

PIERCING ARRANGEMENT AND RELATED BEVERAGE EXTRACTION SYSTEM

Field of the invention

The present invention relates to the field of preparation of beverages with a system including
5 a single-serve container comprising a beverage ingredient and a machine with an extraction
chamber designed to receive and extract the container.

Background of the invention

Single serve containers for the automatic preparation of beverages encompass various
10 formats of containers that can be relatively soft or flexible, such as pods, and made of any
material, recyclable or non-recyclable, biodegradable or non-biodegradable, such as
aluminium, plastic, filter paper.

WO 2020/089404 describes such a system extracting beverages from soft or flexible pods.
These pods comprise a pod body and a lid attached to the flange of the pod body: their shape
15 is asymmetrical relatively to the plane comprising the flange of the pod body. The extraction
device is provided with an extraction chamber configured to adapt its size to the shape and
volume of the pod introduced. The extraction chamber comprises:

- an upstream part defining a cage and bearing an upstream piercing arrangement for opening
the bottom wall of the pod and a liquid injector to supply liquid through the opened bottom wall,
20 and

- a downstream part defining a plate that comprises a downstream plane piercing arrangement
for opening the lid of the pod. This plate, often abusively called pyramid plate, comprises rising
elements designed to pierce, open or tear the inflated lid and holes to evacuate the beverage
flowing out of the holes in the lid created by the rising elements.

25 During the process of extraction, water is supplied in the pod through the opened bottom wall
which increases pressure inside the pod. The downstream plane piercing arrangement is
designed for opening the lid by relative engagement with the lid under the effect of this rise in
pressure of the injected liquid in the pod body chamber and inflation of the lid against the
piercing arrangement.

30 In order to respect environment, it is required today to use pods made of biodegradable and/or
compostable materials, in particular essentially made of paper.

These new materials lead to specific problems during the beverage preparation and the
handling of the pod in the extraction device, in particular optimal extraction of roast and ground
35 coffee is hardly obtained.

In the case of a material made of paper, this material can present a high thickness in order to
provide a certain rigidity for the capsule and to maintain the shape of the capsule. In addition,

since paper does not protect the beverage ingredient from the atmosphere, a material made of paper generally comprises a layer that creates a protective barrier to atmosphere. This layer is usually made of a compostable polymer and the paper material is a laminate of at least a layer of paper and a layer of said compostable barrier polymer. For example, such a barrier layer of compostable polymer is described in WO 2023/052144A1.

The use of this type of paper material impacts the correct extraction of the beverage ingredient, such as roast and ground coffee, within the extraction chamber. In particular, the compostable barrier polymer can present such stretchable properties that it is difficult to get it pierced by current existing downstream plane piercing arrangement. In particular, the material is stretched by the rising elements of the pyramid plate, but due to its stretching property, it is not systematically pierced, opened or torn on each of the rising elements. In addition, even if the material is pierced, opened or torn, due to its stretchable properties, the material tends to tightly surrounds the rising elements with the effect of covering and closing the holes configured for evacuating the beverage.

Due to these problems, optimal extraction is not obtained: flow of coffee is reduced, flow time is increased and the expected taste profile of the final coffee is not obtained. In addition, each pod is extracted differently depending on the number of openings created in the pod and the number of holes remaining free for evacuation of the beverage, which makes the system of the machine and the pod not consistent in quality of the extracted beverage.

It has been observed that this high stretchability of the material paper is particularly flagrant when the pod is used and stored in humid conditions such as tropical conditions. The stretchability of the paper material can increase by 5 times in such tropical conditions. Consequently, this problem of quality of extraction is amplified in countries with tropical climate.

In the state of the art, there have been defined different types of downstream plane piercing arrangement comprising rising elements designed to pierce the inflated wall and holes to evacuate the beverage flowing out of the openings created by the rising elements. In particular, the arrangement can position of the evacuation holes according to different embodiments.

In EP1247480 and EP81295554, the rising elements are needles presenting a conical shape. Each of these needles comprise an opening communicating with a beverage outlet conduit. This opening is a slit extending along a generating line of said conical surface. Such needles and opening do not enable a reliable piercing and evacuation of beverage when a capsule made of a stretchable paper material is used.

An object of the invention is to address the above existing problem.

Summary of the invention

In a first aspect of the invention, there is provided a piercing arrangement for piercing a pod containing a beverage ingredient, preferably roast and ground coffee, said piercing arrangement comprising:

- 5 - a plate wherein the upper surface of said plate comprises opening elements rising from said surface, and
 - traversing holes,
- and each of said opening elements present:
 - a tip end, and
- 10 - a surface comprising a beverage outlet opening cooperating with the traversing holes, wherein the piercing arrangement is an assembly of an upper sub-part plate and a lower sub-part plate,
 - and wherein, for each of said opening elements,
 - the beverage outlet opening is positioned above an intermediate position (h) between the
 - 15 upper surface of the plate and the tip end of the opening element, and
 - the beverage outlet opening is a slit extending along a plane parallel to the plane of the upper surface of the plate, and
 - wherein the upper sub-part plate and the lower sub-part plate are designed so that, when assembled, the beverage outlet opening and/or the opening elements are formed.

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In an embodiment, the surface of the beverage outlet opening is dimensioned to filter grains presenting a diameter of about 0.3 mm.

In an embodiment, the slit can present length L of about 0.5 mm and a height of about 0.15 mm.

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In an embodiment, for each of the opening elements:

- the upper sub-part plate comprises an upper sub-part of the opening element rising from the upper surface of the upper sub-part said plate and a corresponding receiving hole extending through said upper plate, and
- 30 - the lower sub-part plate comprises a corresponding lower sub-part of the opening element rising from the upper surface of said lower sub-part plate and a corresponding traversing hole extending through said lower sub-part plate to evacuate the beverage, and
 - wherein the receiving hole of the upper plate is designed to receive the lower sub-part plate of the opening element of the lower plate when the sub-part plates are assembled, and
 - 35 wherein the upper and lower sub-parts of the opening element are designed so that, when the sub-part plates are assembled, the beverage outlet opening is formed between the assembled sub-parts of the opening elements.

The use of an assembly of two sub-part plates to form the piercing arrangement provides the advantage of defining beverage outlet openings of very small size and to reach an opening size that would not be possible to obtain by manufacturing the device in one piece of material. This device is usually made of plastic and manufacturing by plastic injection does not enable
5 the design of holes smaller than 0.4 mm, in particular slits with dimensions inferior to 0.5 mm.

In an embodiment, the opening elements comprise:

- a base presenting the shape of a truncated cone,
 - the tip end presenting the shape of a cone,
- 10 wherein the cone and the truncated cone present the same axis, and
wherein the angle (α_2) of the generating line of the cone of the base with the axis is smaller than the angle (α_1) of the generating line of the cone of the tip end with the axis.

As a result, the encroachment of numerous opening elements on the surface of the plate can be minimised while keeping a sufficient height of the tip end of the opening elements above
15 the upper surface of the plate. A paper wall of the pod, as better detailed below, can be pierced by a sufficient number of opening elements and flattened against the surface of the plate between the opening elements with less risk that the paper becomes folded and that it plugs the beverage outlet openings. The shape design of the opening elements provides a sufficient distance between the numerous opening elements and limits that risk.

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In an embodiment, in the upper sub-part plate, the upper sub-part of the opening element comprises:- an end that is the cone-shaped tip end of the opening element, and

- a base corresponding to a longitudinal truncation of the base of the opening element.

25 In an embodiment, in the lower sub-part plate, the lower sub-part of the opening element rising from the upper surface of said lower sub-part plate:

- presents a base complementary to the base of the opening element of the upper sub-part, and
- comprises an indent designing the beverage outlet opening and the beverage outlet conduit
30 when assembled to the corresponding upper sub-part of the opening element.

In a second aspect, there is provided a beverage extraction device for extracting a beverage from a pod, said pod containing a beverage ingredient, preferably roast and ground coffee, said extraction device comprising:

- 35 - upstream and downstream pod enclosing parts relatively movable between an open position for inserting and/or ejecting the pod and a closed position for forming an extraction chamber enclosing the pod during extraction,

- the upstream part bearing:
 - . an upstream piercing arrangement for opening a first enclosing wall of the pod and
 - . a liquid injector,
 - the downstream part comprising a downstream piercing arrangement for opening an
- 5 enclosing wall of the pod, during the operation of extraction, said downstream piercing arrangement being a piercing arrangement such as described above.

The extraction device is typically comprised in a beverage preparation machine configured for receiving pods. Preferably it is a coffee machine, though the machine can be designed to

10 prepare tea, chocolate or soup for instance, depending on the ingredient enclosed in the pod. In particular, the device is arranged for preparing within the extraction chamber a beverage by passing water, preferably hot, or another liquid through a pod containing an ingredient of the beverage to be prepared, preferably roasted ground coffee, or eventually tea leaves or instant coffee or instant tea or chocolate or cacao or milk powder or dehydrated soup. In the preferred

15 embodiment, the beverage ingredient is roasted and ground coffee.

The device is configured for extracting a beverage ingredient contained in a pod by supplying an extraction liquid such as water into the pod. The device comprises upstream and downstream pod enclosing parts relatively movable between an open position for inserting

20 and/or ejecting such pod and a closed position for forming an extraction chamber enclosing the pod during beverage ingredient extraction.

In an embodiment, upstream and downstream pod enclosing parts are relatively translatable along a longitudinal axis (XX'). Typically, the pod can be inserted into the device from above under the effect of gravity. Ejection or removal of the pod upon reopening of the enclosing

25 parts may also be driven by gravity.

Generally, during the preparation of a beverage, the extraction device is configured:

- in a first step, to enclose the pod between the upstream and downstream pod enclosing parts, and
- 30 - then, in a second step, to introduce liquid inside the enclosed pod through the liquid injector.

The upstream part or injecting part comprises an upstream piercing arrangement in the form of one or more piercers for piercing the first wall of the inserted pod and at least one liquid injector for supplying liquid through the pierced first wall of the pod.

35 This upstream piercing arrangement can comprise piercers in the form of blades. These blades can be designed and positioned to pierce the first wall of the pod body when the upstream and downstream pod enclosing parts are brought to the closed position. The liquid injector, such

as a shower at the upstream part of the cage, can introduce the extracting liquid through the pre-pierced openings.

In an alternative, this upstream piercing arrangement can comprise at least one hollow needle configured to pierce the wall of the bottom of the pod body and the hollow needle(s) can
5 comprise an internal axial channel for guiding the extracting liquid in the chamber of the pod.

The downstream part or dispensing part defines a downstream piercing arrangement for opening the second wall of the pod when the extracting liquid is introduced inside the pod. Usually, this downstream plane piercing arrangement is designed for opening the second wall
10 by relative engagement with the second pod enclosing wall under the effect of the rise in pressure of the injected liquid in the chamber of the pod and inflation of the second wall against the piercing arrangement. This downstream plane piercing arrangement comprises a plate, that is preferably rigid, and that comprises opening elements.

In addition, the plate comprises traversing holes to evacuate the beverage dispensed from the
15 opened second wall to a tube or nozzle collecting and dispensing beverage to a drinking cup. Generally, the opening elements present a shape enabling the opening, piercing, cutting or tearing of the second enclosing wall. Usually, this shape is such that the transversal section decreases from the bottom to the end. These opening elements can present the shape of pyramids, stepped pyramid or preferably a conical shape. The shape can be a combination of
20 a bottom cylindrical or parallelepiped part and a top pyramidal or conical end. Preferably, the opening elements present a conical shape.

Whatever the shape, the opening elements present a tip end. This end is sufficiently pointed to pierce or cut the paper layer of the paper material when this paper layer is pressed on the tip end, in particular when the upstream and downstream enclosing parts are moved from the
25 open position to the closed position forming the extraction chamber around the pod. Preferably, this tip end presents a conical shape.

This tip end extends by a height H from the upper surface of the plate. Generally, this height (H) can be defined according to the nature of the material of the pod designed to be used in the extraction device. In particular, the height must be sufficient to obtain the opening of the
30 paper material when the paper material is pressed against the tip end during inflation of the lid due to the rise of pressure inside the pod while water is being injected. In general, the height (H) can be of at least 1.5 mm.

In addition, the surfaces of the opening elements comprise beverage outlet openings which cooperate with the traversing holes of the downstream piercing arrangement. Accordingly,
35 beverage produced in the pod is able to flow through these outlet openings of the opening elements and to be dispensed out of the extraction chamber.

In an opening element, the beverage outlet opening is positioned above an intermediate position (h) between the upper surface of the plate and the tip end of the opening element, and preferably closer to the tip end of the opening element rather than from the upper surface of the plate. As a result, the chance that the beverage outlet opening is positioned above the torn stretchable paper is increased compared to outlets positioned inside the plate or positioned at the interface of the plate and the bottom of the opening elements.

This intermediate position (h) can be defined according to the nature of the material of the pod designed to be used in the extraction device. In particular, the height must be sufficient to guarantee that the stretched paper does not cover the beverage outlet opening when the paper material is pressed against the tip end during inflation of the lid due to the rise of pressure inside the pod while water is being injected. For example, the intermediate position can be set at least 1 mm from the surface of the plate.

When the beverage ingredient is roasted and ground coffee, the intermediate position (h) can be defined too so that the beverage outlet is positioned inside the bed of roasted and ground coffee enclosed in the pod.

In addition, in an opening element, the beverage outlet opening is a slit, such as long narrow space or long thin cut, and this slit is oriented to extend along a plane parallel to the plane of the upper surface of the plate (that is a plane transverse to the central axis of the cone too). As a result of this orientation of the slit, there is a limited risk that the torn stretchable paper remains stretched above a part of the slit and a consistent dispensing can be obtained because the outlet is not partially blocked by the paper resulting in a hazardous dispensing surface.

Preferably, all the opening elements comprise a beverage outlet.

Preferably, all the beverage outlets present the same shape.

Usually, the shapes of the upstream and enclosing parts of the extraction device are defined according to the shape of the pod configured to be extracted therefrom. Usually, these shapes are configured so that the internal walls of the closed extraction chamber correspond to the external shape of the pod.

In an embodiment, the extraction device can be designed to extract a pod that presents an asymmetrical shape. In particular, the pod can be configured so that:

- the first enclosing wall is a pod body, said pod body comprising a side wall and a bottom wall defining the chamber and a circumferential annular body flange, said pod body containing the beverage ingredient, and

- the second enclosing wall is a top lid attached to the circumferential flange, said top lid closing the top opening of the pod body.

Then, the extraction device is configured so that:

- the upstream part defines a cage designed to enclose the pod body and bears an upstream piercing arrangement for opening the bottom wall of the pod,
- the downstream part defines a plate transverse to the longitudinal axis (XX'), said plate comprising a downstream piercing arrangement for opening the lid of the pod.

5 When a pod is present and ready for extraction, the pod body is surrounded by the cage of the upstream part and the pod lid extends along the downstream piercing arrangement. The asymmetrical shape of the pod presents the advantage of forcing the operator to position the pod correctly inside the extraction device, precisely with the lid in front of the downstream piercing arrangement.

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In another embodiment, the extraction device can be designed to extract a pod that presents a symmetrical shape. In particular, the pod can be configured so that:

- each of the first and second enclosing walls is a pod body, said pod body comprising a side wall and a bottom wall defining half of the chamber and a circumferential annular body flange,
- 15 - the circumferential annular body flanges of said pod bodies are attached together.

Then, the extraction device is configured so that the upstream and downstream parts define together a cage for enclosing the pod.

In this second embodiment, generally, the upstream and downstream enclosing parts present similar shapes corresponding to said half-shells and the pod is symmetric along the plane defined by the flange. Accordingly, this pod can be indifferently oriented with the first enclosing all or the second enclosing wall facing the upstream pod enclosing part or the downstream enclosing part. For this reason, preferably both enclosing walls present the same nature of material as described below.

25 In a third aspect, there is provided a beverage preparation machine comprising a beverage extraction device such as described above.

Generally, this beverage machine comprises a liquid supply system connected to the upstream enclosing part. This liquid supply system can comprise:

- 30 - a liquid supply such as a liquid tank,
- pumping means to drive liquid from the liquid supply to the extraction device,
- heating and/or cooling means to adapt the temperature of the liquid before it is introduced inside the pod.

The liquid is usually water.

35 The beverage machine can comprise means to actuate the movement of the upstream and enclosing parts of the extraction device either in a manual manner or motorized manner.

Usually, the beverage machine comprises a control unit configured to control the supply of

liquid to the extraction device.

In an embodiment, the extraction device can be part of a beverage preparation machine and attached in the machine in a non-removable manner. Each of the downstream and enclosing
5 parts are fixedly attached to the machine and configured to be relatively movable one to the other inside the machine during the operations of preparation of a beverage.

Generally, the machine can comprise an insertion section for inserting the pod in the device. Generally, this section is positioned above the upstream and downstream pod enclosing parts so that the pod is inserted by gravity between these two parts. Depending on the shape of the
10 pod, this insertion section can be designed so that the user is urged to position the pod with its lid facing the downstream piercing arrangement.

In another embodiment, the downstream part of the extraction device can be positioned in the beverage machine in a removable manner.

15 In particular, the machine can comprise:

- a removable pod holder configured for receiving and holding the pod, and
- a pod holder receiving area for receiving this removable pod holder,

wherein the removable pod holder comprises at least the downstream part of the extraction device.

20 With such a machine, in order to introduce a pod in the machine, the pod holder is removed from the receiving area of the machine and a pod is positioned inside the holder. The pod holder is then moved into the receiving area of the machine, where the pod becomes ready for extraction.

In particular, the extraction device can be manually removed from the beverage machine
25 during the step of introduction and ejection of the pod and then manually introduced back in the machine for the beverage extraction.

In one first mode, the upstream part of the extraction device can be fixed in a non-removable manner inside the receiving area of the machine. Accordingly, when the pod holder is received
30 in the receiving area, the extraction device is formed around the pod.

In one second preferred mode, the removable pod holder comprises the upstream part of the extraction device. Accordingly, when the pod is introduced inside the pod holder, it can already be enclosed between the downstream part and the upstream part of the extraction device, then the pod holder just needs to be introduced in the receiving area to enable the connection
35 of the upstream part with a liquid supply.

Either in the first or second mode, this machine can comprise actuating means configured to move the pod holder and a liquid supply, such as a needle, relatively one to the other to enable the introduction of the liquid in the pod hold in the holder.

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In a fourth aspect, there is provided a system comprising a beverage preparation machine and a pod containing a beverage ingredient, preferably roast and ground coffee, wherein the beverage preparation machine is a beverage preparation machine such as described above or comprises an extraction device such as described above, and

10 wherein the pod comprises a first and a second enclosing walls, said first and second pod enclosing walls defining a chamber for enclosing the beverage ingredient, and wherein said first and second pod enclosing walls of the pod are made of a material, and wherein at least a part of said material is stretchable.

Due to the configuration of the opening elements of the downstream piercing arrangement, in particular the position and the orientation of their beverage outlets, the risk the stretched material covers these outlets is avoided and consistent coffee extraction operations can be obtained.

15 In particular, the system enables consistent extraction when a stretchable part of said material presents an elongation at break of at least 40 %.

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In an embodiment, the first and second pod enclosing walls of the pod are made of a multilayer paper material, said material comprising at least one layer of paper (A) assembled with at least one layer of plastic (B), preferably a compostable plastic layer, said layer of plastic being stretchable.

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The system can comprise pods made of a material wherein the elongation at break of the stretchable part of the material increases when said stretchable part of the material is submitted to:

- a temperature of 30°C in an atmosphere presenting a water vapour rate of 70 % during 48 hours, which corresponds to use of the pods in tropical climate, or
- 30 - a temperature of 20°C in an atmosphere presenting a water vapour rate of 65 % during one week, which corresponds to storage of the pods in a temperate climate before they are used.

Consequently, the system can be used with pods presenting a variable stretching property depending on the conditions of storage or use of these pods. Even if the stretchable part of the material becomes more stretchable due to long storage in temperate climate or use in hot and humid conditions, like tropical conditions, a consistent extraction can be reached.

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Usually, this multilayer paper material is oriented so that at least one layer of plastic faces the internal part of the chamber of the pod.

- 5 Preferably, the pod contains a compacted beverage ingredient, preferably compacted roast and ground coffee.

When a part of the extraction device pushes the pod to press it against the opening elements of the downstream piercing arrangement, compacted coffee provides a counter surface that improves the tearing of the paper layer during the first step.

- 10 For example, coffee can be compacted as described in WO2020/089403 or any other process.

Usually, the layer of paper of this multilayer paper material can be a sheet of paper.

Alternatively, but preferably for the pod body, this layer of paper can be formed:

- by wet pulp moulding. Therein, the process of forming the body may comprise the step of
15 placing pulp slurry in a mould, for example by filling the mould with the slurry or by drowning the mould in the slurry. The pulp slurry may be pressed in the mould, and the so formed body may be dried. The pulp can be a material, such as cellulose pulp, bamboo pulp, wood pulp, bagasse, non-wood pulp, cellulose based pulp or other alternative sources of pulp in any form.
or

- 20 - by dry pulp moulding. Therein, the process of forming the body may comprise the step of providing a blank of preferably dried cellulose fibres. Then, the blank may be formed with a tool preferably under the application of heat and/ or water into the shape of the body.

- Preferably, the layer of paper of the multilayer paper presents a grammage of at least 20 g/m², preferably at most 150 g/m². The layer of paper of the forming wall forming the body can
25 present a higher grammage than the layer of the paper in the lid because it needs to be stretched and deformed during manufacturing.

The layer of paper of this multilayer paper material can also be identified as the primary layer in the present application.

- 30 Whatever the type of the layer of paper, this layer of paper is assembled with at least one layer of plastic. This layer of plastic can also be identified as the secondary layer in the present application.

The layer of plastic can be selected in the list of:

- a polylactic acid (PLA) layer,
35 - a polybutylene succinate (PBS) layer,
- a polybutylene adipate terephthalate (PBAT) layer,
- a polyhydroxy alkanoate (PHA) layer,

- a polycaprolactone (PCL) layer,
- a layer of a polymer blend formed of any combination of above polymers.

The paper layer can be assembled with several of these different layers of plastic.

This plastic layer reinforces the protection of the paper layer against liquid, gas and moisture

5 for the beverage ingredient.

Usually, the part of the multilayer paper material that is stretchable is this layer of plastic.

In addition to these paper and plastic layers, preferably, the multilayer paper material can
10 comprise an additional layer of material providing a barrier to oxygen. This layer can also be identified as the tertiary layer in the present application.

This layer can be selected in the list of:

- a polyvinyl-alcohol copolymer (PVOH) layer, in particular a butenediol-vinyl-alcohol-copolymer (BVOH) layer,
- a polyglycolic acid (PGA) layer,
- 15 - a metallization coating,
- a SiO_x based coating,
- an AlO_x based coating,
- a combination thereof.

20 It has been noticed that a polyvinyl-alcohol copolymer (PVOH) layer, in particular a butenediol-vinyl-alcohol-copolymer (BVOH) layer, can present variable stretchable properties.

Consequently, for pods made of a material including at least a layer of this type of copolymer, the use of the piercing arrangement according to the present invention is particularly recommended.

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In one particular embodiment where this additional or tertiary layer is a plastic polymer, the secondary and tertiary layer can be assembled together as a multilayer plastic film. In this embodiment, this multilayer layer of plastic can comprise the internal tertiary layer positioned between two external secondary layers.

30 Preferably, the internal tertiary layer is a polyvinyl alcohol copolymer (PVOH) film, in particular a butenediol vinyl alcohol (BVOH) film.

Preferably, the external secondary polymer layers can be chosen among films of polylactic acid (PLA), polybutylene succinate (PBS), polyhydroxyalkanoates (PHA), polybutylene adipate terephthalate (PBAT) and starch. The secondary film can also be composed of a
35 polymer blend formed of any combination of these listed polymers,

Preferably, these three layers are attached by means of two intermediate adhesive layers, preferably an anhydride modified polymer resin. Generally, this multilayer layer of plastic is produced by co-extrusion.

- 5 The multilayer paper material can further comprise an ink printing on one of its surfaces. The ink printing is preferably food safe.

The multilayer paper material can further comprise a protective layer at its most external surface. This protective layer can provide a protection in case of ink printing. In that case this
10 protective layer is preferably transparent.

In addition, depending on the quality of the used paper, this protective layer can provide the function of preventing paper from sticking to the downstream piercing arrangement with the risk that some small pieces of torn paper remain attached to the downstream piercing arrangement when and after the pod is ejected from the extraction device.

15 The assembly of the different layers of the material can be obtained by any type of process depending on the nature of the layers such as:

- co-lamination or co-extrusion of the layers,
- coating or deposit of one compound on another layer to form a layer on the other,
- 20 - co-extrusion coating.

In addition, the different layers can be bound one to the other by an intermediate adhesive layer.

Generally, the first and the second enclosing walls are made of the same multilayer paper
25 material except that, at least for the second enclosing wall, the external surface of the multilayer paper material is covered by a protective layer. Depending on the type of pod, all the enclosing walls can be covered by this protective layer, this is particularly the case when the pod can be introduced in whatever orientation inside the extraction device, like for the second embodiment of the pod described above.

30 This protective layer can be:

- a polylactic acid (PLA) layer,
- a cellulosic layer (cellophane),
- a polybutylene succinate (PBS) layer,
- a polybutylene adipate terephthalate (PBAT) layer,
- 35 - a polyhydroxy alkanoate (PHA) layer,
- a polycaprolactone (PCL) layer,
- a layer of a polymer blend formed of any combination of the above listed polymers.

Preferably, this protective layer is a film comprising regenerated cellulose, in particular Cellophane™.

Usually, the system is configured to extract a coffee beverage from pod comprising roast and ground coffee. In this process of preparation of a coffee beverage from the system, at least the following steps occur:

- in a preliminary step, the pod is inserted between the upstream and downstream pod enclosing parts that are positioned in their opened position. This operation can be operated manually by the user or automatically by a motor of the beverage machine. Usually, the pod is received in a pod holder that keeps it between the two pod enclosing parts which are held far from each other in their opened positions.

- then, in a first step, the upstream and/or downstream pod enclosing parts are moved relatively one to the other to their closed position in order to form the extraction chamber that encloses the pod for the coming extraction. At that step, the external surfaces of the first and second walls of the pod are in contact with the surfaces of the upstream piercing arrangement and the downstream piercing arrangement. Usually, the upstream piercing arrangement, such as blades or hollow needle, pierces the first enclosing wall of the pod, except if this upstream piercing arrangement is retractable and can be moved in a further step.

- then, in a second step, the extraction water is injected by the liquid injector through holes pierced inside the first wall of the pod by the upstream piercing arrangement. As water is being injected, it fills the chamber of the pod. Pressure rises until the second wall of the pod opens. Opening happens when the pressure makes the second wall inflate so much that its engagement with the downstream piercing arrangement tears or pierces it. Once tearing happens, coffee extracted by pressurised water from roast and ground coffee flows and is dispensed from the machine.

In the present application:

- the term "pod" is used to broadly designate any kind of single-dose container suitable for preparing beverages or other edible products such as capsule, cartridge, portioned or individual package without limitation to the shape of this container, in particular the shape of the body, or the types of piercing means needed to extract the beverage therefrom.

- the expression "compostable material" may be understood as any material that can be broken down into environmentally innocuous products by (the action of) living things (such as microorganisms, e.g., bacteria, fungi or algae). This process could take place in an environment with the presence of oxygen (aerobic) and/or otherwise without presence of

oxygen (anaerobic). This may be understood, for example, as meaning that composting can be carried out without reservation. In particular, at the end of a composting process there are no residues of the material, which may be problematic for the environment, or any non-biodegradable components. International standards, e.g., EU 13432 or US ASTM D6400, specify technical requirements and procedures for determining compostability of a material.

- elongation at break is provided according to ASTM D 882 at room temperature.

- machine direction relates to the machine direction orientation (MDO) of the polymer film during the manufacturing of said film and cross direction to the transversal direction to this machine direction orientation.

The above aspects of the invention may be combined in any suitable combination. Moreover, various features herein may be combined with one or more of the above aspects to provide combinations other than those specifically illustrated and described. Further objects and advantageous features of the invention will be apparent from the claims, from the detailed description, and annexed drawings.

Brief description of the drawings

Specific embodiments of the invention are now described further, by way of example, with reference to the following drawings in which:

- Figures 1A and 1B are views of pods used in the system of the present invention according to a first embodiment,
- Figures 1C and 1D are views of pods used in the system of the present invention according to a second embodiment,
- Figure 1E schematically illustrates the multilayer paper material of the pods,
- Figures 2A and 2B are side and top views of an extraction device used in the system of the present invention in the closed position,
- Figure 3A is an isolated side view of the upstream and downstream pod enclosing parts of the extraction device in the opened position,
- Figure 3B is an isolated side view of the upstream and downstream pod enclosing parts of Figure 3A in the closed position,
- Figure 3C is an isolated side view of the upstream and downstream pod enclosing parts of Figure 3A in the position of ejection of the pod,
- Figure 4A is an isolated perspective view of the upstream pod enclosing part of Figure 3A,
- Figure 4B is an isolated perspective view of the piercing arrangement of the downstream pod enclosing part of Figure 3A,

- Figure 5 is a schematic view of the fluid system of the beverage preparation machine,
- Figure 6A is a perspective view of a downstream piercing arrangement of an extraction device according to the invention,
- Figure 6B is a magnified view of the opening elements of the downstream piercing arrangement of Figure 6A,
- Figure 7 is a side view of one opening element of the downstream piercing arrangement of Figure 6A,
- Figure 8 is a magnified view of the slit in the opening element of Figure 7,
- Figure 9 is a perspective view of a transversal section of the downstream piercing arrangement of Figure 6A,
- Figure 10A is a side view of opening elements of the downstream piercing arrangement of Figure 6A,
- Figure 10B is a top view of the downstream piercing arrangement of Figure 6A,
- Figure 11A a perspective view of the upper sub-part of the downstream piercing arrangement of Figure 6A,
- Figure 11B is a magnified view of Figure 11A,
- Figure 12A a perspective view of the lower sub-part of the downstream piercing arrangement of Figure 6A,
- Figure 12B is a magnified view of Figure 12A,
- Figure 12C is another point of view of the opening elements sub-part of Figure 12B,
- Figures 13A and 13B illustrate the assembly of the lower and upper sub-parts of Figures 11A and 12A, Figure 13A providing an upper view of the upper sub-part and Figure 13B providing a lower view of the upper sub part,
- Figures 12D and 12E illustrate an alternative production of the upper sub-part of the assembly,
- Figure 14 is a partial view of a downstream piercing arrangement according to the state of the art,
- Figure 15 illustrates a beverage machine comprising a removable extraction device according to the invention.

Detailed description of exemplary embodiments

Figures 1A (perspective view) and **1B** (exploded view) illustrate a first embodiment of the pods 3 that can be used in the extraction device of the invention.

The pod 3 comprises a pod body 31 with one sidewall 311 that extends axially from a bottom wall 313 towards a top. The sidewall 311 extends towards a top opening 312. At the top opening 312, the body comprises a circumferential annular flange 314 that extends radially outward from the sidewall 311 along the circumference of the opening 312.

The flange comprises a top surface 3142 facing the top and a bottom surface 3141.

Generally, any transversal cross section of the body is circular from the bottom to the top and the flange is circular too.

The body delimits a chamber for containing a beverage ingredient.

- 5 This beverage ingredient packed is preferably an ingredient able to be extracted under pressure like roast and ground coffee. Preferably, this roast and ground coffee is compacted. In a less preferred manner, the beverage ingredient can be infused like tea leaves or dissolved like a water soluble powder ingredient such as : instant coffee powder, milk powder, cream powder, instant tea powder, cocoa powder, soup powder, fruit powder or mixture of said
- 10 powders or even a soluble liquid ingredient or a beverage concentrate such as a syrup or milk concentrate. The powders can be compacted, agglomerated or sintered.

The capsule comprises a lid 32 that is fixed, sealed or attached to at least a part of the top surface 3142 of the circumferential flange and accordingly covers and closes the top opening 312.

- 15 The bottom wall 313 is adapted to be pierced so that liquid can be injected in the pod through the pierced openings, as described further below. In Figures 1A-B, this bottom is rather flat, yet the bottom can present other shapes such conical or frustoconical shapes.

The lid 32 is adapted to be opened by relative engagement with a piercing arrangement under the effect of the liquid pressure increase inside the pod during injection of liquid.

- 20 The pod shape is symmetric relatively to the central axial axis ZZ' extending from the bottom wall to the lid and the pod shape is asymmetrical relatively to the plane of the lid 32 and the flange 314.

- Preferably the pods 3 are essentially made of a biodegradable or compostable material,
- 25 preferably a home compostable material since extracted coffee cakes can easily be made composted at home.

- Preferably, the body and the lid of the pod are made of a multilayer paper material, that comprises a layer of paper coated with at least a layer of plastic.

30

- In this multilayer paper material, the paper layer is formable, i.e., a sheet of paper can be given a three-dimensional shape that is the form of the body of the above-described pod. Contrary to common pods made of filter paper, this paper is thick and keep the three-dimensional shape provided during a shaping step of manufacturing of the pod in order to enable handling and
- 35 extraction in the extracting device of the present invention.

Preferably, the paper layer of the pod can have a grammage of at least 20 g/m², preferably at most 150 g/m². The paper of the body can present a higher grammage than the paper of the lid because it needs to be stretched and deformed during manufacturing.

The grammage of the paper of the body can be comprised between 80 and 150 g/m².

- 5 The lid can present a grammage comprised between 20 and 120 g/m².

In the multilayer paper material, the layer of plastic provides additional properties such as air barrier, stretchable or deformable properties, for example as described in WO 2020/114995 or WO 2022/022899.

- 10 In fact, in order to shape the paper as a container for the beverage and to create a barrier to protect the beverage ingredient, the paper must be sufficiently thick. In addition, to create a barrier to atmosphere, in particular oxygen to which roast and ground coffee is particularly sensitive, the multilayer paper comprises compostable layers of plastic. Sealants layers are often necessary to attach the different layers and prevent delamination.

- 15 According to the preferred embodiment, the layer of plastic of the multilayer paper is a multilayer layer of plastic comprising an internal barrier film positioned between two external polymer films, wherein:

- the internal barrier film is a butenediol vinyl alcohol (BVOH) film (tertiary layer),
 - the external polymer films can be chosen among films of polylactic acid (PLA), polybutylene succinate (PBS), polyhydroxyalkanoates (PHA), polybutylene adipate terephthalate (PBAT) and starch (secondary layer).
- 20

This layer provides the part of the paper laminate with stretching properties, in particular the internal barrier film made of butenediol vinyl alcohol (BVOH) film.

- 25 The multilayer paper material of the lid can comprise at least one additional layer that the paper material of the body does not necessarily comprise. Yet, it is possible that the multilayer paper materials of the lid and the body are the same too.

- Precisely, the external surface of the multilayer paper material of the top lid can be covered by a protective layer. According to the preferred embodiment, this protective layer is a film comprising regenerated cellulose. Like the layer paper, this protective layer is torn by the downstream piercing arrangement during the first step.
- 30

Figure 1E schematically illustrates the multilayer paper of the lid 32 comprising from the internal surface facing the chamber to the external surface facing the outside of the pod:

- 35
- a layer of plastic B with barrier properties,
 - a layer of plastic A,
 - optionally a protective layer C.

Figures 1C (perspective view) **and 1D** (exploded view) illustrate a second embodiment of the pods 3 that can be used in the extraction device of the invention.

The pod comprises the first and second enclosing walls 31, 31' that are identical: each of them
5 comprise is a pod body 311, 311', said pod body defining half of the chamber and a circumferential annular body flange 314, 314', and
. the circumferential annular body flanges of said pod bodies are attached together so as to delimit a chamber for containing the beverage ingredient 33.

With this second embodiment, the pod shape is symmetric relatively to the central axial axis
10 ZZ' extending from the bottom wall to the lid and relatively to the plane of the attached flanges 314, 314'. Consequently, the pod can be indifferently oriented inside the extraction device with the first enclosing all 31 or the second enclosing wall 31' facing the upstream pod enclosing part. For this reason, it is preferable that both enclosing parts 31, 31' present the same the multilayer paper material with the external surface covered by the protective layer C_as
15 illustrated in Figure 1E.

Below description relates to an extraction device that can be used with the above pods 3 according to the first embodiment of Figure 1A, 1B in an advantageous manner.

For the pods according to the second embodiment, below description applies with the
20 difference that the extraction device must be adapted to receive such pods. For example, the extraction device described in WO2007/135135, WO2004/071259, WO2013026844 or EP1767129 can be used.

Figure 2A is a side view of an extraction device according to the invention comprising an
25 upstream pod enclosing part 2 and a downstream pod enclosing part 1 relatively translatable along a longitudinal axis XX'. Usually, this axis XX' is essentially horizontal. In Figure 2A, these two parts are in a closed position and form an extraction chamber configured to enclose a pod during extraction. The pod is introduced through an insertion section 4 positioned above the two enclosing parts 1, 2, from which it can fall by gravity to these two enclosing parts 1, 2.
30 After extraction, the pod can fall by gravity again below these two enclosing parts 1, 2 when they move apart one from the other. The arrow F illustrates the movement of the pod from the insertion inside the extraction device to the ejection from said device.

The two pod enclosing parts 1, 2 are hold and movable between two lateral and longitudinal metal sheets 6a, 6b. At least one of these parts is movable in translation between these two
35 sheets in order to assess different relative and functional positions. In the preferred illustrated embodiments, the downstream enclosing part 1 is fixed and only the upstream enclosing part 2 is movable back and forth along the longitudinal axis XX'.

Figure 2B is a top view of the extraction device in the same relative positions of the upstream pod enclosing part 2 and the downstream pod enclosing part 1. The insertion section 4, in particular its housing, is designed to enable the introduction of the pod 2 with its lid 32 facing the downstream pod enclosing part 1 and accordingly the piercing arrangement 12 of said
5 enclosing part as developed below. Consequently, the user is urged to position correctly the asymmetric pod 3 inside the extraction device.

As illustrated in **Figure 5**, in the beverage preparation machine that comprises the extraction device, the upstream pod enclosing part, precisely the liquid injector 25, is connected with a
10 supply of liquid, preferably pressurised water. This liquid supply system usually comprises:

- a liquid supply such as a liquid tank 71,
- a pump 72 to drive liquid from the liquid supply to the liquid injector 25,
- heating and/or cooling means 73 to adapt the temperature of the liquid before it is introduced inside the pod by the liquid injector.

15 This beverage machine comprises a control unit 8 configured to the supply of liquid to the extraction device.

The downstream pod enclosing part 1 is configured to collect the beverage 91 prepared from the extraction of the pod and to dispense it in a drinking cup 9 by means of a dispensing pipe.

20 **Figures 3A-3C** are isolated side views of the upstream and downstream pod enclosing parts 1, 2 of the extraction device of Figures 2A, 2B in different relative and functional positions. In these isolated views, the insertion section 4 and the longitudinal sheets 6a, 6b were removed for a better vision of the different elements of the parts 1, 2. In addition, the position of the pod 3 is schematically illustrated in dotted lines.

25 In **Figure 3A**, the upstream and downstream pod enclosing parts 1, 2 are positioned in the open position for inserting a pod from the upper side. A pod holder 11 is visible in front of the downstream pod enclosing part 1 in a receiving position for receiving and holding the pod as further described below in relation with Figure 4A.

In **Figure 3B**, the upstream and downstream pod enclosing parts 1, 2 are positioned in the
30 closed position and form an extraction chamber enclosing a pod during extraction.

Figure 3C illustrates the moment where the upstream pod enclosing part 2 is being moving from the closed position of Figure 3B to a pod ejection position as showed by arrow H.

Figure 4A is an isolated perspective view of the upstream pod enclosing part 2 of Figures 3A
35 and 3B.

The upstream part defines an empty cage or cavity 21 for enclosing the pod body.

The upstream wall of the cage bears an upstream piercing arrangement 22 for opening the bottom wall 313 of the pod body. The upstream wall comprises at least one liquid injector 25 for supplying liquid into the pod through the holes opened in the bottom wall of the pod.

This upstream piercing arrangement can comprise piercers in the form of blades. These blades
5 can be designed and positioned to pierce the wall of the bottom of the pod body when the upstream and downstream pod enclosing parts are brought to the closed position as in Figure 3B. The liquid injector 25, such as a shower at the upstream wall of the cage, can introduce the extracting liquid in the cage and through the pre-pierced openings.

10 **Figure 4B** is an isolated perspective view of the downstream pod enclosing part 2 of Figure 3A. The downstream part 1 defines a plate perpendicular (that is transverse) to the longitudinal axis XX'. This plate comprises a fixed central downstream plane piercing arrangement 12 for opening the lid 32 of the pod when the extracting liquid is introduced inside the pod and inflates the lid. Usually, this central downstream plane piercing arrangement 12 is circular like the lid
15 of the pod.

Opening happens by relative engagement of opening means 122 with the lid under the effect of the rise in pressure of the injected liquid in the pod body chamber.

The downstream part 1 comprises a pod holder 11 that is attached to the peripheral area 13. While being attached the pod holder can be moved between two positions. In Figure 4B, the
20 pod holder 11 is in the first position for receiving and holding the lid of the pod in front of the downstream plane piercing arrangement. When the upstream enclosing part is moved to the downstream enclosing part and the chamber is closed, this movement urges the lid of the pod against the downstream plane piercing arrangement 12. Simultaneously, the pair of retaining elements 11a, 11b are moved from the receiving position to a second retracted position at the
25 lateral sides of the downstream plane piercing arrangement.

Although the design of the enclosing parts illustrated Figures 4A and 4B are specific to the extraction of pods such as illustrated in Figures 1A, 1B (pod shape asymmetrical relatively to the plane of the lid and the flange), the principle of the downstream piercing arrangement 12
30 described below applies to the downstream enclosing part designed for the extraction of pods such as illustrated in Figures 1C, 1D.

Figure 15 illustrates an alternative embodiment to the beverage preparation machine of Figure 5. This machine comprises a capsule holder 10 that is removable from a receiving area 101
35 of the machine for the operations of introduction of the pod 3 and ejection of the pod in a manual manner. The pod holder 10 comprises at least the downstream part of the extraction device. The upstream part of the extraction device can be:

- part of the pod holder, for example under the form a moveable cover configured to cover a pod introduced in the holder or uncover the pod during the introduction and ejection operations. The cover can be attached to the pod receiving area of the pod holder by a hinge. This cover can comprise piercing means to pierce the lid 32 of the pod and enable the introduction of water inside the pod.

or

- can be part of the receiving area where it can be configured to cooperate with the pod once the pod holder is positioned inside the receiving area.

Inside the machine, the upstream part of the extraction device is connected with a supply of liquid, preferably pressurised water. This liquid supply system usually comprises:

- a liquid supply such as a liquid tank,
- a pump to drive liquid from the liquid supply to the liquid injector of the upstream part of the extraction device,
- heating and/or cooling means to adapt the temperature of the liquid before it is introduced inside the pod by the liquid injector.

This beverage machine comprises a control unit configured to the supply of liquid to the extraction device.

The upstream pod enclosing part is designed to collect the beverage 91 prepared from the extraction of the pod and dispense it in a drinking cup 9 by means of a dispensing pipe.

Figure 6A is an isolated view of the downstream piercing arrangement 12 of an extraction device according to the present invention.

The downstream piercing arrangement 12 comprises a plate 121 and opening elements 122 rising from said surface.

As illustrated in **Figure 6B**, that is a magnified view of some of these opening elements 122. These opening elements 122 rise from the surface 121 of the plate and present a conical shape with a tip end 1221. This tip end facilitates the piercing of the paper material during the extraction. In particular, this tip end can enter the bed of coffee hold inside the pod so that the hole 1222 can be positioned inside said bed of coffee during the coffee preparation.

The surfaces of these opening elements comprise beverage outlet openings 1222 configured to enable the dispensing of beverage from the pierced pod to a drinking a cup. As illustrated in **Figure 9**, that is a transversal cross section view of the downstream piercing arrangement, each of these openings cooperate a traversing hole 123 configured to drive the beverage from the beverage outlet opening 1222 through and downstream the plate 12.

Figure 7 exemplifies one of these opening elements 122.

The tip end 1221 extends by a height H from the upper surface 1211 of the plate.

The beverage outlet opening 1222 is positioned above an intermediate position h between the upper surface 1211 of the plate and the tip end 1221 of the opening element. Accordingly, when a stretchable material is used, the risk that the beverage outlet opening 1222 is obstructed by the stretched material is avoided.

- 5 In addition, the beverage outlet opening 1222 is a slit extending along a plane parallel to the plane of the upper surface 1211 of the plate. Consequently, the risk that a part of the beverage outlet opening 1222 is partially closed by the paper material, precisely the part closer to the base 1220 of the opening, is avoided. As a result, the full surface of the beverage outlet opening 1222 remains free for evacuation of the beverage and enables a consistent
10 preparation of the beverage which is not the case when a beverage outlet presents a design along a generating line of the cone. The extraction of coffee is obtained through all the calibrated holes 1222 in a consistent manner.

- Figure 8** illustrates a preferred embodiment of the beverage outlet opening 1222 in the form
15 of an essentially rectangular opening with the longest dimension being parallel to the upper surface of the plate. Other shapes for the slit can be implemented with the condition that the lower part of the shape is parallel to the plane of the upper surface 1211 of the plate to avoid obstruction by the stretched material. Usually, a rectangular opening represents the easier shape to design, in particular when manufactured by plastic injection moulding.
- 20 Preferably, the dimensions are fixed so as to prevent coffee particles to pass through. In particular, the slit can be dimensioned to filter grains presenting a diameter of about 0.3 mm. In the illustrated embodiment, the length L of the slit can be of about 0.5 mm and the height l of the slit of about 0.15 mm.

- 25 **Figure 10A** illustrates a preferred embodiment of the opening elements 122. The opening element comprises:

- a base 1220 presenting the shape of a truncated cone, usually a frustrum cone because the cone is cut by a plane parallel to the plane of the base of the cone.

and

- 30 The cone and the truncated cone present the same central axis XX' but the two cones differ by the angles of their generating lines with said central axis XX' . Precisely, the angle α_2 of the generating line of the cone of the base with the axis is smaller than the angle α_1 of the generating line of the cone of the tip end with the axis.

- With this preferred embodiment, the encroachment of the opening elements on the surface of
35 the plate can be minimised while keeping:

- a sufficient height of the tip end of the opening elements above the upper surface of the plate, and

- a sufficient number of opening elements rising from the plate.

As result, when the chamber of the extraction device is closed around the pod and the surface of the pod enclosing wall is positioned along the downstream piercing arrangement, then the surface between the opening elements 122 is sufficiently large to enable the paper laminate wall to extend along the upper surface 122 of the plate between several rising opening elements 122. The risk the paper becomes folded between the opening elements 122 is limited.

The wall of the pod can be flattened against the surface of the plate between the opening elements with less risk that the paper becomes folded and that it plugs the beverage outlet openings. The shape design of the opening elements provides a sufficient distance between the opening elements and limits that risk.

Figure 10B illustrates this encroachment of the opening elements with the distance d between the closest opening elements.

Depending on the type of system of pod and beverage extraction machine, the plate can a code destructor 124 between the opening elements. This code destructor is configured to damage, destroy, erase a code provided at the surface of the wall of the pod and to prevent a second use of the pod or of the code to prepare a beverage from the machine.

This code destructor can simply comprise rising elements that sufficiently damages the code to make it non-readable.

The code destructor is positioned on the code at the zone where the machine is configured to read the code from the pod.

As illustrated in **Figures 13A and 13B**, the downstream piercing arrangement 12 is preferably an assembly of an upper sub-part plate 12a and a lower sub-part plate 12b where the upper sub-part plate 12a and the lower sub-part plate 12b are designed so that, when assembled, the beverage outlet opening 1222 and/or the opening element are formed.

In particular, each of the sub part plates 12a, 12b can comprise a part of each opening element 122 of the assembled downstream piercing arrangement.

The upper sub-part plate 12a comprises, for each opening element, an upper sub-part 122a of the opening element and a receiving hole 120a designed for the assembly with the lower sub-part plate. The lower sub-part plate 12b comprises, for each opening element, a lower sub-part 122b of the opening element.

For each opening element 122, the shapes and dimensions of the lower sub- part, the upper sub-part and the receiving hole are designed so that the lower-sub part 122b is able to slide in the receiving hole 120a of the upper sub-plate (as illustrated in Figure 13) and, when positioned in said receiving hole, to cooperate with the upper sub-part 122a to form the complete downstream piercing arrangement 12.

The two parts can be simply assembled together without any sealing member in between so that they can be easily detached one from the other for cleaning or maintenance. For example, they can be assembled by snap-fitting.

5 As shown in the upper sub-plate 12a of **Figures 11A and 11B**, the upper sub-part 122a of each opening element comprises an end corresponding to the cone-shaped tip end 1221 of the opening element and a base 1220a corresponding to a longitudinal truncation of the base of the opening element.

10 As shown in the lower sub-plate 12b of **Figures 12A, 12B and 12C**, the lower sub-part 122b of each opening element:

- presents a base 1220b complementary to the base 1220a of the opening element of the upper sub-part 122a, so that, when these upper and lower sub-parts are assembled, the opening element 122 is formed and designed to open the wall of the pod.
- comprises an indent 1222b that designs the beverage outlet opening 1222 in the surface of
- 15 the opening element when the upper and lower sub-parts are assembled.
- comprises the beverage outlet conduit 1223b leading to the traversing hole 123 through the lower sub plate 12b (see Figure 9).

This construction of the downstream piercing arrangement 12 with two sub-plates enable the design of a beverage outlet opening 1222 inside each opening element if very small size which

20 would not be possible to reach by injection moulding of a plate made of one single piece of material.

Figures 12D and 12E illustrate an alternative manufacturing of the upper sub-part 12a for the assembly 12. In order to avoid the presence of plastic burrs in front of the beverage outlet

25 openings 1222 (for example, it can happen in the upper sub-part 12a illustrated in Figure 11B), the parting line 122b with the mould is positioned remotely from the beverage outlet opening 1222 with no risk that such burrs bend inside the beverage outlet openings 1222 when the lid of the pod is pierced.

30 **Examples**

Coffees were prepared from the pod illustrated in Figures 1A and 1B and comprising 7.5 g of roast and ground coffee.

The multilayer paper material of the bodies 31 of the pods presented a thickness of 195 µm

35 and comprised:

- an external layer of paper A, and

- an internal plastic layer B comprising an internal barrier film positioned between two external polymer films, wherein:
 - . the internal barrier film was a sheet of BVOH (Nichigo G-Polymer™ supplied by Nippon Goshei), and
 - 5 . both external polymer films were of the same nature and were polymer blends of polylactic acid (PLA), polybutylene succinate (PBS) and polybutylene adipate terephthalate (PBAT) (Ecovio® supplied by BASF).

- The multilayer paper materials of the lids 32 of the pods presented a thickness of about 165
- 10 μm and comprised:
- an internal plastic layer B identical to the internal plastic layer used for the pod body,
 - an intermediate layer of paper A presenting a lower thickness than the layer of paper used in the body multilayer paper material, and
 - one external protective layer C made of regenerated cellulose (cellophane 23NE
- 15 manufactured by Futamura).

The internal plastic layer B is stretchable, and its stretchability increases under tropical conditions as measured in Table 1. In particular, the elongation at break in the cross direction of the plastic film B increases by 5 times after only 2 days in tropical conditions (temperature

20 of 30°C in a 70 % humidity atmosphere).

The measures were realised on the plastic layer B alone (meaning not laminated to the paper).

Table 1

	Elongation at break (%)	
	along machine direction (CD)	along cross machine direction (CM)
before conditioning in tropical conditions	83.3	49.3
2 days in tropical conditions	110.0	270.0
4 days in tropical conditions	130.0	290.0
7 days in tropical conditions	120.0	310.0
10 days in tropical conditions	110.0	220.0

- Coffee beverages were prepared from pods according to two different conditions:
- 25
- first, with the extraction device comprising a downstream piercing arrangement such as illustrated in Figures 6A to 13 inside a beverage machine such as illustrated in Figures 2A to 5. The downstream piercing arrangement presented the following characteristics:

- . H = 1.9 mm
 - . h = 1.1 mm
 - . l = 0.15 mm
 - . L = 0.5 mm
- 5 - secondly, with an extraction device of the state of the art comprising a downstream piercing arrangement such as illustrated in **Figure 14** inside a beverage machine such as illustrated in Figures 2A to 5. This downstream piercing arrangement of the state of the art comprises opening elements 12 in the form of cones rising from the upper surface 1211 of a plate. These opening elements 12 comprise beverage outlet openings 1222. These openings 1222 are
- 10 provided at the base of the opening elements: they extend from the upper surface 1211 of the plate along the surface of the opening elements up to an intermediate height. The principal characteristics are:
- . height of the tip end of the cones from the upper surface of the plate: H = 1.9 mm
 - . height of the opening extending in the cone: 1.02 mm
- 15 . length of the opening extending in the plate: 0.6 mm

The coffees were prepared in the same manner in the two extractions devices: the coffee pods were extracted with 40 ml (espresso) or 110 ml (lungo) of hot water at 85°C and supplied at a pressure comprised between 10 and 12 bars.

- 20 The coffees were prepared with:
- pods taken from a secondary pack on which they were packed after manufacturing,
 - pods stored 7 days in tropical conditions (temperature of 30°C in a 70 % humidity atmosphere).

The following features of the extraction were measured:

- 25 - the flow time corresponding to the time the coffee flows in the drinking cup. The flow time starts from the first drop of coffee in the cup and stops when the target extraction volume (40 ml or 110 ml) is obtained.
- the time for low flow corresponding to the time between the moment the pump starts and the moment the flowrate reaches the value of 20 ml/min in the cup. The time for low flow is
- 30 representative of the period of time where coffee is flowing drop by drop at the beginning of the extraction; a too long time for low flow can trigger a stop of the machine because such low flow cannot be detected by the flowmeter of the machine and the control unit of the machine can interpret this time as an empty water tank and can stop the pump e.g., after 10 sec. For this reason, the time for low flow shall not be too long.

35

The results are provided in Table 2:

Table 2

		Flow time when stored in secondary pack (sec)	Flow time when stored after 7 days in tropical conditions (sec)	Time for low flow when stored after 7 days in tropical conditions (sec)
Espresso 40 ml	Downstream piercing arrangement according to the invention	18.3	15.7	3.5
	Downstream piercing arrangement according to the prior art	11.0	15.9	5.6
Lungo 110 ml	Downstream piercing arrangement according to the invention	53.0	41.4	4.2
	Downstream piercing arrangement according to the prior art	33.1	52.2	9.0

It can be observed that, with the downstream piercing arrangement of the state of the art, the flow time for the preparation of espresso and lungo coffee systematically increased after 7 days in tropical conditions; this was due to the stretched plastic layer obstructing the beverage outlets in the downstream piercing element. With the downstream piercing arrangement of the prior art, the increase after 7 days in tropical conditions was of about 5 seconds for the espresso and 20 sec for the lungo: such differences in relation with the volumes of coffee (40 ml and 110 ml resp.) do impact the tastes of the extracted coffees and create inconsistency although the same pods and the same machines were used. The preparations of coffees with the machine of the prior art were not consistent.

On the contrary, with the machine of the present invention, the flow time for the preparation of espresso and lungo coffees did not increase after 7 days in tropical conditions: it remained similar for the espresso (difference of 2.6 sec) and even decreased for lungo. The flow time is more consistent and does not depend on the exposure of the pod to tropical conditions.

It was observed that the time for low flow with the present invention was decreased compared to the prior art which limits the risk that the coffee preparation is stopped (by pump switched off) because of stretched material covering the outlet openings.

Although the invention has been described with reference to the above illustrated embodiments, it will be appreciated that the invention as claimed is not limited in any way by these illustrated embodiments.

Variations and modifications may be made without departing from the scope of the invention as defined in the claims. Furthermore, where known equivalents exist to specific features, such
5 equivalents are incorporated as if specifically referred in this specification.

As used in this specification, the words "comprises", "comprising", and similar words, are not to be interpreted in an exclusive or exhaustive sense. In other words, they are intended to mean "including, but not limited to".

List of references in the drawings:

	downstream enclosing part	1
	pod holder	11
5	downstream piercing arrangement	12
	upper sub-part plate	12a
	opening elements sub-part	122a
	parting line	122b
	receiving hole	120a
10	truncated base	1220a
	lower sub-part plate	12b
	opening elements sub-part	122b
	truncated base	1220b
15	plate	121
	surface	1211
	opening elements	122
	base	1220
20	tip end	1221
	beverage outlet opening	1222
	lower sub-part	1222b
	beverage outlet conduit	1223b
	traversing hole	123
25	code destructor	124
	hole	125a
	peripheral area	13
	chassis	14
30	upstream enclosing part	2
	cage	21
	upstream piercing arrangement	22
	liquid injector	25
35	pod	3
	body	31, 31'

	side wall	311, 311'
	top end	3111
	top opening	312
	bottom wall	313
5	flange	314, 314'
	top face	3141
	bottom face	3142
	lid	32
	ingredient	33
10	insertion section	4
	lateral sheet	6a, 6b
	tank	71
	pump	72
15	heater	73
	control unit	8
	cup	9
	beverage	91
20	removable pod holder	10
	pod holder receiving area	101

CLAIMS

1. Piercing arrangement (12) for piercing a pod containing a beverage ingredient, preferably roast and ground coffee, said piercing arrangement comprising:
- 5 - a plate (121) wherein the upper surface (1211) of said plate comprises opening elements (122) rising from said surface, and
- traversing holes (123)
- and each of said opening elements (122) present:
- a tip end (1221), and
- 10 - a surface comprising a beverage outlet opening (1222) cooperating with the traversing holes (123),
- characterized in that the piercing arrangement (12) is an assembly of an upper sub-part plate (12a) and a lower sub-part plate (12b), and wherein, for each of said opening elements (122),
- the beverage outlet opening (1222) is positioned above an intermediate position (h) between
- 15 the upper surface (1211) of the plate and the tip end (1221) of the opening element, and
- the beverage outlet opening (1222) is a slit extending along a plane parallel to the plane of the upper surface (1211) of the plate, and
- wherein the upper sub-part plate (12a) and the lower sub-part plate (12b) are designed so that, when assembled, the beverage outlet opening (1222) and/or the opening element are
- 20 formed.
2. Piercing arrangement (12) according to claim 1, wherein the surface of the beverage outlet opening (1222) is dimensioned to filter grains presenting a diameter of about 0.3 mm.
- 25 3. Piercing arrangement (12) according to any one of claims 1 or 2, wherein, for each of the opening elements (122):
- the upper sub-part plate (12a) comprises an upper sub-part (122a) of the opening element rising from the upper surface of the upper sub-part said plate and a corresponding receiving hole (120a) extending through said upper plate, and
- 30 - the lower sub-part plate (12b) comprises a corresponding lower sub-part (122b) of the opening element rising from the upper surface of said lower sub-part plate and a corresponding traversing hole (123) extending through said lower sub-part plate to evacuate the beverage, and
- wherein the receiving hole (120a) of the upper plate is designed to receive the lower sub-part plate (12b) of the opening element of the lower plate when the sub-part plates are assembled,
- 35 and

wherein the upper and lower sub-parts (122a, 122b) of the opening element are designed so that, when the sub-part plates (12a, 12b) are assembled, the beverage outlet opening (1222) is formed between the assembled sub-parts (122a, 122b) of the opening elements.

- 5 4. Piercing arrangement (12) according to any one of the precedent claims, wherein the opening elements (122) comprise:

- a base (1220) presenting the shape of a truncated cone,
- the tip end (1221) presenting the shape of a cone,

wherein the cone and the truncated cone present the same axis, and

- 10 wherein the angle (α_2) of the generating line of the cone of the base with the axis is smaller than the angle (α_1) of the generating line of the cone of the tip end with the axis.

5. Piercing arrangement (12) according to claims 3 and 4, wherein, in the upper sub-part plate (12a), the upper sub-part (122a) of the opening element comprises:

- 15 - an end that is the cone-shaped tip end (1221) of the opening element, and
- a base (1220a) corresponding to a longitudinal truncation of the base of the opening element.

6. Piercing arrangement (12) according to claim 5, wherein, in the lower sub-part plate (12a), the lower sub-part (122b) of the opening element rising from the upper surface of said lower sub-part plate:

- 20 - presents a base (1220b) complementary to the base (1220a) of the opening element of the upper sub-part (122a), and
- comprises an indent (1222b) designing the beverage outlet opening (1222) and the beverage outlet conduit when assembled to the corresponding upper sub-part (122a) of the opening
25 element.

7. Beverage extraction device for extracting a beverage from a pod, said pod containing a beverage ingredient, preferably roast and ground coffee, said extraction device comprising:

- 30 - upstream and downstream pod enclosing parts (1, 2) relatively movable between an open position for inserting and/or ejecting the pod (3) and a closed position for forming an extraction chamber (5) enclosing the pod during extraction,
- the upstream part (2) bearing:
 . an upstream piercing arrangement (22) for opening a first enclosing wall (31) of the pod
 and
35 . a liquid injector (25),

- the downstream part (1) comprising a downstream piercing arrangement (12) for opening an enclosing wall (32) of the pod, said downstream piercing arrangement being the piercing arrangement (12) according to any one of claims 1 to 6.

5 8. Beverage preparation machine comprising a beverage extraction device according to claim 7.

9. Beverage preparation machine according to claim 8 wherein the extraction device is positioned in the beverage machine in a non-removable manner.

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10. Beverage preparation machine according to claim 8 wherein at least the downstream part (1) of the extraction device is positioned in the beverage machine in a removable manner.

11. Beverage preparation machine according to claim 10, wherein said machine comprises:

15 - a removable pod holder (10) configured for receiving and holding the pod (3), and
- a pod holder receiving area (101) for receiving the removable pod holder (10), and
wherein the removable pod holder (10) comprises at least the downstream part (1) of the extraction device, and preferably the upstream part of the extraction device.

20 12. System comprising a beverage preparation machine and a pod containing a beverage ingredient, preferably roast and ground coffee,
wherein the beverage preparation machine being the beverage preparation machine according to any one of claims 8 to 11, and
wherein the pod (3) comprises a first and a second enclosing walls (31, 31', 32), said first and
25 second pod enclosing walls defining a chamber for enclosing the beverage ingredient (33),
and
wherein said first and second pod enclosing walls of the pod are made of a material, and
wherein at least a part of said material is stretchable.

30 13. System according to claim 12, wherein said first and second pod enclosing walls of the pod are made of a multilayer paper material, said material comprising at least one layer of paper (A) assembled with at least one layer of plastic (B), preferably a compostable plastic layer, said layer of plastic being stretchable.

35 14. System according to claim 13, wherein at least one layer of plastic (B) is made a polyvinyl-alcohol copolymer (PVOH) layer, in particular a butenediol vinyl alcohol (BVOH) layer.