can produce a coffee-based beverage in a timely fashion.

Additionally, there is a need to provide a biodegradable product which may be used with any conventional espresso maker, i.e. a biodegradable capsule

product configured for use in a standard portafilter, such as the E98 Faema, without the need to puncture the capsules before or during use to enable efficient water flow.

There is also a need to provide a biodegradable product capable of providing a high quality double espresso or double espresso-based beverage without excessive cost.

It shall be understood that a biodegradable capsule relates to a capsule which is capable of being decomposed by bacteria or other biological means. A compostable capsule shall be understood to mean a biodegradable capsule which can be used as a fertilizer after being at least partially decomposed by bacteria or other biological means.

Summary of the Invention

According to a first aspect of the present invention, there is provided a biodegradable capsule configured for use in a portafilter unit and capable of holding a volume of ground coffee to produce a double espresso, wherein the capsule comprises a rigid biodegradable sidewall configured to fit an adapter for a portafilter unit, a biodegradable filter base and a biodegradable top sealing portion.

Preferably, the capsule has a height from the filter base to the top sealing portion from 2.5 cm to 3.5 cm, an interior diameter at the top sealing portion from 4 cm to 6 cm, and an interior diameter at the base from 2.8 cm to 4 cm.

Particularly preferably, the capsule may have a height from 2.5 cm to 3 cm, and especially preferably the capsule may have a height of about 2.8 cm.

It shall be understood that a portafilter is a standard component of traditional espresso makers and that portafilters are of standard industry sizes, composed of a separate handle and a filter basket or all in one units.

It shall also be understood that the portafilter unit may relate to an integral portafilter handle and basket wherein the basket has been configured to support

such a capsule; or to an adapter unit configured to be mounted in a basket of an integral portafilter handle and basket, an open ring of a portafilter handle, or in a separate basket configured to be mounted in a portafilter handle. Thus, the present invention may be configured to fit any standard portafilter. For example, the capsule may be configured for use in a 58 mm diameter basket, such as an E98 Faema portafilter by using the adaptor basket described herein.

The biodegradable capsules may be a single use item configured to produce a single beverage. Optionally, the capsule may be used to produce an amount of espresso coffee beverage which may be split to produce multiple coffee beverages.

In order to fit a standard portafilter, an adapter is used. The adapter may be configured to be mounted in an open ring portafilter unit which may be provided by any number of espresso maker manufacturers. Alternatively, the adapter may be integrally formed with the portafilter.

The adapter may be non-disposable. That is, the portafilter may be repeatedly used with any number of single use capsules, which may be removed from the adapter after use.

The adapter may be made of any suitable material such as metal, plastic, resins, alloys or combinations thereof. Preferably, the adaptor may be made of food grade stainless steel or aluminium. Optionally, the adaptor may be constructed inside a standard portafilter handle for specific use with the capsules of the present invention. Such handles may be made of any suitable material, including, but not limited to metals, woods, stones, ceramics, marbles and mixtures thereof.

Preferably, where the adapter is integrally formed with a portafilter handle, the handle may be formed of a suitable material such that the handle temperature does not substantially rise during heating of the adapter prior to or during use.

Preferably the adapter may be configured such that when the adapter is mounted in an espresso maker, either by being mounted in or integrally formed

with a standard portafilter unit, handle or basket, and a capsule according to the first aspect of the present invention is mounted in the adapter, the top of the capsule is positioned at an optimal distance from the fluid inlet of the espresso maker.

Furthermore, the adapter may be configured to prevent fluid, such as water and/or steam, from exiting the espresso maker without first traversing through the capsule. That is, the adapter may be configured to prevent the passage of such fluids around the capsule. Consequently, when mounted in the adapter, and placed in an espresso machine, the adapter may block all paths by which fluid may exit the espresso maker other than those paths which traverse through the capsule in order to ensure that an optimal beverage is provided. Thus, there may be no opportunity for the fluid to bypass the capsule, which might otherwise result in a weaker beverage having a lower coffee concentration.

Preferably, the base of the adapter comprises a plurality of holes configured to allow a maximum flow of fluid while optimizing the créma of the produced coffee beverage and retaining the capsule in the adapter.

The plurality of holes may also prevent a vacuum being formed between the capsule and the adapter during use, allowing the capsule to be easily removed from the adapter after use.

Optionally, the adapter may be configured to have a different interior geometry to the capsule exterior in order to produce one or more void spaces. Such void space may aid in créma production. For example, where a capsule comprises a step feature at or towards the base of the capsule, the lack of a corresponding feature in the adapter may result in an air pocket being formed at the base of the capsule. The provision of a plurality of holes at the base of the adapter may result in a hindrance and/or disturbance of the flow of coffee out of such an air chamber aiding in optimal créma formation.

An optimal créma may form a cap over the coffee, preventing volatile aromas from escaping prematurely. The smooth consistency of the créma may also affect the texture of the coffee, producing a thicker feel or more robust coffee texture which may linger in the mouth.

The adapter may also ensure that when a suitable amount of ground coffee for producing a double espresso is provided in the capsule, the depth of the ground coffee is suitable for producing an optimally brewed double espresso and that the capsule is maintained in the correct position in the portafilter. For example the capsule may be maintained in a central position in the portafilter.

It shall be understood that a capsule having either a very large or a very small cross-sectional area will result in different depths of coffee to which the fluid, such as water and/or steam, must traverse in order to produce the coffee beverage. The capsule may therefore have a particular geometry which corresponds to the amount of coffee intended to be housed therein, in order to produce an optimal coffee beverage. Since portafilters are of a standard size, the provision of the adapter enables an optimal capsule design to be utilised, with the adapter filling any remaining, unnecessary space in the portafilter.

For example, the adapter may have a height from the adapter base to the adapter top from 4 to 6 cm. The adapter may also have an open top having a diameter greater than 58 mm, suitable for use in a standard 58 mm portafilter unit, and a main adapter cavity having a diameter from 35 to 45 mm, in order that an appropriately sized capsule may be mounted to achieve an optimal beverage.

The presence of the adapter also prevents the capsule from moving around within the portafilter during use. Additionally, the adapter may be configured to support at least a portion of the sidewalls, top and/or base of the capsule in order to prevent explosion of the capsule under elevated pressures. In addition to reducing the risk of explosion during use, the presence of the adapter may also reduce the amount of materials necessarily present in the capsule in order

for it to maintain its structural integrity during use. This may reduce the overall cost of the capsule.

Optionally, the adapter may comprise an annular ring about an interior surface of the adapter. The annular ring may be a convex ring extending into the centre of the adapter cavity into which a capsule may be mounted. The annular ring may contact the exterior sidewalls of the capsule when mounted in the adapter. The annular ring and capsule may be configured such that the capsule fits snugly against the annular ring, enabling the capsule to be easily mounted in an optimal position in the adapter. For example, the annular ring may direct the capsule such that it is centred in the adapter.

The annular ring may also enable the capsule to be mounted in the adapter without force, and to be held against the adapter by friction such that the capsule does not become accidentally dislodged. Optionally, the annular ring may provide sufficient contact between the adapter and the capsule such that the capsule does not easily fall out of the adapter when turned upside down.

The provision of an annular ring in the adapter may enable the surface tension between the exterior surface of a wet capsule and the interior surface of the adapter to be minimised such that the capsule may be easily removed after use. The annular ring may also aid in preventing a vacuum forming between the sidewalls of the capsule and the adapter which may otherwise hinder capsule removal.

The capsule may have a height from the filter base to the top sealing portion of from 2.5 cm to 3.5 cm, an interior diameter at the top sealing portion from 4 cm to 6 cm, and an interior diameter at the base from 2.8 cm to 4 cm.

Such capsules may be suitable for mounting in a conventional portafilter of a standard espresso maker, via an adapter. Such capsules may also be of a suitable size for housing a sufficient mass of ground coffee to produce a double espresso.

Surprisingly, it has been found that biodegradable top sealing portions and biodegradable filter bases extending across the top and bottom surfaces of a capsule of such a size may have sufficient structural integrity to survive the coffee brewing process when mounted in an adapter.

The provision of a capsule having an interior diameter at the top sealing portion from 4 cm to 6 cm, and an interior diameter at the base from 2.8 cm to 4 cm may enable the capsule to encapsulate a sufficient mass of ground coffee to produce a double espresso. Furthermore, such a capsule may have a sufficient cross sectional area, perpendicular to the filter base to provide an optimal depth of ground coffee, when tamped, for producing a double espresso.

Suitable depths of coffee may be from about 1.8 cm to about 3.5 cm. For example the depth of coffee may be from 1.8 cm to 3 cm. Preferably, the coffee depth may be from about 2.0 cm to about 2.8 cm.

In some embodiments, the ground tamped coffee may fill substantially the whole void between the top sealing portion and filter base.

Optionally, the interior diameter of the capsule at the top sealing portion may be from 4 cm to 5 cm, and may preferably be from 4 cm to 4.5 cm. Alternatively or in addition, the interior diameter of the capsule at the base may be from 2.5 cm to 3.5 cm, and preferably may be from 2.8 cm to 3.2 cm.

According to some embodiments the main body of the capsule may have a generally frusto-conical geometry. That is, a substantial portion of the main body of the capsule may have a tapered-cylindrical shape. When mounted in the adapter, and subsequently in the espresso maker for use, the widest end of the frusto-cylinder may form the top of the capsule positioned against or about the water ingress spout or zone, while the tapered end of the frusto-cylinder may be formed at the base of the capsule. For example, the interior angle between the filter base and capsule sidewall may be from 91 to 120 degrees. Preferably the interior angle may be from 91 to 100 degrees and particularly preferably the interior angle may be about 96 degrees.

Such capsules may be inserted into the adapter such that the exterior walls of the capsule are flush with the sides of the adapter, and held in an optimal position under gravity. Alternatively, where the adapter comprises an inwardly extending annular ring, the capsule may be mounted such that the exterior walls of the capsule contact the annular ring. Preferably, the fit between the sidewalls of the capsule and at least a portion of the adapter may be such that no fluid can pass there between. Thus, it may not be possible for water to traverse the adapter between the opposing faces of the capsule sidewalls and the capsule and all the water used to produce the coffee beverage may flow through the capsule.

Optionally, the capsule may be shaped to include a step portion. The step portion may aid in producing an optimised créma by forming an air pocket between the capsule and adapter through which the coffee beverage may pass and aerate..

According to some embodiments, the biodegradable capsule may have an interior diameter of about 4.3 cm at the widest point and about 3.1 cm at the narrowest point. Such a geometry may provide an optimal depth of ground coffee for producing a double espresso.

According to some embodiments, the biodegradable capsule may have an interior volume from about 20 cm^3 to 60 cm^3. Preferably, the capsule may have an interior volume from about 22 cm^3 to about 35 cm^3. For example, the capsule may have an interior volume of about 30 cm^3.

The provision of a capsule having such a volume may enable the capsule to house an amount of fluid and ground coffee suitable for obtaining an optimal brewing environment. This may be based on standard water and/or steam ingress pressures and flow rates used by conventional espresso makers. For example, suitable flow rates and pressures may be from 6-16 bar of pressure at a flow rate of 5-15 ml/s.

According to some embodiments, neither the biodegradable top sealing portion nor the filter base may be required to be pierced during beverage production. Additionally or alternatively, neither the biodegradable top sealing portion nor the filter base may be required to be pierced before beverage production. Preferably, the biodegradable top sealing portion and the filter base are un-pierced and remain un-pierced throughout the beverage production process.

In some embodiments there is no need for the user to pierce any part of the capsules prior to use. Use of such capsules may therefore be more user-friendly, quicker to use, produce less mess and have a reduced number of steps providing less opportunity for failure of the device or variability of the coffee produced. Furthermore, there is no requirement to adapt a conventional espresso maker to include a piercing component, such as the many known branded machines designed to produce coffee-based beverages using correspondingly branded capsules. Additionally, since the adapter is not required to include a piercing component, there is a reduced risk of injury and/or machine failure resulting from incorrect piercing of the capsule, and a reduced cost to the user of ancillary equipment.

Preferably, both the biodegradable top sealing portion and the biodegradable filter base may be formed of water permeable materials. That is, these components may be formed of materials which allow the passage of water there through when subjected to the elevated temperatures and pressures present in conventional espresso makers during use. Any biodegradable water permeable material may be used, including woven and nonwoven materials. An exemplary material is filter paper.

Suitable filter paper for both the top sealing portion and the filter base includes 92 GSM standard coffee/tea filter paper. Other filter papers thicknesses may also be used. For example, filter paper having a thickness from 50 gsm to 55 gsm may be used. Optionally, different thicknesses of filter paper may be used for the top sealing portion and the filter base. The provision of a filter paper base having a thickness of 55 gsm may particularly provide suitable stability and consistent functionality to the capsule under the pressures of extraction.

Optionally, the top sealing portion is entirely formed of a water permeable material, such as a filter material and forms a top filter portion. For example, the entirety of the top sealing portion may be formed of a filter paper.

Contrary to conventional capsules which may be punctured or pierced to provide a stream or inlet of water and/or steam, the provision of an extended area of water permeable material provides an extended area through which water and/or steam may enter the capsule. The distribution of water and/or steam across a large surface area of the capsule provides a showering or percolation effect providing a more uniform passage of water through a cross-section of the ground coffee.

Preferably, the top sealing portion is formed entirely of a filter paper. In such capsules the filter paper enables even percolation of water across the whole surface area of the tamped coffee enabling the water and/or steam to infiltrate the puck evenly. This may result in higher quality, more reproducible coffee beverages. In some embodiments the rigid sidewall of the biodegradable capsule may comprise a peripheral flange extending outwardly about the top of the capsule. Preferably the peripheral flange may be integrally formed with the sidewall of the biodegradable capsule.

The presence of a peripherally extending flange may aid in the mounting and removal of the capsule in the adapter. When mounted in the adapter, the peripheral flange may extend across a portion of the top surface of the adapter. Thus the peripheral flange may prevent the capsule from sinking too far down into a hollow or recess provided in the adapter, into which the capsule may be mounted. Furthermore, the portion of the peripheral flange which extends across a portion of the top surface of the adapter, when the capsule is mounted in the adapter, may be grasped by a user in order to remove the capsule from the adapter.

Optionally, the peripheral flange may be configured to prevent the flow of fluids around the exterior of the capsule.

According to some embodiments, the top sealing portion is heat-sealed to the peripheral flange. Preferably the top sealing portion is heat-sealed about the entire periphery of the capsule across the entire width of the peripheral flange. Optionally, the top surface of the peripheral flange may have a width of at least 3 mm. Preferably, the top surface of the peripheral flange may have a width of at least 5 mm. Optionally, the width of the flange may be at least 10% of the maximum interior diameter of the biodegradable capsule.

The presence of a wide peripheral flanged may provide an extended surface area by which the top sealing portion may be sealed to the rigid sidewall of the biodegradable capsule. The provision of an extended region of bonding between the top surface area and the capsule sidewall may aid in the ability of the capsule to withstand the high pressure, high temperature and moist conditions associated with beverage production.

In some embodiments the filter base is heat-sealed to an interior surface of the rigid biodegradable sidewall. For example, the filter base may be heat-sealed to a portion of the rigid biodegradable sidewall which extends annularly over a portion of the base of the capsule. Preferably the filter base is heat-sealed about the entire circumference of the biodegradable capsule. This may limit and/or prevent coffee grinds from exiting the capsule prior to or during use. Optionally the filter base may be heat-sealed to an extended portion of the interior sidewall of the biodegradable capsule about the entire circumference of the capsule. For example the heat-sealed contact zone between the filter base and the interior of the rigid biodegradable sidewall may extend over a thickness of at least 2 mm. Optionally, the heat-sealed contact zone may extend across at least a 5 mm portion of the rigid sidewall.

In such biodegradable capsules the filter base may be capable of remaining firmly affixed to the rigid biodegradable sidewall of the capsule throughout the high-temperature, high-pressure and moist beverage production process.

Alternatively, the filter base may simply be placed into the capsule prior to filling with ground coffee which is then tamped. In such cases the filter base may be

held in position by the presence of the tamped coffee after sealing of the capsule with the top filter portion. According to some embodiments, the rigid biodegradable sidewall may extend annularly across a portion of the biodegradable filter base and provide a platform upon which a loosely mounted filter base may be placed.

The extension of the rigid biodegradable sidewall across a portion of the biodegradable filter base and/or the step portion of the capsule sidewalls may provide support to a heat-sealed or loose filter base, enabling the base to withstand the moist, high-temperature and high-pressure conditions associated with beverage production. In particular, the annular extension of the rigid sidewall across a portion of the biodegradable filter base may provide additional support about the exterior circumference of the filter base, and may particularly support the binding region wherein the biodegradable filter base may be heat-sealed to the capsule sidewall. Consequently, the presence of an annularly extending biodegradable rigid sidewall across a portion of the biodegradable filter base may prevent the filter base from separating from the rigid sidewall of the capsule during use.

Furthermore, the presence of an annularly extending biodegradable rigid sidewall across a portion of the biodegradable filter base may prevent the filter base from separating from the rigid sidewall of the capsule during extraction of the capsule from the adapter after use when both the ground coffee and filter are wet, causing the ground coffee to be heavier and the filter base, such as a filter paper, to be weaker.

Where the filter base is not bonded to the interior sidewalls of the capsule, the provision of a step portion and/or a portion of the rigid sidewall extending across a portion of the base may aid in the retention of the filter base in the correct position, and/or prevent the seepage of ground coffee particles around the edge of the filter base and out of the capsule prior to and/or during use.

The filter base may be of any suitable geometry. For example, the filter base may be circular. Optionally, the filter base may be from 2.2 cm to 5 cm in

diameter. Preferably, the filter base may be of a suitable diameter to be heat-sealed to the base of the capsule at an interior surface of the rigid sidewall extending annularly across a portion of the base of the capsule. For example, the filter base may be between 2.2 and 2.5 cm.

Alternatively, larger filter bases made be used, for example filter bases having a diameter from about 3 cm to about 4 cm. This may negate the need to heat seal the filter base to the interior of the capsule, reducing the complexity and cost of capsule production.

The rigid sidewall may be formed by any known method and from any suitable biodegradable materials. Suitable materials may include paper fibres, plant fibres or a mixture thereof. In some embodiments the rigid biodegradable sidewall may comprise at least one of bamboo, paper pulp, or mixtures thereof.

Such materials may have good biodegradability and form a rigid sidewall having sufficient strength and robustness to withstand the beverage production process.

In some embodiments, the rigid biodegradable sidewall may comprise a different biodegradable material to the biodegradable top sealing portion and biodegradable filter base.

Optionally, the rigid biodegradable sidewall may be formed by a moulding process using elevated pressures. For example, the main body may be formed by soaking a raw material, such as paper fibres, plant fibres or a mixture thereof, in water, or any suitable fluid, to form a pulp. The pulp may then be piped into a mould, which may be heated. Optionally, the mould may be the adapter discussed in the first aspect of the invention. Alternatively, the mould may be a separate unit having the same or similar interior geometry as the adapter. The mould may further comprise an internal mesh screen. A force of from about 10 to about 40 tonnes, preferably about 25 tonnes, may be applied to remove water and/or any alternative fluid to cast the rigid biodegradable sidewall. Optionally the water and/or alternative fluid may be recycled for further

use. Optionally, the rigid biodegradable sidewall may be heated from about 1 minute to about 3 minutes, preferably about 2 minutes.

Optionally, multiple sidewalls may be cast in a single sheet. In such cases, the rigid biodegradable sidewalls may be die cast from the main sheet once cooled.

Optionally, the biodegradable top sealing portion may comprise filter paper. Alternatively, or in addition, the biodegradable filter base may comprise filter paper. In some embodiments, both the biodegradable top sealing portion and the biodegradable filter base may comprise filter paper.

Such materials are known to be fully biodegradable and compostable. Furthermore, it has surprisingly been found that such materials may be used to produce the biodegradable capsule according to the first aspect of the invention, wherein the resultant biodegradable capsule can be formed in a sufficiently large size to contain a sufficient amount of ground coffee to produce a double espresso while also being capable of withstanding the harsh conditions associated with brewing, without leading to rupture of the capsule during use.

The capsule is configured to be capable of containing a sufficient quantity of ground coffee to produce a double espresso. Traditionally, a double espresso produced by a fully trained barista using a traditional espresso maker uses between 12 to 20 g of ground coffee, for example about 14 g of ground coffee. Accordingly, in some embodiments the capsule is configured to house from 12 to 20 g of ground coffee. Preferably, the capsule may be configured to house from 12 to 16 g of ground coffee. Particularly, preferably the capsule may be configured to house from 13 to 15 g of ground coffee. For example, the capsule may be configured to house about 14 g of ground coffee.

The provision of a capsule capable of containing a sufficient quantity of ground coffee to produce a double espresso, i.e. configured to house from 12 to 16 g, preferably about 14 g, of ground coffee, enables the capsule to be used to produce a double espresso, or double espresso-based coffee beverage, of

comparable flavour and aroma to a traditionally produced barista-made double espresso, or double espresso-based coffee beverage, without the need of a fully trained barista.

In order to produce a double espresso, or double espresso-based coffee beverage, of comparable flavour and aroma to a traditionally produced barista-made double espresso, or double espresso-based coffee beverage, without the need of a fully trained barista, the capsule may be configured to withstand an applied force suitable for tamping the ground coffee to achieve a density from about 0.25 g/cm^3 to about 0.55 g/cm^3, without deformation or damage. Suitable forces may be from about 10 to about 30 pounds per square inch.

Such capsules may be capable of withstanding the pressures associated with tamping of the coffee within the capsule.

In some embodiments a biodegradable capsule is provided, wherein the capsule comprises from 12 to 16 g of ground coffee. In preferred embodiments, a biodegradable capsule is provided, wherein the capsule comprises about 14 g of ground coffee.

A biodegradable capsule comprising such an amount of ground coffee may be capable of producing a double espresso, or double espresso-based coffee beverage, of comparable flavour and aroma to a traditionally produced barista-made double espresso, or double espresso-based coffee beverage, without the need of a fully trained barista.

In some embodiments a biodegradable capsule is provided, wherein the capsule comprises from 12 to 16 g of ground coffee, wherein the ground coffee is tamped. In preferred embodiments the ground coffee is tamped at a pressure suitable to achieve a density from about 0.25 g/cm^3 to about 0.55 g/cm^3. Preferably, the ground coffee is tamped at a pressure suitable to achieve a density from about 0.35 g/cm^3 to about 0.45 g/cm^3. For example, the ground coffee may be tamped at a pressure suitable to achieve a ground coffee density of about 0.4 g/cm^3. Ground coffee tamped at such a pressure may enable the

capsule to produce a double espresso, or double espresso-based coffee beverage, of comparable flavour and aroma to a traditionally produced barista-made double espresso, or double espresso-based coffee beverage, without the need of a fully trained barista.

According to some embodiments the capsule may be provided in an individually sealed airtight pouch.

The provision of such biodegradable capsules ensures that a reproducible and optimal coffee beverage may be produced without necessitating the need for a skilled barista.

In particular, each capsule provides a set amount of accurately ground coffee. Consequently, where multiple capsules are used to produce multiple coffee beverages, each beverage is produced from an identical mass of coffee, negating the need for accurate weighing by a trained barista.

The coffee housed within each capsule is pre-ground to an optimised level of fineness which may depend on the coffee bean type and age. The provision of pre-ground coffee negates the need for a trained barista to determine an optimal level of fineness, and additionally negates the need for a trained barista to reproducibly grind the coffee to said optimal fineness. Since this process otherwise requires a high degree of skill, even where a trained barista performs the grinding process, the provision of capsules of the present invention may be utilised to provide more reproducible coffee beverages. Capsules of the present invention also provides evenly and accurately tamped coffee enabling optimal and reproducible coffee beverages to be produced without the need for a skilled barista to correctly tamp ground coffee prior to each coffee beverage production.

Since the capsule may be pre-produced as a single unit comprising a pre-weighed, ground and tamped coffee product, the capsule may also be quickly inserted into a portafilter unit. This may reduce the time in which the portafilter unit must be removed from the espresso machine, resulting in better

temperature regulation which may otherwise lead to the production of inferior coffee beverages.

The provision of a biodegradable capsule in an individually sealed airtight pouch may prevent the degradation of the ground coffee housed within the capsule due to air and/or moisture exposure. Consequently, the provision of such a biodegradable capsule, housed in an airtight pouch may enable the biodegradable capsule to have an extended shelf-life. Shelf-lives of such biodegradable capsules may be in excess of 2 weeks, 2 months, 6 months or 1 year. This negates the need for a trained barista to freshly grind coffee prior to each beverage production.

Detailed description

Features of some preferred embodiments of the present invention are described with reference to the following non-limiting figures. The different features illustrated and described with reference to the single configurations can be combined as desired.

Figure 1 depicts an exterior side view of a biodegradable capsule according to an embodiment of the present invention.

Figure 2 depicts a top view of the biodegradable capsule of Figure 1.

Figure 3 depicts a bottom view of the biodegradable capsule of Figure 1.

Figure 4 depicts a cross-sectional view of the biodegradable capsule of Figure 1.

Figure 5 depicts a capsule according to an embodiment of the present invention mounted in an adapter of a portafilter unit.

Figure 6 depicts a schematic of an adapter for use with a capsule according to the present invention, as part of a portafilter unit.

Figure 7 depicts a portafilter unit and adapter for use with a capsule according to the present invention.

Figure 8 depicts a variety of biodegradable capsules after six weeks degradation as set out in Example 1 for participant E.

As depicted in Figure 1, a biodegradable capsule 1 according to an embodiment of the present invention comprises a rigid biodegradable sidewall 2 having a generally frusto-conical geometry, a biodegradable top sealing portion 3, and a biodegradable filter base 4.

The rigid biodegradable sidewall 2 includes a step portion 5 configured to aid in correct positioning of the biodegradable capsule in an adapter, as depicted in Figure 5. While the step portion is depicted as existing about the entire circumference of the capsule, it shall be understood that alternative embodiments may include either no step portion, or one or more stepped portions each extending over a portion of the circumference of the biodegradable capsule.

The presence of the step portion provides an airspace which may enhance or aid créma formation during beverage production.

The rigid biodegradable sidewall extends outwardly from the top of the capsule to form a peripheral flange 6. The peripheral flange may be at least 3 mm wide and may extend about the entire circumference of the biodegradable capsule.

As depicted in Figure 2, a heat seal 7 is formed between the opposing faces of the peripheral flange 6 of the rigid biodegradable sidewall 2 and the biodegradable top sealing portion 3. The annular seal exists over a sufficient surface area relative to the area of the biodegradable top sealing portion 3, in order to prevent the sealing portion from becoming detached from the biodegradable capsule during beverage production. Furthermore, the annular seal is of sufficient surface area to maintain a suitable tension across the sealing portion during beverage production to prevent failure or rupture of the sealing portion.

As depicted in Figure 3, the rigid biodegradable sidewall 2 also forms an annular extension 8 over a portion of the filter base 4. The annular extension 8 may support the filter base 4, preventing it from becoming dislodged from the rigid biodegradable sidewall 2 during beverage production and/or removal of the capsule from the adapter after use.

As depicted in Figure 4, the ground coffee 9 may fill substantially the entire void between the top filter portion 3 and filter base 4. The filter base 4 is heat sealed 10 between a portion of the rigid sidewall which extends annularly over a portion of the base and the filter base to prevent egress of the coffee grinds during capsule use.

In use, the biodegradable capsule 1 is mounted in the portafilter adapter 11, as depicted in Figure 5. The top of the capsule 1 is lower than the top of the adapter 11, enabling the sidewalls of the capsule to be supported by the adapter. As a result, the biodegradable sidewalls of the capsule may be able to withstand the high temperatures and pressures associated with beverage production. Alternatively, the top of the capsule may be substantially flush with the top of the adapter.

As depicted in Figure 6, the adapter 11 comprises a support ring 12 configured to support the flange of the biodegradable capsule 1 when mounted therein. The provision of such a ring enables the adapter to have a large opening allowing for quick and easy capsule insertion, while also aiding in centring the capsule in the optimal position to ensure an even showering of water across the top of the tamped coffee during use. Additionally, the support ring may prevent the base of the biodegradable capsule from contacting the base of the adapter. As a result, and air gap may exist between the filter base of the capsule and the adapter base. The percolation of a coffee beverage through such an air gap may result in an aerated beverage having an optimal créma.

It will be understood that alternatively, the base of the capsule may rest upon the interior base of the adapter when the capsule is mounted therein.

The adapter 11 further comprises a convex annular ring 13 extending into the centre of the adapter cavity 14 into which a biodegradable capsule may be mounted. The convex annular ring aids in capsule positioning and retention of the capsule position during loading of the mounted capsule in an espresso machine. Additionally, after use, the convex annular ring 13 disrupts the surface interactions between the wet interior sidewalls of the adapter and wet biodegradable capsule sidewall 2 aiding in capsule removal.

Prior to use, the adapter 11 is mounted in a portafilter unit 15 which includes a handle and open basket, as depicted in Figure 7. It will be understood that alternatively, the adapter may be integrally formed with the portafilter handle and basket. The mounted biodegradable capsule is therefore able to be used with a conventional espresso maker.

During use, high temperature and/or pressure water and/or steam may be supplied from the espresso maker to the top sealing portion of the biodegradable capsule 1, passing through the top sealing portion 3 and entering the biodegradable capsule.

Inside the capsule, the water and/or steam comes into contact with the tamped, ground coffee 9 and causes an increase in the internal pressure of the capsule. A combination of this pressure and gravity is used to drive the fluid through the ground coffee at an appropriate flow rate in order to achieve an optimal brew prior to exiting the biodegradable capsule through the biodegradable filter base 4 to produce a double espresso. The double espresso may optionally be combined with additional components, such as water, milk, cream, cocoa and the like to form other coffee based beverages.

After use the portafilter unit 15 may be removed from the espresso maker and the capsule removed from the adapter 11. This may optionally be achieved by grasping the peripheral flange 7 and pulling the capsule from the adapter. Alternatively, the provision of an inwardly extending annular ring 13 which reduces the hydrostatic forces and surface tension between the exterior surface of a wet capsule and the interior surface of the adapter enables the capsule to

be easily dislodged from the adapter 11 by shaking, tipping up-side down and/or tapping.

Once removed, the biodegradable capsule may be recycled and/or composted.

The foregoing description of various embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to limit the invention to the precise forms disclosed. Many modifications, variations and refinements will be apparent to practitioners skilled in the art. For example, embodiments of the device may be adapted to produce alternative beverages, multiple espressos and/or other coffee-based beverages.

Elements, characteristics or parts from one embodiment can be readily combined or substituted with one or more elements, characteristics or parts from other embodiments to form numerous additional embodiments within the scope of the invention. Hence, the scope of the present invention is not limited to the specifics of the described embodiments, but is instead limited solely by the appended claims.

Examples

Composting Trial

Compostability trials of various capsules were carried out over a a 3-month composting period followed by testing. Twelve participants were recruited to take part.. The participants were divided into three categories as follows: four with a 'normal' composting bin, four with a Hot Bin and four with a turning composting bin. Each participant was given a total of eight capsules, two of which were capsules according to the present invention, and two of each of three alternative commercially available third party capsules that are marketed as "eco-friendly", "biodegradable" or "compostable". Participants were also given a thermometer (unless they had a Hot Bin), instructions and a data recording sheet. The participants were not told which capsule were which.

The participants started the composting process and allowed it to run for three weeks, before the trial began to ensure that the necessary environment had been created within the bins. Once started, readings were taken from the surface and core of the material in the bin, on average two or three times per week.

In addition, towards the end of the trial, four participants were selected at random and asked to provide samples for the laboratory tests.

For the tests, approximately 0.8 g+/- 0.05g of each sample was weighed into tetraflouromethacrylate (TFM) vessels. A mixture of 2ml 70% analytical reagent grade nitric acid, 6ml 37% analytical reagent grade hydrochloric acid and 2ml type 1 ultrapure water was added to each tube to form the aqua regia digestion fluid (as described in Chen, M. and Q Ma, L. (1999) Comparison of three Aqua Regia digestion methods for twenty Florida soils. Soil Science Society of America Journal. 65 (2): 491-499). The samples were digested by microwave digestion in a CEM Mars 6 digestion unit using the digestion procedure outlined in Table 1.

Table 1: Breakdown of the microwave digestion temperature, power and heating

Stage	Temperature (°C)	Power (watts)	Duration (minutes)
1	Ramp to 120	1000	8
2	Hold at 120	1000	3
3	Ramp to 170	1500	10
4	Hold at 170	1500	3
5	Ramp to 180	1500	4
6	Hold at 180	1500	20
7	Cool	n/a	20

The digested samples were diluted to 50ml in volumetric flasks using Type 1 ultrapure water and after a period of settling for approximately 5 minutes, a subsample was decanted into 10ml polypropylene centrifuge tubes for analysis. Samples were analysed using a Thermo iCAP 6500 Duo View ICP-OES. A range of 30 samples randomly selected from a number of sampling sites were initially analysed with a 1mg kg^{-1} multi-element standard to determine the

elements of sufficient concentration to be successfully detected, and wavelengths free of interference from other elements. Of the usable elements determined, a range of four standards were made up around the concentrations found in the trial samples. The standards used were Fisher Assurance SPEX Certi Prep Standards at 1000mg kg^{-1} or 10,000 mg kg^{-1} made to volume with Type 1 ultrapure water.

Capsule Degradation Results

The results suggest two key issues impacted upon the degradation of the capsules, namely: (1) there was variation in the rate of decomposition of the coffee capsules (Fig. 8); and (2) the biodegradation was linked to the type of bin, as well as the capsule.

On average, capsules according to the present invention decomposed at a faster rate as compared to the other capsules (around 4 weeks). The other capsules degraded later or not at all. For example, Table 2 shows the comparison between the capsules of the present invention and the commercially available "eco-friendly" capsules in terms of the composition of the capsule. In all 12 cases, the capsules according to the present invention biodegraded within around four weeks.

For the first prior art "eco-friendly" capsules, there was complete or partial biodegradation in 3/12 cases (25%), within the specified three month time period. For the 2nd "eco-friendly" prior art capsule, degradation took place in 2/12 cases (16%). While the 3rd "eco-friendly" prior art capsule did not degrade, in 3/12 cases (25%), the capsules were empty.

Table 2: A comparison of the breakdown of by week of capsules according to the present invention versus other known capsules

Participant	Bin type	Capsules of the present invention (weeks until fully biodegraded)	Commercially available 1 (weeks until fully biodegraded)	Commercially available 2 (weeks until fully biodegraded)	Commercially available 3 (weeks until fully biodegraded)
A	Normal	5	Capsule empty	In tack	In tack
B	Hot Bin	4	Capsule empty	8	6
C	Normal	4	Capsule empty	In tack	In tack
D	Normal	4	In tack	In tack	In tack
E	Tumbler	4	In tack	In tack	In tack
F	Tumbler	6	In tack	10	In tack
G	Normal	6	In tack	In tack	In tack
H	Hot Bin	5	In tack	Only capsule top composted	7
I	Hot Bin	5	In tack	In tack	In tack
J	Tumbler	4	In tack	In tack	In tack
K	Tumbler	4	In tack	In tack	In tack
L	Hot Bin	4	In tack	In tack	In tack

From this data it is shown that capsules of the present invention were able to fully degrade within a period of 4-6 weeks. Conversely, the allegedly biodegradable capsules of the prior art were found were generally found to not fully degrade even within an extended 10 week period.

However, in addition to the type of capsule, degradation was also dependent on the type of composting bin utilised. For example, Tables 3 and 4 show the temperature regime for participant B, who had a Hot Bin and participant A who had a normal bin. As can be seen there was variation in temperature between the two. After two months, the Hot Bin was on average 41°C at the outer and 50°C at the core, while the normal composting bin was 17°C at the outer and 21°C at the core.

Table 3: The temperature regime for the bin for participant B

Week	Location of temperature reading	Day (started to fill bin Sunday 6th August)			Types of scraps included in the compost
		1 Sunday	2 Wednesday	3 Friday	
1	Outer	-	16c	24c	Organic uncooked kitchen waste, no meat fish or dairy. Green leaves, weeds, supplied bark chips, spent flowers.
	Core	-	16c	20c	
2	Outer	33c	45c	38c	Sunflower heads, leaves, more kitchen waste
	Core	20c	46c	52c	Coffee added 18/8
3	Outer	40c	32c	40c	Kitchen waste
	Core	60c	38c	40c	Leaves, stems, egg shells
4	Outer	28c	26c	30c	Nothing added
	Core	40c	39c	48c	Kitchen waste
5	Outer	44c	32c	28c	Cuttings
	Core	50c	48c	54c	
6	Outer	28c	39c	40c	Greenery, leaves
	Core	46c	60c	58c	
7	Outer	42c	60c	48c	Nothing added
	Core	Not taken	60c	54c	
8	Outer	46c	40c	38c	Pansy/viola flowers
	Core	58c	58c	58c	
9	Outer	32c			
	Core	56c			
10	Outer				
	Core				
11	Outer				
	Core				
12	Outer				
	Core				

Table 4: The temperature regime for participant A

Week	Location of temperature reading	Day			Types of scraps included in the compost
		1	2	3	Bean stalks, grass, weeds, plant matter, lettuce, food preparation scraps
1 14/8	Outer	32	26	30	Grass, maize leaves, potato tops
	Core	42	33	32	
2 21/8	Outer	29	25	29	Weeds, tree leaves/brash
	Core	32	25	32	
3 28/8	Outer	31	29		Tomato leaves, grass, egg cartons, weeds
	Core	34	32		
4 4/9	Outer	26	28	22	Weeds, peelings, pineapple, turned pile
	Core	33	29	29	
5 11/9	Outer	19	18		Dead beans, weeds, apples, peelings
	Core	27	29		
6 18/9	Outer	16	18		Maize leaves, egg boxes, potato stalks. Emptied the heap to find the capsules hence temps down
	Core	22	20		
7 25/9	Outer	17	16		Potato peelings and water, weeds, dead flowers, apples
	Core	22	20		
8 2/10	Outer	16	18	16	Peelings, maize leaves, egg boxes, weeds and soil, water
	Core	21	20	21	
9 9/10	Outer	18	16		Weeds, tomatoes, apples, old vegetables
	Core	20	18		
10 16/10	Outer	18	17	16	Weeds, potato peelings, apples, cardboard, grass
	Core	18	20	19	
11 23/10	Outer	16	14		Weeds, grass, apples, maize, leaves
	Core	18	16		
12 30/10	Outer	12	11		Peelings, cardboard, weeds/soil. Emptied the bin to find capsules, see picture.
	Core	14	14		
13 6/11	Outer				

Toxicity results

Table 5 shows the levels of various elements present after degradation of capsules of the present invention

Table 5: levels of elements in the four samples

Element	Sample 1 (µg/g)	Sample 2 (µg/g)	Sample 3 (µg/g)	Sample 4 (µg/g)
Cadmium (Cd)	1.1871	1.0336	3.2153	2.3589
Cobalt (Co)	3.4968	2.917	7.6348	8.2575
Chromium (Cr)	28.2748	18.4164	30.7486	39.4042
Copper (Cu)	14.213	41.7048	36.4143	13.5371
Nickel (Ni)	8.6297	8.979	17.9552	19.2338
Zinc (Zn)	107.124	237.2981	289.7899	88.4194

Cd, Cr, Cu, Ni, Zn are considered to be potentially toxic elements in soil conditioners/compost and as such are subject to upper limits as per PAS 100:2011 (WRAP (2014) Guidelines for the specification of quality compost for use in growing media. Available from http://www.wrap.org.uk/sites/files/wrap/Growing_Media_Specification.pdf [last accessed 01/03/18]). These metals tend to bioaccumulate within the body as they are not easily eliminated. The potentially toxic elements and targets and 8 upper limits are shown in Table 6. As can be seen, apart from the Cd levels for Samples 3 and 4, all of the elements in the trial were below the required thresholds.

Table 6: Potentially toxic elements (mg kg^{-1} dry matter) limit as per PAS 100:2011(Dean, JR. (2007). Bioavailability, bioaccessibility and mobility of environmental contaminants. Wiley.)

Parameter	Target	Upper limit
Cd	<0.5	1.5
Cr	<50	100
Cu	<50	200
Ni	<50	50
Zn	<150	400

The high values for Zn and Cu may have been as a result of the presence of leafy vegetables and pulses in the composting material. In addition, the high values relating to Cu could also be attributed to:

- Increased use of copper containing fungicides
- Increased proportion of copper pipes used in the supply of water and irrigation in vegetable production
- Increased use of copper as a food additive

Summary

In summary, there was variation in the rate at which the capsules biodegraded. However, this degradation was linked not only to the type capsule, but also to the type of bin used. The capsules of the present invention generally biodegraded at around one month. While there was also some degradation of commercially available "eco-friendly capsules" from 16% to 25%, this was dependent on utilising a temperature regime of around 58°C at the core and 41°C outside. Thus, in many household and commercial composting units, biodegradation of commercially available and prior art "eco friendly" capsules may not occur or may be incomplete.

Thus, the present invention provides a biodegradable capsule suitable for home composting. Furthermore, the levels of the selected toxic elements were generally all below the accepted threshold limit.

Claims

1. A biodegradable capsule configured for use in a portafilter unit and capable of holding a volume of ground coffee to produce a double espresso, wherein the capsule comprises a rigid biodegradable sidewall configured to fit an adapter for a portafilter unit, a biodegradable top sealing portion and a biodegradable filter base.

2. The biodegradable capsule of Claim 1, wherein the capsule has a height from the filter base to the top sealing portion of from 2.5 cm to 3.5 cm, an interior diameter at the top sealing portion from 4 cm to 6 cm, and an interior diameter at the base from 2.8 cm to 4 cm.

3. The biodegradable capsule according to Claim 1 or 2, wherein the main body of the capsule has a generally frusto-conical geometry having an interior diameter of about 4.3 cm at the widest point and about 3.1 cm at the narrowest point.

4. The biodegradable capsule according to any proceeding claim, wherein the capsule has an interior volume from about 22 cm^3 to 35 cm^3.

5. The biodegradable capsule according to any proceeding claim, wherein neither the biodegradable top sealing portion nor the filter base are pierced either before or during capsule use.

6. The biodegradable capsule according to any proceeding claim, wherein the capsule is configured to house from 12 to 20 g of tamped ground coffee.

7. The biodegradable capsule according to Claim 6, wherein the capsule is configured to house about 14 g of ground coffee.

8. The biodegradable capsule according to any proceeding claim, wherein the rigid biodegradable sidewall further comprises a peripheral flange extending outwardly about the top of the capsule.

9. The biodegradable capsule according to Claim 8, wherein the top sealing portion is heat sealed to the peripheral flange and the filter base is heat sealed to an interior surface of the rigid biodegradable sidewall.

10. The biodegradable capsule according to any proceeding claim, wherein the rigid biodegradable sidewall extends across a portion of the filter base.

11. The biodegradable capsule according to any proceeding claim, wherein the biodegradable top sealing portion and the biodegradable filter base each comprise filter paper.

12. The biodegradable capsule according to any proceeding claim, wherein the rigid biodegradable sidewall comprises at least one of bamboo, paper pulp, or mixtures thereof.

13. The biodegradable capsule according to any proceeding claim, wherein the rigid biodegradable sidewall is comprised of a different material to the top sealing portion and filter base.

14. The biodegradable capsule according to any proceeding claim, wherein the capsule comprises from 12 to 20 g of ground coffee.

15. The biodegradable capsule according to Claim 14, wherein the capsule comprises about 14 g of ground coffee.

16. The biodegradable capsule according to any one of Claims 14 or 15, wherein the ground coffee is tamped.

17. The biodegradable capsule according to Claim 16, wherein the ground coffee is tamped at a pressure suitable to achieve a density from about 0.25 g/cm^3 to about 0.55 g/cm^3.

18. The biodegradable capsule according to any proceeding claim, wherein the capsule is individually sealed in an airtight pouch.

19. A biodegradable or compostable capsule as substantially described herein with reference to the figures.

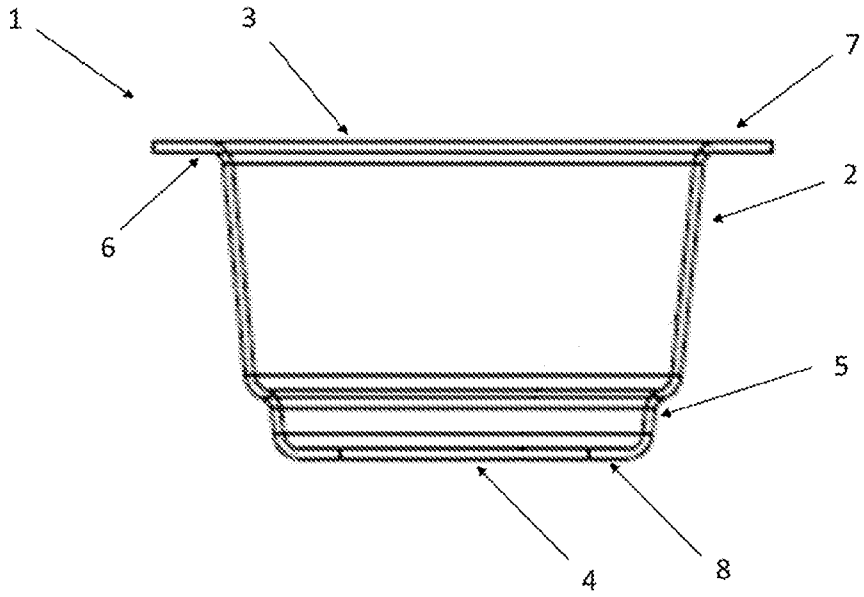


Figure 1

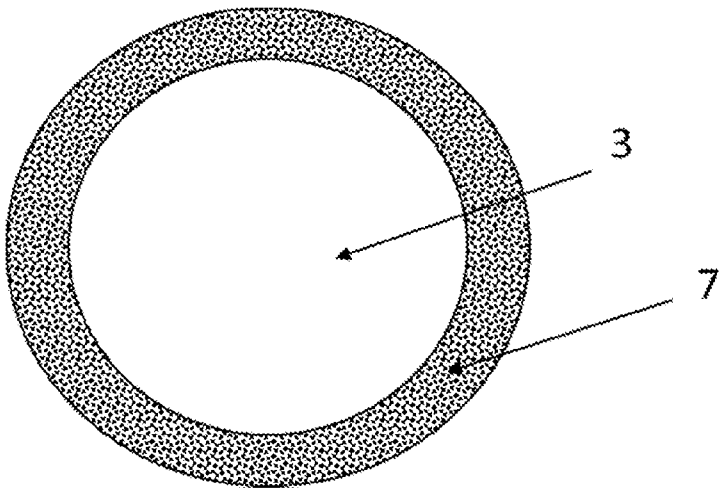


Figure 2

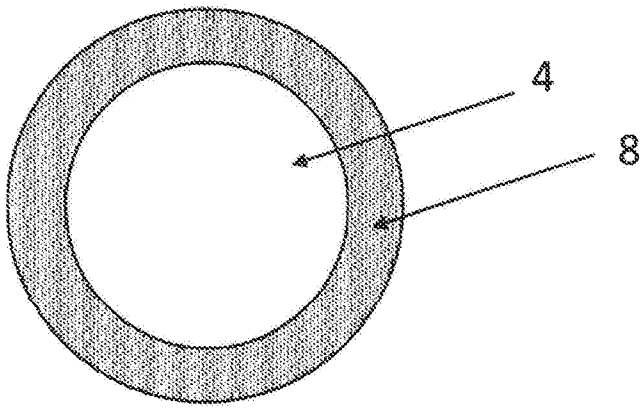


Figure 3

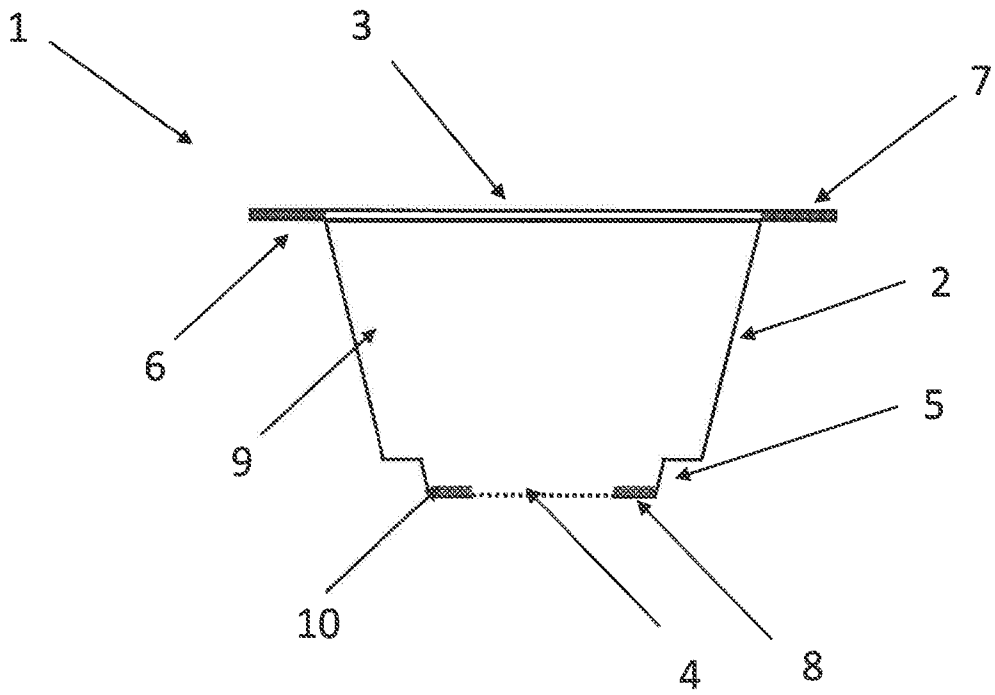


Figure 4

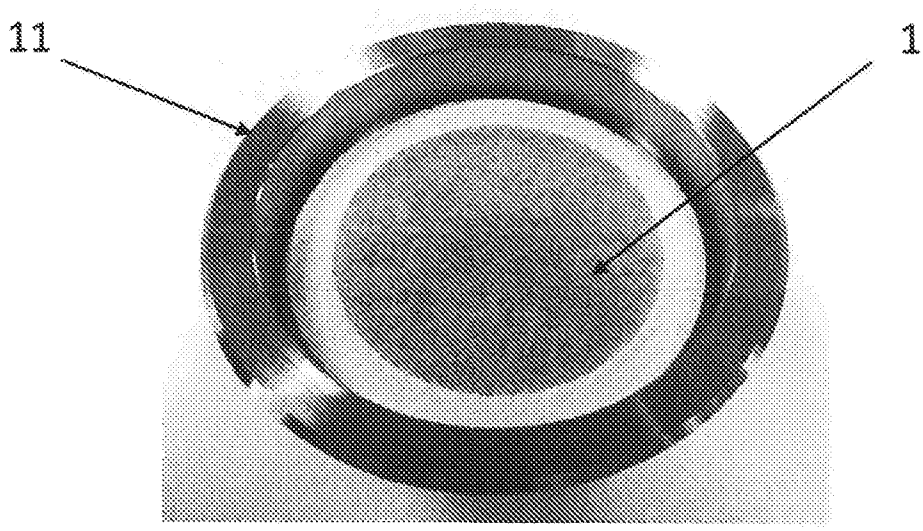


Figure 5

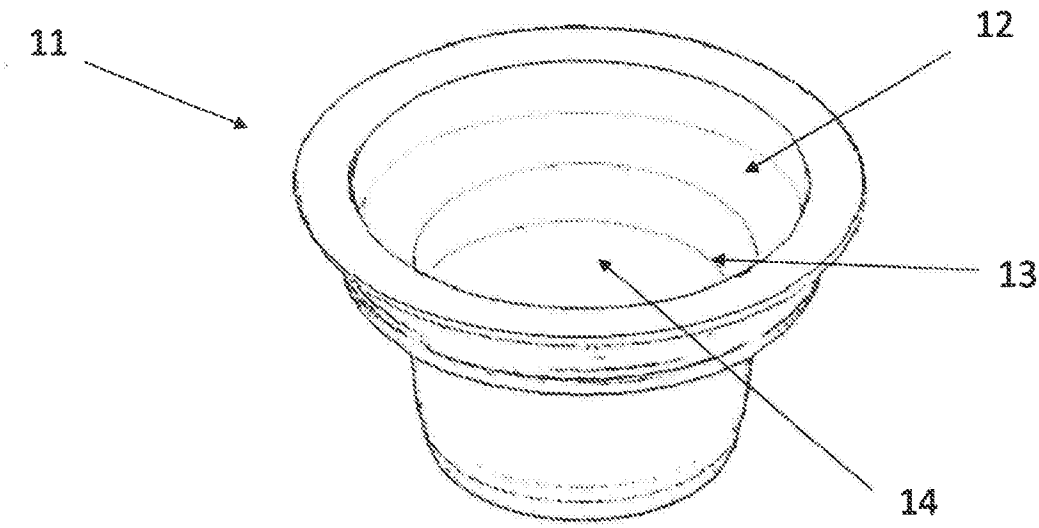


Figure 6

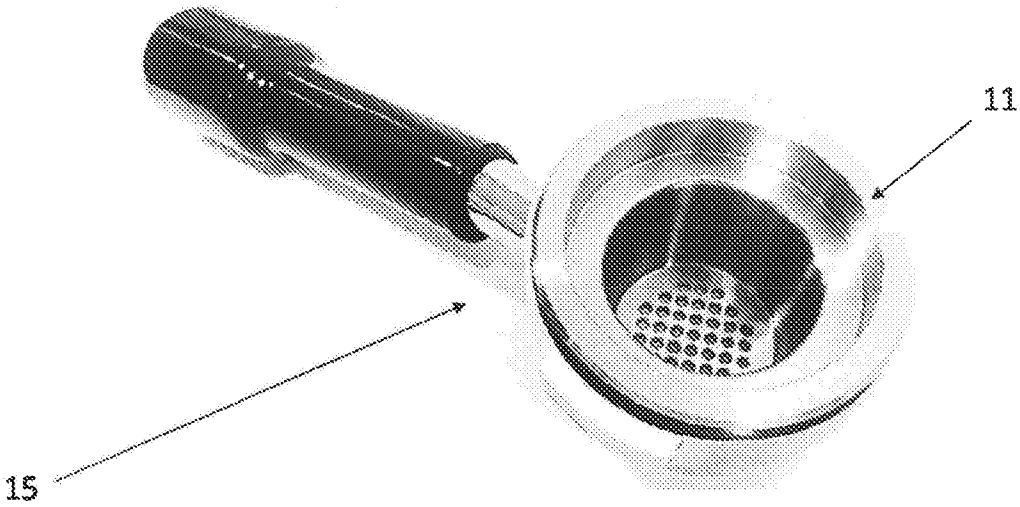


Figure 7

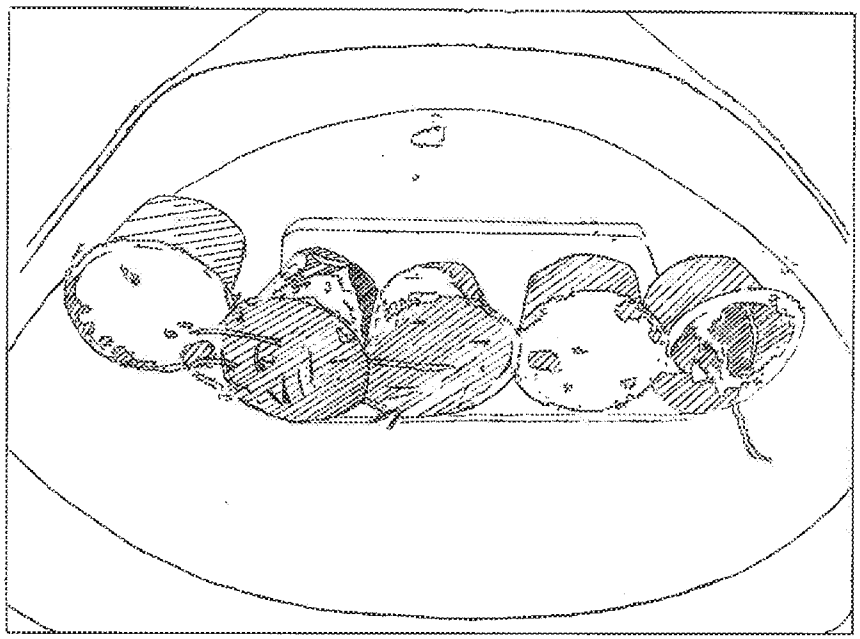


Figure 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2018/051979

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65D85/804
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B65D

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/158656 A1 (STARBUCKS CORP DBA STARBUCKS COFFEE CO [US]) 2 October 2014 (2014-10-02) paragraphs [0006] - [0118] figures 3A-7	1-19
X	WO 2016/020813 A (BRUN GIANCARLO [IT]) 11 February 2016 (2016-02-11) pages 1-20 figures 1-9	1-7, 10-19
X	CH 434 609 A (GAY ALPHONSE [CH]) 30 April 1967 (1967-04-30) column 1, line 1 - column 2, line 34 figures 1-3	1-19

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 September 2018	10/10/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Duc, Emmanuel

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2018/051979

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 522 260 A1 (ESPRESSOCAP S P A [IT]) 14 November 2012 (2012-11-14) paragraphs [0001] - [0026] figures 1A-4 -----	1-19
X	GB 2 542 272 A (FRANCESCO SPIGNESI [IT]) 15 March 2017 (2017-03-15) pages 1-4 figures 1-4 -----	1-8, 10-12, 14,15, 18,19

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2018/051979

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014158656 A1	02-10-2014	AR 095412 A1	14-10-2015
		AU 2014242043 A1	08-10-2015
		BR 112015022485 A2	18-07-2017
		CA 2904835 A1	02-10-2014
		CN 105283387 A	27-01-2016
		EP 2969776 A1	20-01-2016
		JP 2016519580 A	07-07-2016
		KR 20150127624 A	17-11-2015
		TW 201446198 A	16-12-2014
		US 2014272018 A1	18-09-2014
		US 2018072490 A1	15-03-2018
		WO 2014158656 A1	02-10-2014
WO 2016020813 A	11-02-2016	---	
CH 434609 A	30-04-1967	NONE	
EP 2522260 A1	14-11-2012	CN 102164832 A	24-08-2011
		CN 103948317 A	30-07-2014
		EP 2396251 A2	21-12-2011
		EP 2522260 A1	14-11-2012
		US 2011177205 A1	21-07-2011
		WO 2010091872 A2	19-08-2010
GB 2542272 A	15-03-2017	NONE	