Capsule, System and Method for Beverage Preparation

Abstract: To prepare a beverage, such as coffee, from a capsule having a piercing area (6) and at least one reinforced area (7, 7') different and distinct from the piercing area, and a brewing device comprising piercing means (40) and water injection means, the following steps are carried out: piercing said at least one piercing area (6) of the water inlet wall (3) by piercing means (40) of the brewing device to provide one or more water inlet apertures (6a) in said capsule inlet wall (3); deforming at least part of said at least one piercing area (6) of the water inlet wall (3) under the pressure exerted on said inlet wall (3) by the water injected by water injection means of said brewing device during the beverage preparation, whereby the piercing area (6) around said apertures (6a) is moved inwardly inside said hollow body (5) to free at least in part said apertures (6a) from said piercing means (40) and preferably at least part of the imparted deformation is retained by the piercing area (6) at the end of said brewing cycle.
"Capsule, system and method for beverage preparation"

The present invention relates to a capsule, a system and a method for beverage preparation.

In greater detail, the present invention relates to a capsule for preparing a beverage, such as coffee, from one or more products contained in a disposable capsule by means of a brewing machine, injecting hot pressurized water into the capsule to extract the product contained therein. The invention also relates to a system for beverage preparation comprising a capsule according to the invention and a brewing device for injecting the brewing liquid into the capsule and provided with piercing means intended to perforate the capsule, to provide at least one passage for the injection of the brewing liquid. The invention also relates to a beverage preparation method.

Background of the invention

Capsules for the preparation of beverages, containing for instance soluble, dehydrated, concentrated or freshly ground or minced foodstuffs have become quite popular in the last years, although they are known since the former half of the XX century. These capsules are usually made of soft, semi-rigid or rigid material such as paper, plastic laminates, aluminium, injected-plastics or co-injected-plastics. Recently capsules in thermo-injected or co-injected plastic material have gained popularity and been extensively used as they represent a clean and practical mean to prepare drinks.

Some capsules, such as the one disclosed in WO2010076048, are known to have two opposite walls, perpendicular with respect to the longitudinal axis of the capsules, one, so-called inlet wall, where during use the diluent (usually water) to prepare the drink is injected via appropriate inlet means, and one wall, including a flange, which acts as outlet wall, that is as the outlet for the prepared beverage. A lateral wall, with an essentially frusto-conical shape, connects the two opposite walls to form a closed chamber for the storage of the foodstuffs and the eventual preparation of the finished beverage, which can be obtained via different methods for instance via infusion, brewing or solubilisation of de-hydrated foodstuffs.

It is known to the skilled in the art that inlet and lateral walls may be continuously joined by a single radius and together with the outlet wall they may also be designed and assembled so that the capsules are completely sealed. In such case they may be made of a highly oxygen-impermeable barrier-material, such as aluminium, or EVOH, at times used in combination with other materials and utilising different technologies to allow
obtaining the desired shape. Alternatively they can be made of slightly oxygen-permeable material, allowing for gases and other fine molecules - depending upon the relative pressures with respect to the ambient external to the chamber - to either penetrate or leave the chamber and obtain a limited barrier effect against deterioration of the foodstuffs contained in the capsule.

In rather different embodiments, capsules that can be used with dispensing units compatible with said prior art may present holes on the surface of either or both inlet and outlet walls, which makes the chamber, delimited by the two opposite walls and by the lateral wall, in fact a "semi-opened" chamber. Semi-opened chambers preferably require the capsule to be wrapped in an additional, "secondary" packaging in order to ensure that the foodstuffs therein contained do not become oxidized or otherwise deteriorated by contact with agents such as air, moisture or become simply contaminated being in direct contact with the ambient and pollutants. In these capsules the presence of holes in either or both the inlet or outlet wall(s) is considered, by some known art, a desired feature, as it provides consistent control of the free passage and/or it prevents undesired erratic behavior of the capsule material that may occur during the opening of either the inlet means or outlet means or both.

With respect to the outlet wall, in the mentioned known art this is delimited by a circumferential flange usually but not necessarily made of the same material of the side and inlet walls. The material is properly selected to provide the desired mechanical properties associated with the operating pressures and temperatures used for the preparation of the finished product, the flange usually being designed with sealing means to provide water tight sealing during the drink preparation.

The present invention does not focus on said outlet wall and its associated sealing means, although it is useful to note that technologies currently available may suggest the use of tearable rigid lids, or pre-punched foils, or tearable foils, or suitable injected-disks with pre-arranged holes and several other technologies readily available to the skilled in the art - such as materials that dissolve upon contact with diluents - for letting the fluid flow through the outlet means. In other words in order to provide outlet means for the finished beverage the skilled in the art will be able to choose between a vast array of solutions which can be considered for the capsule described in this application. Suffice to say, for the purpose of this Application, that the preferred field of application uses a completely sealed water outlet wall, which may be opened by using the hydraulic pressure utilised for the product preparation process, or by tearing a weakened wall of a
rigid element or using other methods known to the skilled in the art.

The apparatus meant for use with the capsule object of this application will be of the type available to the skilled in the art, such as for instance WO20091 15474. Particularly it is designed to provide a water-tight, fluid connection between the hydraulic system directing the incoming fluid (usually water) and the chamber of the capsule, in order to allow for the preparation of the drink. The sealing means of the capsule are engaged by matching sealing means in the dispensing unit. Operating pressures will be in the usual range, between 1 and 20 bars.

In order to allow for the water to enter into the chamber via the inlet wall, in known machines piercing means are used (e.g. no. 28, fig. 2 in WO20091 15474). Such piercing means may for instance be produced using metal punching, or other technologies, such as thermo-injection of polymers. In general, these means are designed in the shape of blades with a slanted plane and acuminated points to provide an adequate interaction with the capsule.

The nature of such interaction, which may be not necessarily a tearing one, in fact differs accordingly to the technology deployed with respect to the technology chosen to ensure a fluid connection between the capsule's chamber and the water circuit of the dispensing apparatus.

EP2476633, for instance, discloses a capsule and a water inlet wall made from a thermoformed laminate where the blades are meant to pierce the inlet wall. This is a well-known interaction, for instance taught also in WO20091 15474.

Nevertheless, it is observed by the Applicant that - as the capsule in EP2476633 is made of thermo-formed laminated-plastic material - it may not create the required, consistent fluid connection result achieved by aluminium capsules and the capsules' behaviour is not predictable, resulting in very variable drink quality or even the possibility that no beverage is delivered at all. In fact severe crushing of the capsule may result when fluid connection is poor.

EP2452893 discloses yet another interface between piercing means and inlet wall, whereby the blades ("perforating means") do come in contact with the inlet wall of the capsule, which in this case is made of thermo-injected plastic material suitably equipped with pre-pierced holes. In this application, though, the pressure exerted upon the inlet wall by the blades is meant not to tear the inlet wall open, but to widen said pre-pierced inlet holes, in order to provide a supposedly improved free passage for the diluent.

GB2489409 teaches a capsule where the blades may engage the inlet wall and through
such engagement, albeit without creating inlet means for the diluent as these are conveniently pre-punched in said wall, may cooperate to deform a resiliently deformable section of the capsule.

The prior art embodiments provide inadequate interface between the piercing means and the capsule, by either requiring pre-pierced holes in the inlet wall, which in turn allow for oxygen to rapidly deteriorate the foodstuffs contained within the chamber, especially when ground roasted coffee is used, or suggesting the use of aluminium. In the case of plastic capsules where the inlet wall is pierced open by blades, the Applicant has found that the blades provide an obstacle for the water to penetrate inside the chamber, as they occupy the area of the plastic material which has been torn open and doing so they impede a correct preparation of the foodstuffs contained in the chamber.

A further problem of the known capsules is that of sealing the receptacle of the brewing machine against the capsule during the brewing cycle to avoid water leaking outside the machine. Sealing is difficult with capsules made in a single plastic material because of the high pressure used in the cycle for the brewing water.

It is therefore needed an improved capsule that can provide firstly a reliable, consistent hydraulic connection between the water-feeding means of the dispensing unit and the capsule chamber, so that the capsules deliver an improved quality of the finished product.

Secondly it is also needed a completely sealed capsule in which inlet means are created after inserting the capsule in the dispensing unit (brewing device) for drink preparation. This ensures maximum aroma retention, while - with respect to secondary packaging - it avoids the environmental cost and inconvenience associated to said packaging.

Thirdly, it is needed a capsule where predictable behavior is required during its opening, and product preparation cycle, in order to avoid unstable conditions and therefore allowing for a reliably constant quality of the finished drink.

An aim of the invention is to solve, or at least partially ameliorate, the above problems. A further aim of the invention is to provide a capsule bearing a surface shape and construction which may be adaptable to advanced co-injection technologies so that a barrier is built within its body against oxidants or substances that deteriorate the foodstuffs contained in the chamber, to provide for long-lasting quality of the contained foodstuffs.

Moreover, the improved capsule object of this invention is aimed at providing an extended range of piercing patterns to provide inlet means in a completely sealed
capsule, in order to maximise flexibility in the design of the dispensing appliance to be used for the preparation of the finished product and in the manipulation, during the production process, of the capsule itself.

The present application is, finally, also aimed at providing a system, composed by the improved capsule and a dispensing unit, that improves the extraction or solubilisation of the foodstuffs contained in the chamber and thus the quality of the finished products.

Summary of the invention

These and other aims are achieved by means of the capsule of the present invention, that is a capsule for the preparation of a beverage from a dose of a product, according to claim 1. Further objects of the invention are a system and a method for beverage preparation, respectively according to claims 18 and 24. Preferred embodiments are objects of the depending claims.

The capsule according to the invention comprises a lateral wall, a water inlet wall and an outlet wall forming a hollow closed body where a brewing product is contained. The water inlet wall comprises at least one piercing area that is pierceable by piercing means of a brewing device for providing one or more water inlet apertures on said capsule inlet wall to feed water under pressure inside the capsule in a brewing cycle, In use the at least one piercing area of the water inlet wall is suitable to be perforated by suitable piercing means provided on the beverage preparation device (i.e. a brewing device) in which the capsule is inserted.

Additionally, the water inlet wall comprises at least one reinforced area, and the at least one piercing area of the water inlet wall is distinct from the reinforced area, i.e. it is arranged outside said at least one reinforced area. The term "outside" is used herein to indicate that the piercing area is not part of the at least one reinforced area. The at least one piercing area is dimensioned and made in such a way that it can be plastically deformed during the beverage preparation at least in correspondence of the apertures made by the blades of the brewing machine. The piercing step usually results in some deformation of the pierced area, additional deformation by action of pressurized water occurs after the at least one piercing area has been perforated by said piercing means of the brewing device.

The expression "plastically deformed" or "plastic deformation" is used herein to indicate that the capsule undergoes a deformation of at least part of the at least one piercing area, during the beverage preparation process, whereby at least part of the imparted deformation is retained by the piercing area at the end of said brewing cycle.
In other words, the capsule shape is deformed if compared with the shape of the capsule when it is inserted into the brewing device and at least part of this deformation is retained by the capsule at the end of the brewing cycle.

Advantageously, the presence of at least one reinforced area and at least one piercing area arranged on the water inlet wall, outside said reinforcing area of the water inlet wall, allows to obtain areas of the inlet wall that undergoes different deformations during the beverage preparation process.

In fact, the at least one piercing area of the water inlet wall may be made more flexible and deformable than the other portions of the water inlet wall, and in particular with respect to the reinforced area having an increased rigidity.

By doing so, in use the piercing area of the water inlet wall can be effectively pierced by the piercing means of the beverage brewing device that are brought in contact with the water inlet wall, and in particular with the at least one piercing area of the capsule water inlet wall.

Additionally, a piercing area including at least one aperture made by the blades is advantageously at least in part plastically deformed, by being moved inwardly into the capsule's hollow body, after the piercing area has been pierced by the piercing means of the brewing device. By doing so, at least the portion of the inlet wall where the aperture is located will move with respect to the piercing blade, the area of the aperture free from the blade will increase and the flow rate of water injected into the capsule's hollow body can be increased, too, so as to obtain a complete and effective infusion of the dose of product contained in the capsule.

In fact, according to an aspect of the present invention the at least one aperture present in the piercing area of the water inlet wall, after the piercing area has been deformed, may no longer be in contact with the piercing means of the brewing device. If one or more piercing means are provided, at least one of them may not be in full contact with the piercing area of the capsule after its plastic deformation. Therefore, the water flow injected into the capsule can be increased thanks to the increased space provided between the at least one piercing means and the corresponding aperture in the piercing area of the capsule after its deformation. In other words, after the capsule inlet wall has been deformed, the piercing means of the brewing device do not obstruct or limit the water flow passage into the one or more apertures located onto the at least one piercing area.

According to an aspect of the present invention, at least part of the at least one piercing
area is plastically deformed by a movement of at least 50%, preferably up to 150%, of the penetration depth of said piercing means of the brewing device in the water inlet wall of the capsule. By doing so, an increased water passage between the water inlet wall and at least one of the piercing means can be obtained. The expression "penetration depth" is herein used to indicate the relative displacement of the piercing means from first contact between the piercing means and the capsules outer surface (i.e. the outer surface of the water inlet wall). In other words, the length of the penetration depth corresponds to the distance covered by the piercing means from the position of first contact with the outer surface of the capsule to their final position, reached at the end of the piercing step.

According to an aspect of the present invention, the at least one piercing area is at least in part plastically deformed under the pressure exerted on said inlet wall by the water injected into the capsule. As known in the art, the water, or other brewing liquid, is provided by injection means of the brewing device. Preferably, the water pressure is comprised in the range 2 bar - 6 bar, most preferably 2 to 4 bar, i.e. the capsule inlet is deformed at pressure that can be as low as 2 - 6 bar, preferably 2 - 4 bar. Moreover, the plastic deformation of the at least one piercing area occurs between the pressure build-up inside the hollow body of the capsule and the first outlet of the prepared beverage from the outlet wall. In fact, during the beverage preparation process, after the capsule piercing area is perforated by the brewing device piercing means, the water is injected into the hollow body of the capsule by means of one or more apertures obtained on the piercing area in order to build up pressure inside the capsule to obtain an effective infusion of product contained therein.

The plastic deformation of the inlet wall of the capsule, allows to obtain at least two separate pressure build-up stages of the injected water. A first build up of the pressure is obtained after the at least one piercing area of the capsule is perforated by the piercing means of the brewing device and the water is injected into the capsule. The pressure increases until at least part of the at least one piercing area is deformed, thus allowing an increased passage of the water flow inside the capsule. The second pressure build up is obtained by injecting the water into the capsule through the deformed inlet wall until the product contained into the capsule hollow body is infused and the pressure inside the capsule causes the opening of the capsule outlet wall.

According to an aspect of the present invention, at least one boundary line is defined between at least one reinforced area and at least one piercing area of the water inlet wall. In other words, the at least one boundary line substantially separates the area of the
capsule inlet wall that is not deformed (at least part of the reinforced area) and the area of the inlet wall that is deformed (at least part of the piercing area).

It has to be noted that the at least one piercing area and the at least one reinforced area can be arranged in different positions on the capsule inlet wall, according to different possible embodiments.

According to an aspect of the present invention, the at least one piercing area and the at least one reinforced area are arranged along an alternate pattern (or path) on the water inlet wall. Preferably, said at least one reinforced area and said at least one piercing area are alternating along a radial direction extending from the lateral wall of the capsule, and in particular its peripheral edge, towards a central axis of the capsule hollow body.

In one embodiment, the at least one reinforced area and the at least one piercing area are both arranged along an annular path. However, according to different possible embodiments reinforced area and/or piercing area can be arranged on circular path, i.e. the area corresponds to a circular surface of the capsule inlet wall.

According to preferred embodiments, the capsule comprises at least one peripheral reinforced area, substantially arranged on the capsule inlet wall portion next to the lateral wall. According to different possible embodiments the capsule comprises a central reinforced area substantially arranged on the top portion of the water inlet wall.

The at least one peripheral reinforced area and the at least one central reinforced area can be provided either together or separately on the capsule inlet wall. In fact, according to an exemplary embodiment, the capsule inlet wall can be provided with a peripheral reinforced area and a piercing area extending outside said reinforced area substantially in correspondence of the top portion of the capsule inlet wall. On the contrary, according to a possible embodiment the capsule inlet wall can be provided with a central reinforced area and at least one piercing area can be provided on the inlet wall portion between said central reinforced area and the lateral wall.

In a preferred embodiment at least one peripheral reinforced area and at least one central reinforced area can be provided together on the capsule inlet wall, the piercing area extending between them. According to this preferred embodiment the least one piercing area is extending continuously or discontinuously along a substantially annular area of the water inlet wall between said two reinforced areas.

Advantageously, this configuration allows to obtain an effective perforation of the piercing area and also an effective plastic deformation of at least part of the piercing area. The different behavior of the different areas to water pressure will result in a
deformation occurring preferably in the piercing area, at least at the pierced apertures.

According to an aspect of the present invention, the least one reinforced area comprises reinforcing means and/or it comprises at least a part having an increased thickness with respect to the thickness of said at least one piercing area of the water inlet wall.

Eventually, an increased thickness of the reinforced area with respect to the piercing area can be used also in combination with reinforcing means, such as ribs, intended to define at least one reinforced area.

In any case, the presence of reinforcing means and/or of an increased thickness of the inlet wall in at least one reinforced area allows to increase the rigidity of the area compared with the at least one piercing area of the inlet wall arranged outside said at least one piercing area. Therefore the at least one piercing area can be deformed during the beverage preparation process; deformation is at least in part a plastic deformation that can be seen in the capsule after it has been used in a brewing cycle. The final deformation is different from deformation resulting by the mere piercing step.

According to a possible embodiment, the reinforcing means defining at least one reinforced area extend also at least partially on said lateral wall of the capsule.

Said reinforcing means intended to define at least one reinforced area of the water inlet wall can be produced in different forms according to different possible embodiments. In fact, according to an aspect of the invention, reinforcing means comprises one or more ridges, or ribs, protruding from the water inlet wall surface (either the internal or the external surface of the inlet wall, or from both inlet wall surfaces). The reinforcing means in the form of ribs can be arranged circumferentially and/or radially on said water inlet wall.

The term "rib" is herein used to indicate a narrow ridge or similar protrusion arranged on a wall of the capsule. Moreover, the term "radially" and "circumferentially" are respectively used to indicate that one or more ribs extend along a substantially radial direction with respect to the central axis of the capsule, and along a circumferential line with respect to the central axis of the capsule.

According to possible embodiments, the reinforcing means defining at least one reinforced area comprise at least one recess portion that are either completely contained within the inlet wall or extending on both said lateral wall and said water inlet wall.

It has to be understood that recess portions comprise at least one surface so as to provide a kind of "corrugation" with continuity in the inlet wall of the capsule. In designing, the recess portion can be seen as the "removal" of a portion of volume of the capsule in the
water inlet/lateral wall; thus, the surface of the inlet wall is modified and "sinks" below its original level to rise again to the original level and shape.

In a preferred exemplary embodiment, the number of recess portions, or recesses, is selected from prime numbers, preferably their number is selected from 5, 7, 11 or 13. This was found to be advantageous especially in a system where the number of blades or perforating elements in the brewing device is 3 or otherwise an odd number.

Further details on this type of capsule can be found in co-pending application PCT/IB2012/002408. In an embodiment, the recess portions of the capsule comprise at least one surface that lies on a plane or that contains at least one axis maintaining a constant angle of inclination (α) with respect to said central axis of the capsule or with respect to a vertical axis parallel to the central axis. Moreover, the at least one surface, or axis, extends between the closest and the farthest end parts of the recess portion with respect to said central axis of the capsule. It has to be noted that preferably the inclination of the at least one surface of the recess portion is measured by means of the corresponding inclination of the plane or the axis (straight line) directed towards and/or intersecting the central axis of the capsule, or a vertical axis parallel to the central axis of the capsule. This means that in at least one position, preferably in a plurality of positions, a portion of the water inlet wall is missing and that in those positions the wall is replaced by at least one surface that is defining a "recess portion", i.e. a "sunken portion", of the body of the capsule; the wording "recess" is used with reference to the level of the wall in the rest of the body of the capsule.

According to a preferred embodiment, the at least one surface of the recess portion that maintains a constant inclination angle with respect to the central axis of the capsule, or a vertical axis, is the bottom surface of the recess portion.

In other words, each recess portion comprises at least one surface, preferably "oblique", i.e. inclined, forming an additional surface, preferably a bottom surface of the recess portion that is angled with respect to a vertical axis (i.e. the central axis of the capsule or an axis parallel to it) with a constant inclination.

The surface or the axis is angled with respect to central axis of the capsule or with respect to a vertical axis parallel to said central axis forming preferably an acute angle α with the vertical, i.e. with respect to a direction parallel to the central axis A of the capsule, or (which is the same) with the central axis of the capsule. Preferably the angle α, as defined above, is comprised in the range 10° - 75°, preferably 25°- 60°, most preferably about 35°- 50°.
According to a further aspect of the present invention, at least the lateral wall and the water inlet wall are made in one piece, and preferably they are made of the same material, preferably in plastic material. Different production processes can be used to obtain a simple and economic mass production of the capsule. According to a possible embodiment, at least the water inlet wall and the lateral wall are made by injected or co-injected plastic material.

Experimental tests carried out by the Applicant show that using a plastic material having the below reported thermal and mechanical properties allows to obtain both an effective perforation of the at least one piercing area of the capsule inlet wall and a plastic deformation of at least part of the piercing area by water pressure during the beverage preparation process.

Suitable plastic materials are PP and PE, preferably HDPE provided with a density comprised in the range 850 - 1050 kg/m³, preferably 0.951 kg/m³, (measured according to ISO 1872), a melt flow rate comprised in the range 9 - 13 g/10min, preferably 11 g/10min, (MFR measured according to ISO 1133), tensile stress comprised in the range 23 - 29 MPa, preferably 26 MPa, (measured according to ISO 527-2/1B). A preferred material shows all the above preferred values.

A suitable material has a Charpy Notched Impact strength (at 23°C) in the range of 3.1 to 3.9 kJ/m², preferably 3.5 kJ/m² (measured according to ISO 179). A preferred material shows all the above preferred values and the cited Charpy.

Additionally, Vicat softening point is preferably comprised in the range 50 - 80, preferably 55 - 75, and most preferably 60 - 70 (measured according to ISO 306(B50 method). When measured with standard ASTM D1525 B50 Vicat softening point is preferably comprised in the range 50 - 60, preferably 54 - 58, and most preferably 56.

Melting point (second heating) is preferably comprised in the range of 115 - 145 °C, preferably 131°C (measured according to ASTM D21 17). Suitable material has shore D-hardness comprised in the range 55 - 66, preferably 60 (ASTM D2240).

A suitable plastic material for the capsule production is the one sold as Rigidex® HD521 IEA commercialized by INEOS.

The present invention also relates to a system for preparing a beverage comprising a capsule of the type disclosed above, and a brewing device comprising piercing means for piercing (perforating) said at least one piercing area of the capsule water inlet wall, and injection means to inject water under pressure inside said capsule hollow body, through one or more water inlet apertures realized in the capsule inlet wall by said piercing
means. Advantageously, the least one piercing area of the water inlet wall is at least in part plastically deformed during the beverage preparation.

According to an aspect of the present invention, at least part of the deformed piercing area may not be in contact with at least one piercing means, therefore the apertures provided by the piercing means are not obstructed so that the water flow inside the capsule hollow body can be increased.

Additional aspects of the beverage preparation system are disclosed in the dependent claims. The present invention also relates to a method for preparing a beverage from a capsule of the type disclosed above, and a brewing device comprising piercing means and water injection means according to claim 24.

The method comprises the steps of:
- piercing at least part of said at least one piercing area of the water inlet wall by piercing means of the brewing device to provide one or more water inlet apertures in said capsule inlet wall;
- plastically deforming at least part of said at least one piercing area of the water inlet wall during the beverage preparation under the pressure exerted on it by the water injected by water injection means of said brewing device during the beverage preparation, whereby at least part of the imparted deformation is retained by the piercing area at the end of said brewing cycle.

Additional aspects of the method according to the present invention are disclosed in the dependent claims 25 - 31.

In another aspect, the invention relates to a method for preparing a beverage from a capsule according to the above embodiment, and a brewing device comprising piercing means and water injection means, the method comprising the steps of piercing said at least one piercing area of the water inlet wall by piercing means of the brewing device to provide one or more water inlet apertures in said capsule inlet wall and further comprising the step of deforming at least part of said at least one piercing area of the water inlet wall under the pressure exerted by a pressure element on said inlet wall, whereby the piercing area around said apertures is moved inwardly inside said hollow body to free at least in part said apertures from said piercing means. Preferably at least part of the imparted deformation is retained by the piercing area at the end of said brewing cycle. In this aspect of the invention the pressure is preferably applied mechanically, e.g. by a pressure member movable with the blades, or other piercing means, or relative to the blades, to compress a portion of the inlet wall, e.g. the central
reinforced area or an area close to the blades, and so as to move inwards at least part of
the piercing area and obtain the required degree of freedom of the apertures from the
blades or other piercing means.

A capsule suitable for this method is a capsule corresponding to the one above discussed
for water deformation, wherein at least part of said at least one piercing area of the inlet
wall is deformable under the pressure exerted by a pressure element on said inlet wall,
whereby the piercing area around said apertures is moved inwardly inside said hollow
body to free at least in part said apertures from said piercing means. It is therefore a
further object of the invention a brewing machine as well as a system including a
brewing machine, said machine including a receptacle for housing a capsule and piercing
means, said machine further comprising a pressure element suitable to come into contact
with at least part of the inlet wall to deform it whereby the piercing area around said
apertures is moved inwardly inside said hollow body to free at least in part said apertures
from said piercing means.

Advantageously, as already mentioned above, the plastic deformation of at least a
portion of the capsule piercing area, that includes the apertures made by the piercing
means, allow to increase the water flow passage inside the capsule. In fact, after the inlet
wall deformation, piercing means of the brewing device are no longer an obstruction of
the one or more water apertures realized on the inlet wall due to its perforation.

This results in a shorter brewing cycle and in an increased efficacy of the brewing, as
visible by testing the amount of extracts. Moreover, the pressure of the brewing step
using a capsule according to the invention can be reduced with respect to traditional
capsules with resulting advantages also in the sealing of the receptacle of the system
against the capsule.

In fact, a reduced brewing pressure also allows to use simpler sealing means that do not
need to withstand high pressure values that are currently used in the brewing device,
without incurring in leaks of injected water outside the receptacle housing the capsule. It
is particularly surprising that the above results are obtained with materials different from
the aluminium traditionally used and up to now providing some of the best results in a
brewing cycle.

**Brief Description of the Drawings**

Further advantages and features of the present invention will be more apparent from the
description below, provided with reference to the accompanying drawings, purely by
way of non-limiting examples, wherein:
- Figure 1 is a perspective view of a possible embodiment of the capsule according to the present invention comprising at least one reinforced area having recesses extending on both inlet and lateral walls;
- Figure 2 is a radial sectional view from a plane passing through the central axis of the capsule of Figure 1;
- Figure 3 shows from below the inside portion of capsule hollow body according to Figures 1 and 2;
- Figure 4 is a perspective view of another embodiment of the capsule according to the present invention comprising at least one reinforced area having recess extending on both inlet and lateral walls;
- Figures 5 and 5a show two possible embodiments of the capsule according to the present invention;
- Figure 6 is a perspective view of another possible embodiment of the capsule according to the present invention comprising one reinforced area having recess contained within the inlet wall;
- Figure 7 is a radial sectional view from a plane passing through the central axis of the capsule according to Figure 6;
- Figure 8 shows from below the inside portion of capsule hollow body according to Figures 6 and 7;
- Figure 9 is a perspective view of another possible embodiment of the capsule according to the present invention comprising at least one reinforced area having recess contained within the inlet wall;
- Figure 10 shows another possible embodiment of a capsule according to the invention;
- Figures 11 and 11a show two possible embodiments of the capsule according to the present invention having reinforcing means in the form of recess portions completely contained in the inlet wall;
- Figures 12A and 12B show a partial sectional view and a view from below of an upper portion of another possible embodiment of a capsule according to the invention having reinforcing means in the form of ribs;
- Figures 12 and 13 show another possible embodiment of a capsule according to the invention having reinforcing means in the form of recess portions and ribs;
- Figures 14 and 15 show a partially sectioned perspective view a capsule
according to the present invention with at least part of the piercing area in a
plastically deformed condition;

• Figures 16 - 20 show the results of comparative brewing tests carried out by the
Applicant.

Description of preferred embodiments

Figures 1 - 15 show the capsule 1 according to exemplary embodiments of the present
invention, for the preparation of a beverage, such as coffee, tea, hot and cold drinks, or
any other liquid foodstuff, from a pre-determined amount of an extractable or soluble or
dilutable product, either liquid or solid, contained inside the capsule. Preferably the dose
of product comprise a granular or minced powder product, such as coffee powder or tea
leaves, which are brewed by means of brewing liquid, preferably hot water under
pressure, that is injected into the capsule for obtaining the desired beverage.

The capsule according to the invention is used into a beverage preparation device (i.e. a
brewing device) provided with an enclosing element, or receptacle (not shown in the
figures) intended to house at least part of the capsule during the beverage preparation
process. The brewing device is further provided with piercing means 40, for example
one or more blades or similar elements for piercing the capsule, preferably in
correspondence of the water inlet wall of the capsule (inlet wall) in order to feed the
brewing liquid, preferably hot water under pressure, inside the capsule. While specific
reference will be made to water, it has to be noted that the capsule according to the
invention can be used with brewing liquid of different types. In the attached figures,
some of the piercing means of the brewing device are schematically shown in figures 1,
10, 14 and 15. The brewing water under pressure is injected into the capsule in a known
way, e.g. by injection means of the brewing device comprising for example a water
pump, not shown in the attached figures.

The capsule 1 used in combination with the brewing device forms a system for the
beverage preparation according to the invention, as it will be disclosed in greater detail
later.

In use, the enclosing element of the brewing device is moved with respect to the capsule
1, and/or vice versa, so that a seal-tight engagement with the capsule 1 (at the flange) can
be obtained and the piercing means 40 are brought in contact with the capsule for its
perforation, in particular with the piercing area 6 of the inlet wall 3 of the capsule. The
brewing device and the way it is operated are known in the art and cooperate with the
capsule according to the invention to obtain the claimed system for the beverage
preparation and to perform the steps of the claimed beverage preparation method. The capsule 1 according to the invention comprises a lateral wall 2, a water inlet wall 3 and a lower wall 4, said walls defining a hollow body 5 where the dose of product is located. The water inlet wall 3 is the inlet surface of the capsule and is intended to be perforated by the piercing means 40 of the brewing device to obtain inlet apertures 6a (shown in figures 14 and 15) allowing the passage of the brewing liquid into the capsule. The lower wall 4 allows the exit of the brewed beverage from the capsule into a container and the outlet means of the capsule, i.e. the elements allowing the exit of the brewed beverage, can be made in different ways. The lower wall 4, i.e. the outlet wall, or the wall comprising the outlet from which the beverage exits the capsule, can be a separate element which is connected to the lower portion of the capsule body 5, in order to close the capsule. Any suitable constraint means of the lower wall 4 to the capsule body 5 can be used, and in other possible embodiments the lower wall 4 may be produced in one piece with the capsule's lateral wall.

The lower wall may be produced in different material with respect to the capsule material, for example, the lower wall 4 may be a preferably non-porous membrane, for instance an aluminium or a laminated foil, preferably a laminated foil including aluminium, as shown in the sectional view of figures 2 and 7. Other suitable materials are a paper filter, a non-woven fabric or a cap in thermoplastic or similarly rigid or semirigid material provided with holes, as already known in other capsules for the production of beverage.

According to known alternative embodiments, the outlet means may comprise self-perforating elements that are broken under mechanical and/or pressure force acting on the capsule, or one or more holes that are produced by piercing means of the brewing device. Alternatively, outlet means may include open passages. These technologies are readily available to the skilled in the art.

The self-perforating element suitable for the bottom wall 4 is protruding from the lower surface of bottom wall 4, and is defined by grooves, or lines with reduced thickness, that are breakable under the action of the mechanical force exerted by the brewing device and/or the force exerted by the water fed into the capsule. This type of self-perforating elements is described in detail in application WO2007/063411, to which reference is made for further details.

Other types of outlet means can be provided, i.e. the extraction of the beverage from the
capsule can be obtained, for example, by perforating the capsule by suitable piercing
means of the brewing device; in another embodiment, the outlet means is a water-soluble
membrane.

As shown in the figures, the capsule 1 has a substantially cup-shape, or frustoconical
shape, with a central axis A (vertical axis), in other words, in the exemplary embodiment
shown in the figures, the lateral wall 2 is not parallel to the central axis A and the hollow
body 5 is closed by the lower wall 4 at one end and by the inlet wall 3 at the opposite
end of the lateral wall with respect to the lower wall 4.

The lateral wall 2 comprises a peripheral end 2c from which the water inlet wall 3
extends towards the central axis A. In the embodiment shown in the figures, the
peripheral end 2c of the lateral wall 2, from which the inlet wall 3 extends, is identified
by the circular line 2c. Moreover, even if not shown in the figures, the lateral wall 2 can
be provided with different thickness along its extension between the inlet wall 3 and the
lower wall 4. In the embodiment shown in the figures, lateral wall 2 is substantially
divided by line 15 (see figures 2 and 7) into a lower portion 2a and an upper portion 2b;
the lower portion 2a of the lateral wall 2 is provided with a greater thickness with respect
to the thickness of the upper portion 2b of the lateral wall 2. As visible in the shown
exemplary embodiment, the thickness of the inlet wall 3 is the same as that of the upper
portion 2b of the lateral wall.

Even if in the embodiment of figures 12A and 12B the upper portion of the lateral wall 2
have a different thickness with respect to the inlet wall 3, the capsule can be provided
with a the inlet wall and the upper portion of the lateral wall with the same thickness as
in the other embodiments shown in the figures.

According to possible embodiments, the thickness of the lateral wall 2 and of the inlet
wall 3 is comprised in the range 1.6mm - 0.15mm, and preferably in the range 1.2mm -
0.2mm. In the preferred embodiments, the thickness t1 of the inlet wall 3 is 0.2 - 0.5mm.
The thickness t2 of the lower portion 2a of the lateral wall 2 comprised in the range 0.55
- 0.7 mm.

It has to be noted that in the embodiments shown in the figures, the lower portion 2a of
the lateral wall 2 is provided with a constant thickness t2. However, according to
different possible embodiments the portion 2d of the lateral wall next to the flange-like
rim portion of the capsule can be provided with an increased thickness with respect to
the lower portion 2a of the lateral wall 2. Also in this embodiment the lower portion 2a
of the lateral wall 2 is provided with a greater thickness with respect to the thickness of
the upper portion 2b of the lateral wall 2. As visible from the figures, portions 2a and 2b of the lateral wall may have different inclination with respect to the vertical (i.e. longitudinal) axis A of the capsule.

According to an aspect of the present invention, as shown in the figures, the thickness of the inlet wall 3 is constant, i.e. the at least one piercing area 6 and the at least one reinforced area 7, 7' have the same thickness apart for the ribs. However, according to a possible embodiment the reinforced area 7, 7' of the water inlet wall can be provided with an increased thickness with respect to at least one portion of the inlet wall 3 outside said at least one reinforced area 7.

In the embodiments shown in the figures 1 - 15, water inlet wall 3 of the capsule extends from the central axis A (corresponding to the inlet wall top portion) towards the lateral wall 2 of the capsule so that the capsule upper portion is closed by the inlet wall 3. Moreover, as shown in the figures the water inlet wall 3 extends from the central axis A up to the peripheral end 2c of the lateral wall 2.

It has to be noted that the water inlet wall 3 can be at least partially flat and/or convex and/or tapered, in other words, the inlet wall 3 can be shaped in different manner in order to facilitate both the insertion of the capsule into the receptacle of the brewing device and also the perforation of the inlet wall 3 by piercing means of the brewing device.

In the embodiment shown in figures 1 - 5, inlet wall 3 of the capsule extends towards the peripheral end 2c of the lateral wall 2. The inclination of the inlet wall 3 at the peripheral edge 2c of the lateral wall 2 can be varied according to different possible embodiments, and preferably the angle β (see figure 2) formed (inside the capsule) between the inlet wall 3 and the lateral wall 2 at the peripheral end 2c is equal or greater than 90°. In the embodiment shown in the figures, the capsule is provided with a substantially convex inlet wall 3, and the angle β formed between the lateral wall 2 and the inlet wall 3 is greater than 90°, to provide further rigidity to the structure; a preferred range for angle β is 100° to 130°.

In the further possible embodiment shown in figures 6 - 11, the water inlet wall 3 of the capsule is substantially dome-shaped; this shape of the inlet wall 3 can be obtained, according to different possible embodiments, by means of a curved surface or by means of two or more flat surfaces arranged inclined one to another in order to provide a substantially dome shape.

In other words, in a cross sectional view of the capsule taken from a radial plane passing through the central axis of the capsule, the inlet wall is formed by a curved line, having
substantially a circular or elliptic shape, or by two or more straight lines inclined one to another. In the latter example, the straight lines can be for example arranged to be tangent to a circular or elliptic line.

It has to be noted that according to another possible embodiment the water inlet wall can be formed by one flat surface arranged inclined with respect to the central axis, i.e. to form a conical surface. Furthermore, it has to be noted that the inlet wall can be formed by a combination of curved and flat surfaces.

In the embodiment shown in figures 6 - 10, the capsule comprises a dome shaped water inlet wall formed by a substantially circular surface having a substantially flat top portion 3a. In other words, as best shown in the cross sectional view of figures 7 taken from a radial plane passing through the central axis A of the capsule, the inlet wall 3 is formed by a curved line, having substantially a circular or elliptic shape, except for the top portion that is substantially flat.

In the embodiment shown in figure 10, the substantially dome shape of the water inlet wall 3 is obtained by flat surfaces 3a, 3b, 3c, 3d, 3e inclined to each other. In fact, as shown in the cross sectional view of figure 10, the inclined flat surfaces 3a, 3b, 3c, 3d, 3e of the inlet wall 3 correspond to straight lines inclined one to another. It has to be noted that the flat surfaces/straight lines can be arranged to be tangent to a circular or elliptic line in order to form a substantially dome shaped surface.

Further examples of dome-shaped capsules are shown in figures 11, 11A, 12A and 12B. The capsule 1 according to the present invention comprises at least one reinforced area 7, 7' of the water inlet wall 3 and at least one piercing area 6, intended to be perforated by piercing means of the brewing device, that is arranged outside said at least one reinforced area 7, 7'.

Reinforcement is obtained by means of ribs and/or increased thickness with respect to the piercing area, or different materials.

The at least one piercing area 6 is more flexible and deformable than other portions of the water inlet wall 3, and in particular with respect to the at least one reinforced area 7, 7' of the capsule water inlet wall 3.

Therefore, the at least one piercing area 6 is firstly effectively perforated by the piercing means 40 of the brewing device to provide apertures 6a, and it is subsequently deformed during the beverage preparation process.

According to a preferred embodiment, the at least one piercing area 6, including apertures 6a, is at least in part deformed inwardly inside the capsule hollow body 5, so as
to increase the passage of the brewing water into the capsule through the apertures 6a. In fact, the at least one piercing area 6 is at least in part plastically deformed after said piercing area 6 has been pierced by the piercing means of the brewing device when one or more water inlet apertures 6a has been provided in the piercing area 6 of the capsule inlet wall 3.

A capsule according to the invention having a deformed piercing area is shown in figures 14 and 15. As it will be disclosed later in greater detail, the at least one piercing area 6 can be deformed because of the pressure exerted on capsule inlet wall 3 by the water that is injected into the capsule by suitable injection means of the brewing device; the capsule can be deformed at a water pressure as low as in the range 2 bar - 6 bar, preferably 2 - 4 bar.

According to a preferred aspect of the present invention, said piercing area or areas 6 is pierced by piercing means of the brewing device extending along a predetermined path for perforating said capsule to provide a path for a brewing liquid into the said capsule. According to an aspect of the present invention, the piercing area or areas 6 of the capsule provided on the inlet wall 3 extends at least in part along a path corresponding to the path along which the piercing means of the brewing device are arranged.

The piercing area is pierced and subsequently deformed inwardly inside the hollow body of the capsule so as the piercing area, and in particular at least one of the apertures provided on it are no longer contacted by the piercing means of the brewing device.

According to an aspect of the present invention, at least part of said at least one piercing area 6 is deformed by a movement of at least 50% up to 150% of the penetration depth of said piercing means 40 of said brewing device in the water inlet wall, to provide an increased water passage between said water inlet 3 wall and the piercing means.

In use, the piercing area or areas 6 of the water inlet wall 3 is contacted and perforated by piercing means and subsequently are deformed inwardly, preferably under the action of the water pressure injected into the capsule.

As already mentioned above, the capsule according to the invention comprises at least one reinforced area 7, 7’ of the water inlet wall 3, that allow the effective perforation of the piercing area by stiffening the inlet wall outside the piercing area, the reinforced area(s) 7, 7’ may or may not deformed when pressurized water is injected into the capsule.

According to a possible embodiment of the present invention, not shown in the figures,
the reinforced area 7 of the water inlet wall comprises an increased thickness with
respect to the portions of the water inlet wall 3 outside the reinforced areas 7, and in
particular with respect the at least one piercing area 6 that is arranged outside said
reinforced areas 7.

In other words, according to a possible embodiment the reinforced areas 7 of the
water inlet wall 3 are thicker than the at least one piercing area 6 in order to obtain a
different behaviour of these areas of the inlet wall, so that the piercing areas 6 can first be
effectively pierced by the brewing device piercing means and subsequently deformed by
water pressure.

According to different possible embodiments, the at least one reinforced area 7 of the
water inlet wall 3 of the capsule comprises reinforcing means 10, 20. According to a
possible embodiment, the reinforcing means can extend at least partially also on said
lateral wall 2 of the capsule. It has to be noted that the stiffening of the at least one
reinforced area 7, 7' of the inlet wall can be obtained by a combination of an increased
thickness with respect to the at least one piercing area and the presence of reinforcing
means 10, 20.

According to a possible embodiment, the reinforcing means 10, 20 intended to define at
least one reinforced area 7 on the water inlet wall 3 of the capsule comprises one or more
ridge(s), or ribs, 20 protruding from the inlet wall surface and arranged circumferentially
and/or radially on said inlet wall 3.

According to another possible embodiment, the reinforcing means 10, 20 defining at
least one reinforced area 7 comprises at least one recess portion 10 completely contained
within said inlet wall 3, or extending on both said lateral wall 2 and said water inlet wall
3.

It has to be noted that reinforcing means 10, 20 in the form of ridges 20 and recess
portions 10 can be used together or separately in the same reinforced area 7.

As it will be disclosed in greater details later, at least one boundary line 8, 8' is defined
between at least one reinforced area 7 and at least one piercing area 6 of the water inlet
wall 3. It has to be noted that the boundary line 8 may be an imaginary line and may not
represent a physical line or feature of the capsule. When the at least one piercing area 6
is deformed, the at least boundary line corresponds to the boundary of a deformed
(flexed) part of the inlet wall 3, i.e. the at least one piercing area, and the not deformed
(not flexed) part of the water inlet wall, i.e. the at least one reinforced area 7. Line 8 can
act as a "hinge" between the different portions of the inlet wall.
According to an aspect of the present invention, the at least one piercing area 6 and the at least one reinforced area 7 are arranged along alternate pattern on the water inlet wall 3. Preferably, said at least one reinforced area 7 and said at least one piercing area 6 are alternating along a radial direction connecting said peripheral edge 2c of the lateral wall 2 towards a central axis A of the capsule hollow body 5.

According to a preferred embodiment, as shown in the attached figures, two reinforced areas 7, 7' of the water inlet wall 3 are provided, and at least one piercing area 6 is extending continuously or discontinuously along a substantially annular area of the water inlet wall 3 between two reinforced areas 7.

Preferably, a first reinforced area 7' is provided in correspondence of the central top portion of the water inlet wall 3 and a second reinforced area 7 is provided in correspondence of a peripheral portion of the water inlet wall, preferably next to the peripheral edge 2c between the inlet wall 3 and the lateral wall 2 of the capsule. At least one piercing area 6 is arranged in the inlet wall area between said central reinforced area 7' and said peripheral reinforced area 7.

The capsule according to the embodiment shown in figures 1 - 5 is provided with reinforcing means defining at least one reinforced area 7, comprising at least one, preferably a plurality of recess portions 10 extending on both the inlet wall 3 and on the lateral wall 2 and connecting together areas of said walls. In other words, the capsule is provided with at least one recess portion 10 forming a corrugation in correspondence of the peripheral end 2c of the lateral wall 2. It has to be noted that the at least one recess portion 10 defines a modification of the shape of both the inlet wall 3 and of the lateral wall 2 in correspondence of the peripheral edge 2c of the lateral wall 2 from which the inlet wall 3 extends.

More in detail, the recess portion 10 is provided in correspondence of the peripheral end 2c of the lateral wall 2 from which the inlet wall 3 extends, thus the recess portion extends on both the lateral wall and the inlet wall of the capsule. Recess portion 10 comprises at least one surface connecting the lateral wall to the inlet wall of the capsule forms in fact an additional wall that connects lateral and inlet walls 2, 3, and is angled with respect to both of them.

The at least one recess portion 10 comprises at least one surface 12 that lies on a plane P or it contains at least one axis B maintaining a constant angle of inclination a with respect to the central axis A of the capsule or with respect to a vertical axis parallel to the central axis A. It has to be noted that preferably the angle of inclination a of the surface
12 of the recess portion 10 is measured by means of the corresponding angle of inclination of the plane P or of the axis (straight line) B.
Preferably the plane P or the at least one axis B of the surface 12 are directed towards and/or intersect the central axis A of the capsule or a vertical axis parallel to the central axis A.

In the shown embodiment the thickness of inlet wall 3, lateral wall's upper portion 2b and recess portions 10 is constant; however the invention includes embodiments with different thickness in different areas of the walls. As shown in the sectional view of figure 2, to each external recess portion 10 corresponds a protrusion 11 inside the hollow body 5 of the capsule, i.e. recess portions 10 of the capsule form a modification of both lateral and inlet wall of the capsule providing a correspondent internal protrusion inside the capsule.

The recess portion 10 can be seen as the "removal" of a portion of volume of the capsule from the junction (peripheral edge 2c) between inlet 3 and lateral 2 walls; thus, the walls are modified and they "sink" below their original level to rise again to the original level and shape. Exemplary shapes of the removed volume are prisms or portions of prisms, preferably a prism selected from triangular, parallelepiped, cylinder and hexagonal base prisms or prisms having a base formed by a regular or irregular polygon. So that the at least one surface 12 of the recess portion 10 "belongs" to at least a portion of a prism used, in designing, to "remove" a volume of the capsule.

The recess portion 10 thus comprises a surface 12 connecting the inlet wall 3 to the lateral wall 2 of the capsule. Surface 12 is thus forming an additional wall portion of the capsule. In other words, in correspondence of recess portion 10, inlet wall 3 is connected to the lateral wall 2 by means of at least one surface 12 of the recess portion 10.

According to different possible embodiments, each recess portion 10 is formed by one continuous surface or two or more surfaces that can be oriented in different manner so as to form the recess portion 10. It has to be understood that if the recess portion 10 is obtained by a "removal" of volume corresponding to part of a cylinder, the recess portion 10 comprises only one continuous surface 12 connecting the inlet and the lateral wall (see the embodiment shown in figure 5). In the case the recess portion is obtained by a removal of volume corresponding to part of a prism with different shape such as a parallelepiped or an hexagonal prism, the recess portion is formed with two or more surfaces 12 (see the embodiment shown in figure 5a).

As already mentioned above, in the embodiment shown in the figures 1 - 5, the recess
portion 10 comprises at least one inclined surface 12 with respect to the vertical, that connects the inlet wall 3 with the lateral wall 2.

In the embodiment shown in the figures 1 - 5, the recess portion 10 comprises at least one inclined surface 12 with respect to the vertical, i.e. with respect to the central axis (A) or to an axis parallel to it.

Preferably, the at least one surface 12 of the recess portion 10 that maintains a constant angle of inclination with respect to the central axis A of the capsule or a vertical axis is the bottom surface 12 of the recess portion 10. In other words, each recess portion comprises at least one surface 12, preferably "oblique", i.e. inclined, forming an additional surface, preferably a bottom surface of the recess portion 10 that is angled with respect to a vertical axis (i.e. the central axis A of the capsule or an axis parallel to it) with a constant inclination.

As already mentioned above, and as shown in the figures, the surface 12 of the recess portion 10 is preferably flat, in fact, said surface lies on a plane P or it contains at least one straight line B (axis). Moreover, the at least one surface 12 of the recess portion 10 preferably maintains a constant angle of inclination a with respect to the central axis A of the capsule, or to an axis parallel to it, along its complete extension. In other embodiments, central axis A is forming angled portions, so that the recess portion comprises angled surfaces along axis A.

Preferably, the inclined surface 12 forms an acute angle a (visible in figure 2) with the vertical, i.e. with respect to a direction parallel to the central, vertical rotational axis, i.e. the longitudinal axis A of the capsule, or, more simply, with axis A, as shown in figure 2. Generally the acute angle a, as defined above, is comprised in the range 10° - 75°, preferably 25°- 60°, most preferably about 35°-50°.

As shown in the figures, according to an aspect of the present invention, the surface 12 of the recess portion 10, and preferably the bottom surface, extends between the closest and the farthest end parts 10a, 10b of the recess portion 10, with respect to the central axis A of the capsule.

In other words, the at least one surface 12 extends from the closest end part 10a of the recess portion 10 with respect to the central axis A, to the farthest end part 10b of the recess portion 10 from said central axis A of the capsule.

It has to be noted that with the expression end part 10a of the recess portion 10 closest to the central axis A of the capsule is meant the at least one point, or area, of the recess portion 10 nearest to the central axis A of the capsule. Analogously with the expression
end part 10b of the recess portion farthest from the central axis A is meant the most distant at least one point, or area, of the recess portion 10 from the central axis of the capsule.

According to an aspect of the present invention, the farthest end part 10b of the recess portion 10 is arranged on the lateral wall 2 below the peripheral end 2c of the lateral wall 2. In other words, the at least one point, or area, of the recess portion 10 farthest from the central axis A is below the peripheral end 2c of the lateral wall 2.

More in detail, in the embodiment shown in attached figures 1 - 5, each recess portion 10 is formed by an inclined surface 12 that is provided with two lateral surfaces 12'. The inclined surface 12, is substantially flat and is inclined with respect to the vertical, and the angle a formed between the inclined surface 12 and the vertical, i.e. a direction parallel to the central axis A, is an acute angle. The lateral surfaces 12' of the recess portion 10 are preferably arranged on a plane passing through the central axis A of the capsule.

According to an aspect of the present invention, the recess portions 10 are radially arranged with respect to the central axis A of the capsule, and preferably the capsule comprises a plurality of recess portions 10 arranged with constant spacing along the peripheral end 2c of the lateral wall 2, thus providing an uniform stiffening of both the lateral wall and the inlet wall of the capsule.

Preferably the recess portions 10 are dimensioned so as to provide a constant "full-empty" alternation along the peripheral end 2c of the lateral wall from which the inlet wall 3 extends, i.e. a constant alternation of recess portion 10 (empty) and portion of the lateral wall 2 and the inlet wall where no recess portion are present (full).

In the embodiment of the capsule shown in figures 1 - 4 the number of recess portions 10 is increased with respect to the embodiments shown in figures 5, 5a. Moreover, in the embodiments shown in figures 1 - 4 the recess portions are narrower than the recess portions 10 of the embodiment shown in figures 5, 5a. More in detail, in figures 1 - 4 the width w of the inclined surface 12 of the recess portions 10 is reduced with respect to the embodiments shown in figures 5, 5a.

Figures 5, 5a show an even number of recess portions, namely six recess portions. As previously mentioned, the number of recess portions may be selected from prime numbers, preferably from 5, 7, 11 and 13; figure 4 shows a capsule with eleven recess portions. The choice of a prime number for the number of recess portions results in an increased random positioning of the capsule within the receptacle of the brewing device.
where the capsule is housed to be pierced, with respect to the piercing elements present in the said receptacle. This increase in the random positioning of the capsule with respect to the piercing elements will reduce the possible bad functioning of the system.

Advantageously, according to a possible embodiment of the invention the thickness of the recess portion 10 is equal to the thickness of the inlet wall 3 and/or of the lateral wall 2 outside said recess portion, although other thicknesses can be adapted, accordingly to the specifications of the material used for the manufacturing of the capsule. As already mentioned above, in the present disclosure the expression "thickness of the recess portion" is intended as the thickness of the section of the capsule wall in correspondence of the recess portion, and in particular as the thickness of the at least one surface 12 of the recess portion 10 that connects the inlet wall and the lateral wall of the capsule.

The at least one piercing area 6 of the inlet wall 3 is provided adjacent to the reinforced area 7 of the water inlet wall 3 defined by the recess portions 10, preferably beyond the end part 10a of the at least one recess portion 10 on inlet wall 3.

Preferably a boundary line 8 between the reinforced area 7 and the at least one piercing area 6 is defined by a circular line connecting the end parts 10a of the recess portions 10. It has to be noted that the expression "end part" of the recess portion 10a is used herein to indicate where the recess portion 10 ends on the inlet wall 3, i.e. the part that is closer to central axis A of the capsule, shown with reference 10a in the figures. The side of the recess portion opposite to end 10a is end 10b, that is located on the lateral wall 2; surface 12 connects end parts 10a and 10b.

It has to be noted that according to different possible embodiments the at least one piercing area 6 can be provided in the area between the end parts 10a of the recess portions 10 and the vertex of the inlet wall 3, corresponding to the central axis A of the capsule.

In the embodiment shown in the figures 1 - 5, the water inlet wall 3 of the capsule is provided with a second reinforced area 7', provided in correspondence of the central top portion of the water inlet wall. In the shown embodiment, the reinforced area 7' is defined by reinforcing means in the form a plurality of ribs 20 protruding from the internal surface of the water inlet wall 3. The ribs 20 are preferably arranged in a radial manner from the central portion of the inlet wall 3, substantially from the central axis A.

Ribs 20 provided in the central part of the internal surface of the inlet wall 3 are shown in figure 3, that is a capsule view from below.

Preferably a boundary line 8' between the reinforced area 7' and piercing area 6 is
defined by the circular line connecting the ends 20a of the radially arranged ribs 20. It has to be noted that, in the embodiment of the capsule provided with such ribs 20, the one or more piercing area 6 is preferably arranged between the recess portions 10 and the ribs 20. More in detail, the one or more piercing area 6 are arranged on the inlet wall 3 between the end part 10a of the recess portion 10, i.e. reinforced area 7, and the end part 20a of the ribs 20, i.e. reinforced area 7'.

As already mentioned above, the thickness of the piercing area 6 can be lower than the thickness of the inlet wall 3 in the reinforced area 7.

The embodiments of the capsule shown in figures 6 - 11, are similar to that disclosed in figures 1 - 5, except for the arrangement of the reinforcing means in the form of recess portions 10 intended to define at least one reinforced area 7 of the capsule water inlet wall 3.

In fact, as discussed above, in the embodiment shown in figures 1 - 5 the recess portions 10 are extending on both the inlet wall and the lateral wall, while in the embodiment shown in figures 6 - 11 the recess portions are completely contained within the capsule water inlet wall 3, i.e. they do not extend on the lateral wall 2 and in particular, they do not extend below the peripheral end 2c of the lateral wall 2. In figures 1-5 and in figures 6-11 corresponding features are referred to with corresponding reference numbers.

As discussed with reference to figures 1-5, also in figures 6 - 11, the water inlet wall 3 of the capsule is provided with a second reinforced area 7', located in correspondence of the central top portion of the water inlet wall. In the shown embodiment, the reinforced area 7' is defined by reinforcing means in the form a plurality of ribs 20 protruding from the internal surface of the water inlet wall 3. Details of the central reinforced portion 7' are the same as those above discussed with reference to figures 1-5.

Figures 12, 13 show a further possible embodiment of the capsule according to the invention. More in details, the capsule 1 comprises a plurality of recess portions 10 that, as already disclosed above, can be arranged either on both the inlet and lateral walls 3, 2 of the capsule, or completely contained in the inlet wall 3 of the capsule. Portions 10 provide a first external and peripheral reinforced area 7. A central reinforced area 7' is provided with ribs 20, that are radially arranged; at the two boundary lines 8, 8' there are provided circumferential ribs 20b.

According to a possible embodiment not shown in the figures, the circumferential rib 20b arranged between the central reinforced area 7' and the piercing area 6 can be removed.
In fact, it has to be noted that the circular rib 20b arranged in correspondence of the end portions 20a of the radially arranged ribs 20 located on the central top portion 7' of the inlet wall 3 is optional.

The boundary line 8' between the reinforced area 7', centrally located on the top portion of the inlet wall, and at least one piercing area 6 of the capsule inlet wall 3 substantially corresponds to the circular rib 20b. The boundary line 8 between the reinforced area 7, peripherally located on the inlet wall, and at least one piercing area 6 of the capsule inlet wall 3 substantially corresponds to the circular rib 20b.

Figures 12A and 12B, disclose an embodiment wherein recess portions 10 are replaced by reinforcing means 20c in the form of ribs, preferably radially arranged and extending on the inlet wall 3 or, preferably, on both the inlet wall 3 and the lateral wall 2. A plurality of radially ribs 20c are arranged on the peripheral part of the water inlet wall 3, i.e. the part next to the peripheral edge 2c between the inlet and lateral walls, to provide reinforced portion 7. According to a preferred aspect, the radially arranged ribs 20c also extend on the lateral wall 2 of the capsule.

Additionally, a circular rib 20b is protruding from the lower surface of the inlet wall 3, and preferably it extends circumferentially with respect to the peripheral edge 2c of the inlet wall 3, i.e. forming a circular line with respect to the central axis A of the capsule.

By doing so, the reinforced area 7 arranged on the peripheral part of the water inlet wall 3 is defined by the circular rib 20b and the radially arranged ribs 20c (as shown in the embodiment of figures 12A and 12B). It has to be noted that the boundary line 8 between the reinforced area 7 and at least one piercing area 6 of the capsule inlet wall 3 substantially corresponds to the circular rib 20b. In case the circular rib 20b it is not provided on the capsule inlet wall 3, the boundary line 8 between the peripheral reinforced area 7 and the at least one piercing area 6 can be defined by the ends portions of the radially arranged ribs 20c, which are closer to the central axis A of the capsule.

It has to be noted that according to different possible embodiments the at least one piercing area 6 can be provided in the area between the boundary line 8 of the reinforcing area 7, i.e. the circumferential rib 20b, in the embodiment shown in the figures 12, 13, 12A and 12B, and the top portion of the inlet wall 3, corresponding to the central axis A of the capsule.

In the embodiment shown in the figures 12A and 12B the water inlet wall 3 of the capsule is provided with a second reinforced area 7', provided in the central top portion of the water inlet wall 3. In the shown embodiment, the reinforced area 7' is defined by
reinforcing means in the form of a plurality of ribs 20 protruding, preferably, from the internal surface of the water inlet wall 3. The ribs 20 are preferably arranged in a radial manner from the central portion of the inlet wall 3, substantially from the central axis A. Preferably, the boundary line 8' between the central reinforced area 7' and at least one piercing area 6 is defined by the circular line connecting the ends 20a of the radially arranged ribs 20 of the central reinforced area 7'.

In the embodiment shown in figure 12 A and 12B, as better shown in figure 12B that is a view of the capsule from below, the central reinforced area 7' comprises a first plurality 20' of radially arranged ribs that have their origin in the point corresponding to the central axis A of the capsule.

Additionally the central reinforced area 7' comprises a second plurality of radially arranged ribs 20" having their origin distanced from the point corresponding to the central axis A of the capsule.

Preferably, the boundary line 8' between the central reinforced area 7' and at least one piercing area 6 is defined by the circular line connecting the ends 20a of the second plurality of radially arranged ribs 20".

In the shown preferred embodiments of the capsule provided with ribs 20 radially arranged on the top reinforced portion 7' of the inlet wall, the (one or more) piercing area 6 is arranged between the recess portions 10, or the peripherally arranged radial ribs 20c, and the ribs 20 radially arranged on the portion of the water inlet wall 3. More in detail, in the embodiment shown in the figures 12, 13, one or more piercing area 6 can be arranged on the inlet wall 3 between the end part 10a of the recess portion 10 and the end part 20a of the ribs 20 arranged on the top portion of the inlet wall 3 to define a centrally located reinforced area 7.

As already mentioned above, the thickness of the piercing area 6 can be lower than the thickness of the inlet wall 3 in the reinforced area 7.

In the capsule according to the invention the at least one piercing area 6 is preferably arranged on an annular portion of the inlet wall having two boundary circumference distanced one another of 3.1mm - 4.1mm, and preferably 3.3mm - 3.9mm.

With reference to the shown embodiments, wherein a piercing area 6 is arranged between two reinforced areas 7, 7' (peripherally and centrally located on the inlet wall 3), the boundary lines 8 and 8' between the reinforced areas and the piercing area are spaced one another of 3.1mm - 4.1mm, and preferably 3.3mm - 3.9mm.

In the capsule according to the invention, the peripheral reinforced area 7, i.e. the
reinforced area arranged next to the peripheral edge of the lateral wall 2c, is extending (in a radial direction) on the inlet wall 3 for 20% - 40%, and preferably for 25% - 35%, of the radial distance between the lateral wall 2 (and preferably its peripheral edge 2c) and the top portion of the inlet wall 3 of the capsule (and preferably its central axis A).

In a preferred embodiment each portion 7,7' and 6 extends for 20% - 40%, and preferably for 25% - 35%, of the radial distance between the lateral wall 2 (and preferably its peripheral edge 2c) and the central axis A of the inlet wall 3 of the capsule, with a total of 100% for the radius from axis A to edge 2c.

Furthermore, in the embodiments show in the figures 1-15, except for the embodiments shown in figures 12A and 12B, the capsule is provided with vertical lugs 9 protruding from the internal surface of the lateral wall 2 and intended to impede the capsules from stacking during the production process. The protruding lugs can be truncated, as shown in figure 12A, to control and facilitate stacking if so desired. Thickness, shape and radius of such lug(s) will vary depending on the chosen manufacturing methods, to be selected amongst the ones mentioned earlier, as it can easily inferred by the skilled in the art.

Vertical lugs can extend on both the inlet and lateral walls 3 and 2, or they can be provided only on the lateral wall 2 of the capsule, as in the embodiments shown in figures 1-12 and 13-15. In the embodiment shown in figures 12A and 12B, and in general in a capsule wherein the peripheral reinforced area 7 comprises reinforcing means in the form of ribs 20c extending also on the lateral wall 2, the function of the vertical lugs 9 can be carried out by the portion of the reinforcing ribs 20c extending on the lateral wall 2.

Additionally, in the shown exemplary embodiments, at least one sealing element 30 is provided on the flange-like rim 31 of the capsule, i.e. the portion of the capsule designed to be brought in contact with the receptacle, and in particular with the lower edge of the receptacle, i.e. the pressing portion of the receptacle, for providing the sealing engagement.

Any suitable sealing member can be used.

The capsule according to the invention may be manufactured in plastics, bio-plastics, so-called "green"-plastics (that is plastics derived from renewable sources).

The capsule can be produced by injection molding or by thermoforming. The capsule may be provided with a layer that acts as a barrier to oxygen and gas permeation.

A suitable known barrier material is e.g. EVOH, that can be e.g. present as a multilayer structure with polypropylene such as PP-EVOH-PP or preferably with polyethylene,
such as PE-EVOH-PE. The multilayer structure may be a laminate to be used in thermoforming; alternatively, the multilayer structure is obtained by co-injection moulding of the capsule body; co-injection of coffee capsules is a technique commonly known to the skilled person and is not an object of the present invention. Such technique is commercially available.

The barrier may be also provided externally as a coating. Suitable coatings are those available from e.g. Nanolok™ PT ADV-7 and the PVD or PECVD coatings. Coatings can be applied by spraying or by dipping, suitable coatings, especially nanocoatings, can be obtained from a composition including kaolin clay or silicate nanoparticles and polymers, optionally as an aqueous composition. Such compositions are e.g. concentrated nanocomposite dispersion which includes a silicate filler and a matrix polymer dispersed in an aqueous medium such as those disclosed e.g. in WO2009/114071, WO2006/115729, WO2008/147380, WO2009/114072, US8309230. A further type of barrier can be obtained by adding suitable nanocomposite to the plastic material as disclosed e.g. in WO2007/106671.

According to an aspect of the present invention, at least the lateral wall 2 and the water inlet wall 3 of the capsule are made in one piece. Moreover, according to a further aspect of the invention the water inlet wall 3 and lateral wall 2 are made of the same material, preferably by plastic material.

Different production process can be used to obtain the capsule according to the invention, for example at least the water inlet wall 3 and the lateral wall 2 can be made by injected or co-injected plastic material.

It has to be noted that the mechanical and thermal characteristic of the material used to produce the capsule, and in particular its water inlet wall 3 are critical to obtain a deformation of at least part of the one or more piercing area.

Experimental tests carried out by the Applicant show that using a plastic material having the below reported thermal and mechanical properties allows to obtain at the same an effective perforation of the at least one piercing area of the capsule inlet wall and a following deformation of at least part of the piercing area during the beverage preparation process.

Suitable plastic materials to be used are PP and PE, preferably HDPE provided with a density comprised in the range 850 - 1050 kg/ m³, preferably 0.951 kg/ m³, (measured according to ISO 1872), a melt flow rate comprised in the range 9 - 13 g/10min, preferably 11 g/10min, (MFR measured according to ISO 1133), tensile stress
comprised in the range 23 - 29 MPa, preferably 26 MPa, (measured according to ISO 527-2/1B). A preferred material shows all the above preferred values.

A preferred material has a Charpy Notched Impact strength (at 23°C) in the range of 3.1 to 3.9 kJ/m², preferably 3.5 kJ/m² (measured according to ISO 179). A preferred material shows all the above preferred values and the cited Charpy.

Additionally, Vicat softening point is preferably comprised in the range 50 - 80, preferably 55 - 75, and most preferably 60 - 70 (measured according to ISO 306(B50 method). When measured with standard ASTM D1525 B50 Vicat softening point is preferably comprised in the range 50 - 60, preferably 54 - 58, and most preferably 56.

Melting point (second heating) is preferably comprised in the range of 115 - 145 °C, preferably 131°C (measured according to ASTM D21 17). Suitable material has shore D-hardness comprised in the range 55 - 66, preferably 60 (ASTM D2240).

A suitable plastic material for the capsule production is the one sold as Rigidex® HD521 IEA commercialized by INEOS.

As already mentioned above, the present invention also relates to a system for preparing a beverage comprising a capsule of the type disclosed above.

More in details, the capsule is used in a brewing device comprising piercing means intended to perforate the least one piercing area of the capsule water inlet wall 3 in order to provide one or more water inlet apertures 6a. The brewing device comprises water injection means to inject water under pressure inside the capsule hollow body 5 through said one or more water inlet apertures 6a.

The at least one piercing area 6 of the water inlet wall 3 is at least in part plastically deformed during the beverage preparation.

According to an aspect of the present invention, the piercing area or areas 6 of the capsule provided on the inlet wall 3 extends at least in part along a path corresponding to the path along which the piercing means of the brewing device are arranged.

As already mentioned above, the at least one piercing area of the capsule is at least in part plastically deformed inwardly inside the hollow body. A deformed inlet wall of a possible embodiment a capsule is shown in figures 14 and 15.

In fact, the at least one piercing area 6 is at least in part plastically deformed after said piercing area 6 has been pierced by said piercing means 40 of the brewing device and said one or more water inlet apertures 6a has been provided in said piercing area 6 of the capsule inlet wall 3.

More in details, as shown in figures 14 and 15, the at least one piercing area 6 of the
water inlet wall 3 after its deformation, does not contact anymore said piercing means 40 of the brewing device.

Additionally, according to an aspect of the present invention, the at least part of the at least one piercing area 6 is plastically deformed by a movement of at least 50% up to 150% of the penetration depth of said piercing means 40 of said brewing device in the water inlet wall. By doing so, it is possible to obtain an increased water flow passage between the water inlet wall and the piercing means of the brewing device.

The present invention also relates to a method for preparing a beverage from a capsule of the type disclosed above, and a brewing device comprising piercing means and water injection means.

The method comprising the steps of piercing at least part of said at least one piercing area of the water inlet wall by piercing means of the brewing device for providing one or more water inlet apertures in said capsule inlet wall; and the step of plastically deforming at least part of said at least one piercing area of the water inlet wall during the beverage preparation.

Advantageously, as already mentioned above, the plastic deformation of at least a portion of the capsule piercing area allow to increase the water flow passage inside the capsule. In fact, after the inlet wall deformation, piercing means of the brewing device do not provide for an obstruction of the one or more water apertures realized on the inlet wall due to its perforation.

It has to be noted that, in the method according to the invention, the at least one piercing area 6 is at least in part plastically deformed after the piercing means 40 of the brewing device have perforated at least part of the piercing area in order to provide one or more water inlet apertures 6a.

As mentioned above, the at least one piercing area 6 is at least in part plastically deformed under the pressure exerted on said inlet wall by the water injected by water injection means of the brewing device.

In this regard, the method comprises the step of injecting water inside said capsule hollow body 5 through said one or more water inlet apertures 6a provided on the inlet wall 3 in the method step a), by means of water injection means of the brewing device.

By doing so, the least one piercing area 6 is at least in part plastically deformed in said method step b), under the pressure exerted on said inlet wall 3 by the water injected by water injection means of the brewing device.

Preferably, the water pressure is comprised in the range 2 bar - 4 bar.
According to an aspect of the method, at least two separate pressure build-up stages are determined when said water injection means of the brewing device injects water into said capsule.

Preferably, the plastic deformation of the at least one piercing area occurs between the pressure build-up inside the hollow body of the capsule and the first outlet of the prepared beverage from the outlet wall. In fact, during the beverage preparation process, after the capsule piercing area is perforated by the brewing device piercing means, the water is injected into the hollow body of the capsule by means of one or more apertures obtained on the piercing area in order to build up pressure inside the capsule to obtain an effective infusion of product contained therein.

The plastic deformation of the inlet wall of the capsule, allows to obtain at least two separate pressure build-up stages of the injected water. In fact, a first build up of the pressure is obtained after the at least one piercing area of the capsule is perforated by the piercing means of the brewing device and the water is injected into the capsule. The pressure increases until at least part of the at least one piercing area is deformed, thus allowing an increased passage of the water flow inside the capsule. The second pressure build up is obtained by injecting the water into the capsule through the deformed inlet wall until the product contained into the capsule hollow body is infused and the pressure inside the capsule determine the opening of the capsule outlet wall.

It has to be noted that according to a further aspect of the method, the plastic deformation of said at last one piercing area occurs between the pressure build-up inside the hollow body and the first outlet of the prepared beverage from the outlet wall.

Figures 14 and 15 shows a capsule according to the invention, having a shape similar to that disclosed in connection to figures 1-4, wherein at least part of the piercing area is plastically deformed.

As shown in the figures 14 and 15, at least part of the piercing area is deformed inwardly inside the hollow body of the capsule, and according to an advantageous aspect of the present invention, only the piercing area is at least in part deformed. In fact, the reinforced area or areas 7 are not deformed during the beverage preparation process. More in details, according to an aspect of the invention the deformation of the piercing area is substantially contained within the at least one boundary line 8 that is substantially extending between the at least one reinforced area 7 and at least one piercing area 6.
As shown in figures 14, 15, the piecing area 6 is deformed substantially in the area comprised between the two boundary lines 8 that ideally separate the two reinforced areas 7 from the annular piercing area 6.

Even though in the figures it is shown fully deformed, only at least a part of the piercing area may be deformed.

Moreover, it has to be noted that even if not shown in the figures, the capsule shown in the embodiments of figures 5 - 13 will have a similar behaviour during the beverage preparation process and undergoes a deformation of at least part of the piercing area as in the capsule shown in figures 14 and 15.

The invention will be further disclosed with reference to the following comparative tests between a capsule according to the invention and a commercially available capsule.

The results of comparative tests show an increased brew yield parameter in the capsule according to the invention independently from the machine used.

The brew yield parameter is calculated by means of the mathematical formula reported below:

\[
\% \text{ Brew yield} = \left( \frac{\% \text{ extracted solids} \times \text{ drink weight (g)}}{\text{fill weight of the capsule (g)}} \right) \times 100
\]

The brew yield depends on the percentage of extracted solids, the produced drink weight and the fill weight of the capsule.

The below reported tests have been carried on two different coffee powders:

Coffee A: Blend of Robusta and Arabica roast and ground coffee with a medium-dark roast colour (8.5 La)

Coffee B: 100 % Arabica roast and ground coffee with a dark roast colour (6.5 La)

The following commercially available coffee machines have been used:

"U" Nespresso ® coffee machine, an automatic espresso brewing machine using automatic clamping force,

"Pixie" Nespresso ® coffee machine, an automatic espresso brewing machine using manual clamping force

**Example 1**

Exactly 5.2 g of Coffee A was weighed into the capsule according to this invention. This capsule was then placed in an automatic U Nespresso ® espresso machine and the espresso was brewed. Then the % extracted solids were measured using the densitometer instrument known in the art as "Kyoto" to calculate extractable/extracted solids from the density of the brew and expressed as g per 100 g.
The resulting beverage had 26% brew yield.

**Comparative Example 1**

Coffee A was also brewed using a Nespresso capsule (i.e. without the improved capsule design according to the invention) in the same espresso machine and only 24% brew yield was achieved.

Figure 16 shows a brew yield (%) comparison in the improved capsule vs. Nespresso capsule in the U Machine.

**Example 2**

Exactly 5.2 g of Coffee A was weighed into the capsule according to this invention. This capsule was then placed in an automatic Pixie Nespresso ® machine and the espresso was brewed. When the % extracted solids were measured using Kyoto method and the % brew yield was calculated as described in Example 1. The resulting beverage had 25% brew yield.

**Comparative Example 2**

Coffee A was also brewed in the original Nespresso ® capsule, without the improved capsule design according to the invention, and only 24.5% brew yield was achieved.

Figure 16 shows a brew yield (%) comparison in the improved capsule vs. Nespresso ® capsule in the Pixie Machine.

**Example 3**

Exactly 5.2 g of Coffee B was weighed into both Nespresso ® capsule and into the capsule according to this invention. Both capsules were then placed in a Pixie Nespresso ® machine and the espressos were brewed. Using the improved capsule according to this invention, 21% brew yield was achieved.

**Comparative Example 3**

Coffee B was also brewed in the original Nespresso ® capsule, without the improved capsule design according to the present invention, and only 18.5% brew yield was achieved.

Figure 18 shows a brew yield (%) comparison in the improved capsule vs. Nespresso capsule in the Pixie Machine.

**Example 4**

Exactly 5.2 g of Coffee B was weighed into both Nespresso ® capsule and into the capsule of this invention. Both capsules were then placed in a Pixie Nespresso ® machine and the espressos were brewed. During the brewing, brewing time and brewing pressure were also measured. Coffee B in the capsule of this invention brewed in shorter
time (17 seconds) and at lower pressure (11.5 bar) and still achieved better brew yield i.e. 21%.

**Comparative example 4**

Coffee B was also brewed using a Nespresso ® capsule in the same espresso machine and the brewing time was longer (21 seconds) and at higher pressure (14.5 bar) and lower brew yield was achieved i.e. 18.5%.

Figure 19 shows brew time, Brew pressure and % Brew yield in the Pixie machine with and without the improved capsule design according to the invention.

**Example 5**

Exactly 5.2 g of Coffee B was weighed into both Nespresso capsule and into the capsule according to this invention. Both capsules were then placed in a U Nespresso machine and the espressos were brewed.

During brewing, brewing time and brew pressure were also measured. Coffee B in the capsule of this invention brewed in shorter time (20 seconds) and at lower pressure (15 bar) and still achieved the same % brew yield i.e. 20% as the Coffee B in the Nespresso capsule brewed in a U Nespresso ® machine.

Figure 20 shows Brew time, Brew pressure and % brew yield in the U machine with and without the improved capsule design according to the invention.

The above results confirm the advantages obtained by the capsule according to the present invention.
CLAIMS

1. A capsule (1) for the preparation of a beverage from a brewing device, said capsule comprising a lateral wall (2), a water inlet wall (3) and an outlet wall (4) forming a hollow closed body (5) where a brewing product is contained, wherein said water inlet wall (3) comprises at least one piercing area (6) that is pierceable by piercing means (40) of said brewing device for providing one or more water inlet apertures (6a) in said capsule inlet wall (3) to feed water under pressure inside said capsule hollow body (5) in a brewing cycle, characterized in that said water inlet wall (3) comprises at least one reinforced area (7), that is distinct from said at least one piercing area (6) of said water inlet wall (3), and in that at least part of said piercing area (6) is deformable under the pressure exerted on it by the water contacting the capsule during the beverage preparation, whereby at least part of the imparted deformation is retained by the piercing area (6) at the end of said brewing cycle.

2. A capsule according to claim 1, wherein at least two reinforced areas (7) of the water inlet wall (3) are provided and said at least one piercing area (6) is defined at least in part by said reinforced areas.

3. A capsule according to claim 1 or 2 wherein said at least one piercing area (6) is deformed at least around said one or more water inlet apertures (6a), once said apertures (6a) have been provided on said piercing area (6) of the capsule inlet wall (3), whereby the piercing area (6) around said apertures (6a) is moved inwardly inside said hollow body (5) to free at least in part said apertures (6a) from said piercing means (40).

4. A capsule according to any previous claim, wherein said at least one piercing area (6) of said water inlet wall (3) is at least in part plastically deformable under the pressure exerted on said inlet wall (3) by the water injected by water injection means of said brewing device (40), said water pressure being in the range 2 bar - 6 bar, preferably 2 to 4 bar.

5. A capsule according to any previous claim, characterized in that at least one boundary line (8) is defined between said at least one reinforced area (7) and said at least one piercing area (6) of said water inlet wall (3).

6. A capsule according to any claim 2 to 5, wherein said at least one piercing area (6) and said at least one reinforced area (7) are arranged along alternate pattern on said water inlet wall (3), preferably along a radial direction connecting a peripheral edge (2c) of the lateral wall (2) towards a central axis (A) of the capsule hollow body (5).
7. A capsule according to claim 6, wherein said at least one piercing area (6) is extending continuously or discontinuously along a substantially annular area of the water inlet wall (3) between said at least two reinforced areas (7).

8. A capsule according to any previous claim, wherein after deformation at least one of said apertures (6a) in said deformed piercing area (6) is not in contact with said piercing means (40) of said brewing device.

9. A capsule according to any previous claim, wherein at least part of said at least one piercing area (6) is plastically deformed by a movement of at least 50% up to 150% of the penetration depth of said piercing means (40) of said brewing device in said water inlet wall, to determine an increased water passage between said water inlet (3) wall and said piercing means.

10. A capsule according to any previous claim, wherein at least said lateral wall (2) and said water inlet wall (3) are made in one piece of the same material.

11. A capsule according to any previous claim, wherein at least said water inlet wall (3) and said lateral wall (2) are made by injected or co-injected plastic material.

12. A capsule according to claim 11, wherein said material comprises HDPE provided with a density comprised in the range 850 - 1050 kg/ m³, preferably 0.951 kg/ m³, (measured according to ISO 1872), a melt flow rate comprised in the range 9 - 13 g/10min, preferably 11g/10min, (MFR measured according to ISO 1133), tensile stress comprised in the range 23 - 29 MPa, preferably 26 MPa, (measured according to ISO 527-2/1B).

13. A capsule according to any previous claim, wherein said water inlet wall (3) is substantially dome-shaped.

14. A capsule according to any previous claim, wherein said at least one reinforced area (7) comprises reinforcing means (10, 20) and/or it comprises at least a part having an increased thickness with respect to the thickness of said at least one piercing area (6) of said water inlet wall (3).

15. A capsule according to claim 14, wherein said reinforcing means (10, 20) defining at least one reinforced area (7) extends also at least partially on said lateral wall (2) of the capsule.

16. A capsule according to claim 14 or 15, wherein said reinforcing means (10, 20) defining at least one reinforced area (7) comprises one or more ridges (20) protruding from the water inlet wall (3) surface and arranged circumferentially and/or radially on said water inlet wall (3).
17. A capsule according to any claim 14 - 16, wherein said reinforcing means (10, 20) defining at least one reinforced area (7) comprises at least one recess portion (10) completely contained within said inlet wall (3) or extending on both said lateral wall (2) and said water inlet wall (3).

18. A system for preparing a beverage comprising a capsule (1) according to any of the previous claims and a brewing device comprising piercing means (40) for piercing said at least one piercing area (6) of said capsule water inlet wall (3) for providing one or more water inlet apertures (6a) in said capsule inlet wall (3), said brewing device further comprising water injection means to inject water under pressure inside said capsule hollow body (5) through said one or more water inlet apertures (6a), characterized in that said at least one piercing area (6) of the water inlet wall (3) is at least in part plastically deformed during the beverage preparation cycle.

19. A system according to claim 18, wherein the piercing area (6) around said apertures (6a) is deformed inwardly inside said hollow body (5) to free at least in part said apertures (6a) from said piercing means (40) during said cycle of beverage preparation.

20. A system according to claim 18 or 19, wherein said at least one piercing area (6) is at least in part deformed after said piercing area (6) of said water inlet wall (3) has been pierced by said piercing means (40) of said brewing device and said one or more water inlet apertures (6a) has been provided on said piercing area (6) of the capsule inlet wall (3).

21. A system according to any claim 18-20, wherein said at least one piercing area (6) of said water inlet wall (3) is at least in part deformed under the pressure exerted on said inlet wall (3) by the water injected by water injection means of said brewing device, preferably the water pressure is comprised in the range 2 bar - 6 bar.

22. A system according to any claim 18-21, wherein after deformation at least one of said apertures (6a) in said deformed piercing area (6) is not in contact with said piercing means (40) of said brewing device.

23. A system according to any previous claim, wherein at least part of said at least one piercing area (6) is plastically deformed by a movement of at least 50% up to 150% of the penetration depth of said piercing means (40) of said brewing device in said water inlet wall, to determine an increased water passage between said water inlet (3) wall and said piercing means (40) of said brewing device.

24. A method for preparing a beverage from a capsule (1) according to any claim 1 - 17
and a brewing device comprising piercing means (40) and water injection means, the method comprising the steps of:

a) piercing said at least one piercing area (6) of the water inlet wall (3) by piercing means (40) of the brewing device to provide one or more water inlet apertures (6a) in said capsule inlet wall (3);

characterized in further comprising the step of:

b) deforming at least part of said at least one piercing area (6) of the water inlet wall (3) under the pressure exerted on said inlet wall (3) by the water injected by water injection means of said brewing device during the beverage preparation,

whereby preferably at least part of the imparted deformation is retained by the piercing area (6) at the end of said brewing cycle.

25. A method according to claim 24, wherein said at least one piercing area (6) is deformed at least around said one or more water inlet apertures (6a), once said apertures (6a) have been provided in said piercing area (6) of the capsule inlet wall (3), whereby the piercing area (6) around said apertures (6a) is moved inwardly inside said hollow body (5) to free at least in part said apertures (6a) from said piercing means (40).

26. A method according to claim 25, wherein said at least one piercing area (6) is at least in part plastically deformed after said piercing area (6) of said water inlet wall (3) has been pierced by said piercing means (40) of said brewing device and said one or more water inlet apertures (6a) have been provided in said piercing area (6) of the capsule inlet wall (3).

27. A method according to any claim 24 - 26, wherein said at least one piercing area (6) of said water inlet wall (3) is at least in part plastically deformed under the pressure exerted on said inlet wall (3) by the water injected by water injection means of said brewing device, wherein the water pressure is in the range 2 bar - 6 bar, preferably 2 to 4 bar.

28. A method according to any claim 24-27, wherein at least two separate pressure build-up stages are occurring when said water injection means of said brewing device injects water into said capsule.

29. A method according to any claim 24 to 28, wherein said deformation of said at last one piercing area (6) occurs between the pressure build-up inside said hollow body (5) and the first outlet of the prepared beverage from the outlet wall (4).
30. A method according to any claim 24 to 29, wherein the piercing area (6) around one or more of said apertures (6a) is moved inwardly inside said hollow body (5) to free said apertures (6a) from said piercing means (40) so that said one or more apertures do not contact said piercing means (40) of said brewing device.

31. A method according to any claim 24 to 30, wherein at least part of said at least one piercing area (6) is deformed by a movement of at least 50% up to 150% of the penetration depth of said piercing means (40) of said brewing device in said water inlet wall, to determine an increased water passage between said water inlet (3) wall and said piercing means (40) of said brewing device.
Fig. 8
Fig. 10
U: Interaction Plot for Brew Yield %

Coffee A in Nespresso® capsule  Coffee A in improved capsule

Fig. 16

Pixie: Interaction Plot for Brew Yield %

Coffee A in Nespresso® capsule  Coffee A in improved capsule

Fig. 17
Fig. 20
# INTERNATIONAL SEARCH REPORT

**International application No**

PCT/EP2013/0612 13

## A. CLASSIFICATION OF SUBJECT MATTER

- **INV.** B65D85/816
- **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 A47J

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

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>WO 2012/144885 AI (BI SERKON HOLDINGS LTD [CY]; ZWEEDE SANDER GORDON [NL]; ZWEEDE SANDER GOR) 26 October 2012 (2012-10-26) pages 1-28 figures 1-32</td>
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- Date of the actual completion of the international search: 11 March 2014

- Date of mailing of the international search report: 20/03/2014

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