

METHOD FOR ROASTING COFFEE BEANS

Field of the invention

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The present invention relates to the roasting coffee beans and more specifically to the roasting of blends of different coffee beans, particularly suited for use in the home or in shops and cafes.

10 Background of the invention

For the last decades, numerous roasters have been developed for use in the home or in small shops and coffees. Most of these roasters implement automatic roasting processes with roasting profiles stored or accessible by the control unit of the apparatus.

15 These apparatuses are usually configured to apply roasting profiles each dedicated to specific types of coffee beans. Each roasting profile guarantees an optimal roasting of this specific type of coffee beans. Usually these roasting profiles are pre-determined by experts in roasting. These pre-determined roasting profiles enable operators to roast automatically the corresponding coffee beans with no risk of spilling the beans.

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Today, there is a trend to produce customized roasted beans, in particular by roasting blends of different types of coffee beans. For example, blends can comprise different coffee beans differing by their origins and/or botanical varieties like a blend of Arabica and Robusta coffee beans, or the blend can comprise different coffee beans of same origin or same variety but
25 produced by different farmers. In addition, these blends can present different proportions of each type of coffees.

The roasting parameters defined as optimal for one type of coffee beans of the blend may adversely affect another type of coffee beans of the blend. Some types of beans can become burnt whereas, for others, the desired degree may not be reached or the beans may not be
30 uniformly roasted, or may not provide the optimal sensory profile.

Trying to determine the best roasting profile of a blend is not so straight forward : the operator needs to test different roasting profiles before good results are reached, which requires time and can produce important waste of beans.

An existing solution consists in roasting each type of beans separately and then to mix the
35 different roasted beans to form the final blend (method called "split roasting"). This method can be implemented with blends comprising two different types of beans, but when the blend

comprises more than two types of beans, the method becomes too time consuming and complicated to be implemented. In addition the method requires the storage of each types of roasted beans during the roasting operation of the other types of beans, which is not practical at home or in small shops and cafés.

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Summary of the invention

An object of the present invention is to improve the automatic roasting of coffee beans.

10 It would be advantageous to provide a roasting apparatus enabling optimal roasting whatever the blend of beans to roast.

It would be advantageous to provide a roasting apparatus applying automatically the roasting profile corresponding to the quantity of a blend of beans introduced in the apparatus.

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Objects of the invention are achieved by the method to determine the roasting recipe for roasting a customised blend of coffee beans according to Claim 1, the roasting apparatus according to Claim 12, the computer program according to Claim 13 and the computer readable storage medium according to Claim 15.

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In a first aspect, there is provided a method to determine the roasting recipe R_{blend} for roasting a customised blend of coffee beans $C_A, C_B, \dots$ introduced in a chamber of a roasting apparatus, said recipe R_{blend} providing the temperature $T_{@t1}, T_{@t2}, \dots$ to be applied at discrete successive times $t_1, t_2, \dots$, respectively, said method comprising the steps of :

25 - obtaining for each type of coffee beans C_n comprised in said blend at least :

- . the type C_n of said type of coffee beans, and
- . the quantity m_n of said type of coffee beans C_n introduced in the chamber,

and

- based on the obtained type C_n , getting access at least to :

30 . roasting recipes $RM_A, RM_B, \dots$ of the different types of coffee beans $C_A, C_B, \dots$ respectively of the customised blend, each recipe RM_n being adapted to the roasting of one pre-determined quantity M_n of beans of same type C_n and providing the temperatures $TM_n@t_i$ to be applied at discrete successive times t_i respectively,

and

35 . temperature adaptation factors $K_A, K_B, \dots$ of different types of coffee beans $C_A, C_B, \dots$ respectively of the customised blend,

and

- based on the obtained quantities m_n of the different coffee beans C_n and the accessible roasting recipes RM_n and temperature factors K_n , determining the roasting recipe R_{blend} to be applied to said customised blend of coffee beans introduced inside the chamber.

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The roasting operation is generally implemented in a roasting apparatus comprising a chamber to contain coffee beans during the roasting process. In the chamber coffee beans are heated and preferably mixed to homogenise heating through the beans.

Mixing can be obtained with a fluidic bed of hot air or mechanically with stirring blades or
10 through rotation of a rotating drum.

Preferably the chamber is hot air fluid bed chamber. Within such a chamber, heated air is forced through a screen or a perforated plate under the coffee beans with sufficient force to lift the beans. Heat is transferred to the beans as they tumble and circulate within this fluidized bed.

15 Alternatively the chamber can be a drum chamber wherein the coffee beans are tumbled in a heated environment. The drum chamber can consist of a horizontal rotating drum or the drum chamber can comprise stirring blades to tumble the coffee beans in a heated environment.

The roasting apparatus comprises a device to heat coffee beans contained in the chamber

20 Preferably, the heating device is configured to produce a flow of hot air, said flow of hot air being directed to the coffee beans contained in the chamber in order to heat them. Usually, the heating device comprises at least an air driver and a heater to heat the flow of air produced by the air driver.

As a source of heat, preferably the apparatus comprises an electrical heater. This electrical
25 heater is usually an electrical resistance. An electrically powered source of heat presents the advantage that the air pollutants produced during the roasting are pollutants generated from the heating of coffee beans themselves and not from the burning of gases as it happens when the source of heating is a gas burner using natural gas, propane, liquefied petroleum gas (LPG) or even wood.

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The apparatus comprises a control system operable to control the heating device and the control system is configured to apply a roasting recipe. This roasting recipe R provides the temperature $T_{@t1}$, $T_{@t2}$, ... $T_{@tfinal}$ to be applied at discrete successive times t_1 , t_2 , ..., t_{final} respectively of the roasting process. This roasting recipe is usually represented as a
35 temperature versus time profile.

Usually, this control is implemented based on the measure of at least one temperature sensor positioned in or at the inlet of the chamber in feedback loop control.

Control is applied on the heating device, such as the heater and/or on the air driver.

- 5 When a customized blend of different of at least two different coffee beans $C_A, C_B, \dots$ is introduced inside the chamber within respective quantities $m_A, m_B, \dots$, the present method enables the determination of the roasting recipe R_{blend} adapted for this specific blend.

By customised blend, it is meant a blend of different coffee beans of single origins and/or different pre-existing coffee blends. The new customised blend is created by the operator of the apparatus ; no roasting recipe has been previously determined for this new customised blend and is accessible by the control system.

With the present apparatus, in the case of such a new customised blend, the control system of the apparatus is configured to determine a roasting profile adapted to said new customised blend.

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For a customised blend of different coffee beans ($C_A, C_B, \dots$), the method comprises the first step of obtaining, for each type of coffee beans C_n comprised in said blend at least :

- the type C_n of said type of coffee beans, and
- the quantity m_n of said type of coffee beans C_n introduced in the chamber.

- 20 The quantity can be the weight or alternatively the volume or the level of coffee beans present in the chamber of the roasting apparatus. Preferably the quantity is the weight.

Usually, the type C_n of the beans relates to at least one feature of the beans which has the direct impact on the process of roasting the beans.

- 25 The type of coffee beans can relate to specific features such as :

- the origin of the beans and/or the botanical variety of the beans (Arabica, Robusta, ...) or a particular pre-existing mixture or blend of different beans ; the pre-existing mixture or blend can be defined by the selection of different specific beans and/or by the ratio of these different specific beans.

- 30 - the level of pre-roasting of the beans. The coffee beans to be roasted can be green beans or can be partially pre-roasted beans that is beans having been obtained by heating green coffee beans and stopping said heating process before the end of the first crack. These partially pre-roasted beans can be pre-roasted at different levels with a direct impact on the subsequent final roasting operated in the roasting apparatus.

- 35 - the moisture of the beans,
- the size of the beans.

The types of beans can refer explicitly to the nature of the beans like the origin, the botanical variety, the blend, the level of pre-roasting, ... and/or can be a reference like an identification number, a SKU number or a trademark.

- 5 When the method is applied in a roasting apparatus, the type of beans C_n can be obtained by different ways :
- from the user. In that case, the user interface of the apparatus can display a list of types of beans and urge the user to select the types she/he is introducing inside the chamber. Alternatively, this list can be displayed through the interface of a mobile device configured to
 - 10 communicate with the control system of the apparatus.
 - or
 - from a code, such as a code provided on a beans package. In that case, the apparatus can comprise a code reader and the control system can be configured to urge the operator to scan the code of the beans (for example provided on the beans package) she/he is introducing
 - 15 inside the chamber.

When the method is applied in a roasting apparatus, the quantity m_n of each type of coffee beans C_n part of the blend introduced in the chamber can be obtained :

- from the user. In that case, the apparatus can comprise a user interface to enable the user
- 20 to enter the quantity of each type of beans she/he is introducing inside the chamber. Again, this quantity can be entered through the interface of a mobile device configured to communicate with the control system of the apparatus.
- or
- from a measuring device connected to the control system of the apparatus. In that case, the
- 25 measure of the quantity m_n of the beans can be automatically provided to the control system of the apparatus.

The apparatus can comprise a measuring device configured to measure the quantity m_n of beans C_n introduced in the chamber and, in the step of supplying the controller with the quantity m_n of coffee beans, said quantity of coffee beans can be automatically measured by the

30 measuring device and supplied to the control system of the apparatus.

In one embodiment, the chamber of the apparatus can be transparent and the wall of the chamber can present level indicators readable by the operator.

Consequently, when the operator introduces the beans in the transparent chamber, he/she is

35 able to read the introduced quantity by looking at the level indicator. This information can then

be entered as an input inside the control system of the apparatus, for example through a user interface.

According to one embodiment, the apparatus can comprise the measuring device configured to measure the quantity m_n of beans introduced in the chamber and, in the step of supplying the controller with the quantity m_n of coffee beans, said quantity of coffee beans can be automatically measured by the measuring device and supplied to the control system of the apparatus.

10 The measuring device can be :

- a scale measuring weight of coffee beans, or
- a device comprising at least one cavity of predetermined volume, or
- a level sensor measuring a volume of coffee beans inside the chamber.

Preferably, this quantity is the weight and the measuring apparatus is a weight scale.

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When the measuring device is a device comprising at least one cavity of predetermined volume, this device enables the user to select a cavity of predetermined volume and to fill this cavity completely with beans with the result that a defined volume of beans is measured. The control system of the roasting apparatus is provided with this precise volume of beans.

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When the measuring device is a level sensor, this sensor measures a volume of coffee beans inside the chamber. The process control is configured to deduce the volume of beans from said measured level.

25 If it is the volume of beans that is measured then, based on an identification of the type of the beans, their density can be obtained, and accordingly their precise weight can be deduced.

According to another embodiment, the apparatus can comprise :

- at least two containers to store different types C_n of coffee beans,
- 30 - at least one dosing device to dose and supply coffee beans from the containers to the chamber,

and, in the step of obtaining the quantity m_n of each type C_n of beans introduced in the chamber, the quantity of dosed coffee beans of each type C_n can be automatically supplied to the control system.

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In a particular embodiment, the apparatus can comprise an identification device configured to read identification means from a beans package, said beans package being configured to supply the chamber of the apparatus with its whole content, and said identification means providing directly or indirectly the quantity m_n of beans inside the package in addition to the type of beans C_n .

Based on the obtained type C_n of the different types of coffee beans $C_A, C_B, \dots$ part of the customised blend, the method comprises the step of getting access at least to :

- roasting recipes $RM_A, RM_B, \dots$ of said coffee beans $C_A, C_B, \dots$ respectively part of the customized blend, each recipe RM_n being adapted to the roasting of one pre-determined quantity M_n of beans of same type C_n and providing the temperatures $TM_n@t_i$ to be applied at discrete successive times t_i respectively,
- and
- temperature adaptation factors $K_A, K_B, \dots$ of said coffee beans $C_A, C_B, \dots$ respectively part of the customized blend.

When the method is implemented in a roasting apparatus, these roasting recipes and temperature adaptation factors can be stored in a database or memory accessible to the control system of the apparatus. Further to the step of obtaining the type C_n of the beans part of the customised blend, the control system can be configured to get access to the roasting recipe RM_n and temperature adaptation factor K_n of each identified coffee beans part of the customised blend.

In an alternative embodiment, the type, the roasting recipe for one pre-determined quantity and the temperature adaptation factor of each type of beans can be encoded in a code identifying each beans part of the blend. By the single step of reading the code of the beans, the control system can be configured to obtain the identification and get access to the roasting recipe and the temperature factor.

Each accessible roasting recipe RM_n is adapted for a specific type C_n of coffee beans (or a specific blend of different types of coffee beans as mentioned below) and for a pre-determined quantity M_n of said beans. This pre-determined quantity can be set to correspond to a point between the minimum quantity and the maximum quantity able to be roasted inside the chamber of the roasting apparatus. Accordingly, for one type of beans, at least one roasting recipe adapted to the roasting of said pre-determined quantity M_n is accessible to the control system.

Preferably, this step provides access to the pre-determined quantity M_n associated to the roasting recipe RM_n too. In one embodiment, this pre-determined quantity can be the same for

all the accessible roasting recipes RM_n and this pre-determined quantity can be stored by the control system of the apparatus. In another embodiment, this pre-determined quantity can be different according to the coffee beans C_n and its roasting recipe RM_n . In that latter case, the control system is configured to get access to said pre-determined quantity M_n associated to
 5 the respective roasting recipe RM_n too.

These different roasting recipes adapted to the roasting of pre-determined quantities of one type of beans are usually defined by experimentation. Preferably, the roasting recipe is linked also to the type of roasting apparatus itself such as the type of type of agitation of the beans
 10 (fluidic bed or rotating drum), the internal design like the shape of the chamber, the position of the components (e.g. the temperature sensor) and/or such as the types of components like the nature of the heating device.

In addition, the method comprises the step of getting access to temperature adaptation factors
 15 $K_A, K_B, \dots$ of the different types of coffee beans $C_A, C_B, \dots$ respectively too.

Then, based on the obtained quantities m_n of the different coffee beans C_n part of the customised blend and on the accessible roasting recipes RM_n (and preferably the quantity M_n) and on the temperature factors K_n of the different coffee beans C_n part of the customised
 20 blend, the method comprises the step of determining the roasting recipe R_{blend} to be applied to said customised blend of coffee beans introduced inside the chamber.

Advantageously objects of the invention are solved since the above features enables the control of the roasting apparatus to apply a roasting profile that takes into account the type
 25 and the quantity of each coffee beans used in the customized blend introduced inside the apparatus to guarantee that, whatever the quantities and types, the beans are correctly roasted. In particular, the new roasting profile can be derived from existing pre-established roasting recipes of each type of coffee beans part of the blend, the new roasting recipe of the blend becoming an average of all these pre-established roasting recipes.

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In one embodiment, the determined roasting recipe R_{blend} can be stored and optionally shared in case the customised blend is prepared once again

Preferably, the roasting recipe R_{blend} to be applied on the customised blend of coffee beans is
 35 determined by implementing at least the following steps :

- for each type C_n of coffee beans respectively :

. selecting or determining the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said obtained type C_n , said roasting recipe R_n providing the temperatures $T_{m_n@t_i}$ respectively to be applied at time t_i respectively,

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and

- from said selected and/or determined roasting recipes R_{m_n} and from said accessible temperature adaptation factors K_n , and based on the obtained quantities m_n of beans of type C_n introduced inside the chamber, determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to following formula (I) :

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$$T_{blend@t_i} = \sum_{n=A}^N f_n \cdot K_n \cdot T_{m_n@t_i} \quad (I)$$

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wherein n corresponds to all the types of coffee beans C_A to C_N present in the blend and f_n represents the fraction in weight of coffee beans of type C_n in the customised blend of coffee beans.

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In this preferred embodiment, the roasting recipe of the blend is determined based on a previous step of selection and/or determination of roasting recipes that have been selected or determined to correspond to the specific weight m_n of coffee beans C_n introduced in the chamber.

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By selection, it is meant that the accessible roasting recipe corresponding to one type and one quantity of coffee beans present in the blend is selected. In particular, by getting access to a memory or database that stores a collection of roasting recipes for different quantities for each type of coffee beans, one of these roasting recipes can be selected and then used to determine the roasting recipe of the blend.

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By determination, it is meant that the roasting recipe corresponding to one type and one quantity of coffee beans present in the blend can be calculated. In particular, by getting access to a memory or database that stores at least one roasting recipe corresponding to one type of coffee beans and one quantity of said coffee beans and, from said at least one recipe, other roasting recipes for other quantities of said type of coffee beans can be calculated. Then, this calculated recipe can be used to determine the roasting recipe of the blend.

Depending on the type of accessible roasting recipes for each type of beans part of the blend, the roasting recipe R_{blend} can be determined from selected and/or determined roasting recipes, part of the recipes having been selected, whereas other part of the recipes having been determined.

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The selection of the roasting recipes adapted to the roasting of the specific coffee beans part of the blend and for the specific quantity of said beans part of the blend provides a good starting point to calculate the roasting recipe of the blend.

In addition, the formula (I) uses these selected roasting recipes with a quantity factor f_n which is able to take into account the presence of a greater part of one type of beans C_n inside the blend.

In addition the formula (I) uses these selected roasting recipes with a temperature adaptation factor K_n which enables to provide more or less importance to the roasting profile of one of the type of beans in the roasting profile of the blend. This factor takes into account, among other aspects, of the capacity of the respective beans C_n to absorb heat, which can vary with the size of this bean, its density, its internal structure and/or its chemical composition. For example two types of beans can differ by their sizes, as a result, less heat energy is required for the smaller. This factor can take into account a particular desired property of these beans once roasted in the blend, this desired property can relate to the colour of the roasted beans, its level of acrylamide and/or its sensory profile in the final roasted blend.

Actually, due to the fact that the blend comprises different types of beans presenting different reactions further to the implementation of a common roasting profile, the final roasted blend may comprise roasted beans presenting different colours and/or different levels of specific components like acrylamide or furan generated by roasting and/or different optimal sensory profile. In order to control the production of roasted blends presenting all or some of these properties, temperature adaptation factor are used to keep specific coffee beans, in particular the more sensitive, closer to their respective roasting profile in order to obtain the desired properties of these beans.

For different beans, the key criteria for defining the temperature adaptation factor can be different since some beans may be more or less sensitive to deviation from their optimal roasting profile.

Usually, when a blend is created, it is expected to produce a resulting roasted blend presenting properties corresponding globally to an average of the properties of each types of beans roasted separately in particular the best properties of each of these beans. The temperature adaptation factor guarantees that the properties of the beans that are the more sensitive to temperature will be found in the roasted blend.

The value of the temperature adaptation factor K_n is usually comprised between 0,5 and 2. Factors with low value are adapted to beans being less sensitive to temperature variation whereas factors with high value are adapted to more reactive beans that develop new properties if roasted at temperatures too much different from their optimal roasting profile.

5 These factors are usually defined by experimentation.

The formula enables the automatic calculation of the roasting recipe of the blend. A non-experimented operator becomes able to roast a blend of different types of coffee without risk that the resulting roasted blend presents a poor taste profile, in particular is burnt or not roasted
10 enough. The risk the beans are wasted is prevented.

Interpolation of roasting profiles

If, in at least two of the selected or determined roasting recipes R_{m_n} of coffees C_n , the recipes
15 providing temperatures $T_{m_n@t_i}$, to be applied at discrete successive times t_i , at least a part of the discrete successive times t_i are set differently, then
from the selected or determined roasting recipes R_{m_n} for each coffee C_n of the customised blend, interpolated roasting recipes curves R_{m_n} can be determined by interpolating the curves of the accessible roasting recipes so that all the selected or determined roasting recipes
20 provide the temperatures $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... $T_{m_n@t_{final}}$. respectively to be applied at the same discrete successive times t_1 , t_2 , ... t_{final} .

A coffee roasting recipe is frequently provided as a list of discrete points, each being defined by its time and its temperature, rather than as continuous curve. It can happen that the control
25 system of the apparatus gets access to roasting recipes for different types of coffee beans and weight of said beans and that these roasting recipes provide discrete points for different set times.

In order to be able to determine the roasting recipe of the blend according to above formula (I), for all the roasting recipes previously determined for each types of coffee beans part of the
30 blend and for the weight of said type of coffee beans in the blend, corresponding interpolated recipes can be determined so that all these interpolated recipes provide a list of discrete pairs of time and temperature for the same times.

Usually, in that operation of interpolation of the different curves, specific discrete successive
35 times t_1 , t_2 , ... t_{final} are pre-defined and new interpolated roasting recipes curves R_{m_n} are

determined from the accessible roasting recipes for each of these pre-defined specific discrete successive times $t_1, t_2, \dots t_{\text{final}}$.

These pre-defined specific discrete successive times $t_1, t_2, \dots t_{\text{final}}$ can be times pre-defined at regular intervals during a maximum time period (usually the greater t_{final} of the selected curves) or they can be times pre-defined at specific critical periods of a roasting profile, for example during the period of first crack generation.

The advantage of the interpolation operation is that different roasting recipes of various types of beans can be accessed to and still be used whatever their format in terms of times as the abscissa. In particular, roasting profiles defined by different roasting specialists measuring temperature at different time abscissa can be stored and become accessible whatever their format since the interpolation operation enables the use of said new curve with all other accessible ones.

Determination of blend roasting profile from roasting profiles having different t_{final} .

In addition or independently from the above embodiment, in another embodiment the method can comprise the steps of :

- selecting or determining :

. the roasting recipes $R_{m_A}, R_{m_B}, \dots R_{m_n}, \dots$ of the different identified types of coffee beans of different types $C_A, C_B, \dots C_n \dots$ respectively, each recipe being adapted to the roasting of the quantity m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$ to be applied at discrete successive times t_i up to a final time $t_{\text{final } n}$ respectively, and said final time $t_{\text{final } n}$ being set differently in at least two of said different roasting recipes $R_{m_A}, R_{m_B}, \dots$

$R_{m_n} \dots$, and

- getting access to :

. time adaptation factors $S_A, S_B, \dots S_n$ for each type of coffee beans $C_A, C_B, \dots C_n$ respectively,

and

- determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by implementing the following steps :

- based on the obtained roasting recipes $R_{m_A}, R_{m_B}, \dots R_{m_n}, \dots$,

. obtaining the final times $t_{\text{final } y}$ of all the coffees C_n part of the customised blend,

. sorting said obtained final times $t_{\text{final } y}$ in an ascending order from the smallest final time

$t_{\text{final low}}$ up to the highest $t_{\text{final high}}$

- for times inferior or equal to the smallest final time $t_{final\ low}$, determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I),

5 - for times superior to the smallest final time $t_{final\ low}$, determining the roasting recipe R_{blend} to be applied to said blend of coffee beans introduced inside the chamber by setting temperatures to be applied at calculated times t_y ,

* each of said calculated times t_y being calculated from each corresponding obtained final time $t_{final\ y}$, from $t_{final\ low+1}$ up to $t_{final\ high}$, as follows :

10 $t_y = t_{final\ y-1} + [(t_{final\ y} - t_{final\ y-1}) * \sum(f_{n'} * S_{n'})]$ with n' corresponding to the coffees presenting a final time superior or equal to $t_{final\ y}$,

* up to $t_{final\ high-1}$, temperature being determined at each of said calculated time t_y from the roasting recipes $R_{m_{n'}}$ of all the coffee beans $C_{n'}$ presenting a final time superior or
15 equal to $t_{final\ y}$, according to following formula (II) :

$$T_{blend@t_y} = \sum_{n'} f_{n'} \cdot K_{n'} \cdot T_{m_{n'}@t_y} \quad (II)$$

* at $t_{final\ high}$:

20 . if only one coffee C_z presents a roasting recipe that presents a final time equal to $t_{final\ high}$, then the temperature of the blend is the temperature of the roasting recipe of the quantity m_z of said coffee C_z part of the blend at said final time : $T_{blend@t_{final\ high}} = T_{m_z@t_{final\ z}}$, or

25 . if at least two coffees presents roasting recipes that present the same final time equal to $t_{final\ high}$, then the temperature of the blend is determined according to formula (II).

Preferably, $T_{m_{n'}@t_y}$ corresponds to interpolated values extracted from the recipes $R_{m_{n'}}$.

30 The advantage of this last embodiment is that it is possible to get access to any type of format of roasting profile, in particular there is no need to keep the profile in specific time limits.

Alternatively to the previous embodiment, the method can comprise the steps of :

- selecting or determining the roasting recipes R_{mA} , R_{mB} , ... R_{mn} of the different identified types of coffee beans of different types C_A , C_B , ... C_n respectively, each recipe being adapted to the roasting of the quantity

m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$ to be applied at discrete successive times t_i up to a final time $t_{final\ n}$ respectively, and said final time $t_{final\ n}$ being set differently in at least two of said different roasting recipes R_{mA} , R_{mB} , ... R_{mn} ..., and

- determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by implementing the following steps :

- based on the selected or determined roasting recipes R_{mA} , R_{mB} , ... R_{mn} ,

. obtaining the final times $t_{final\ n}$ of all the coffees C_n part of the customised blend, and

. identifying the smallest final time $t_{final\ 1}$,

- limiting the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber to times inferior to the smallest final time $t_{final\ 1}$, and

- determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I).

In that embodiment, the roasting recipe to be applied to the blend of coffee beans finishes at the final time of the beans presenting the smallest final time $t_{final\ 1}$. As a result the risk of over-roasting the more fragile beans with this smallest final time $t_{final\ 1}$ is limited.

In another alternative embodiment, the method comprises the step of :

- selecting or determining the roasting recipes R_{mA} , R_{mB} , ... R_{mn} of the different identified types of coffee beans of different types C_A , C_B , ... C_n ... respectively, each recipe being adapted to the roasting of the quantity m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$

to be applied at discrete successive times t_i up to a final time $t_{final\ n}$ respectively, and said final time $t_{final\ n}$ set differently in at least two of said different roasting recipes R_{mA} , R_{mB} , ... R_{mn} , and

- determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by implementing the following steps :

- based on the selected or determined roasting recipes R_{mA} , R_{mB} , ... R_{mn} ,

. obtaining the final times $t_{final\ n}$ of all the coffees C_n part of the customised blend, and

. identifying the smallest final time $t_{final\ low}$,

- for times inferior or equal to the lowest final time $t_{final\ low}$, determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according

to formula (I),

- for times superior to the smallest final time $t_{final\ low}$, determining the roasting recipe R_{blend} to be applied to said blend of coffee beans introduced inside the chamber by setting temperatures to be applied at each $t_{final\ n}$, as follows :

- 5 * up to $t_{final\ high-1}$, temperature being determined at each of said time $t_{final\ n}$ from the roasting recipes $R_{m_{n'}}$ of all the coffee beans $C_{n'}$ presenting a final time superior or equal to $t_{final\ y}$, according to following formula (II) :

$$T_{blend@t_{final\ n}} = \sum_{n'} f_{n'} \cdot K_{n'} \cdot T_{m_{n'}@t_{final\ n}} \quad (II)$$

* at $t_{final\ high}$:

- 10 . if only one coffee Cz presents a roasting recipe that presents a final time equal to $t_{final\ high}$, then the temperature of the blend is the temperature of the roasting recipe of the quantity m_z of said coffee Cz part of the blend at said final time : $T_{blend@t_{final\ high}} = T_{m_z@t_{final\ z}}$, or
- 15 . if at least two coffees presents roasting recipes that present the same final time equal to $t_{final\ high}$, then the temperature of the blend is determined according to formula (II).

Preferably, $T_{m_{n'}@t_{final\ n}}$ corresponds to interpolated values extracted from the recipes $R_{m_{n'}}$.

In another alternative embodiment, the method comprises the steps of :

- 20 - selecting or determining the roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} of the different identified types of coffee beans of different types C_A , C_B , ... C_n ... respectively, each recipe being adapted to the roasting of the quantity m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$ to be applied at discrete successive times t_i up to a final time $t_{final\ n}$ respectively, and said final time $t_{final\ n}$ set differently in at least two of said different roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} ,
- 25 and
- getting access to time adaptation factors S_A , S_B , ... S_n for each type of coffee beans C_A , C_B , ... C_n respectively,
- and
- determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by
- 30 implementing the following steps :
- based on the selected or determined roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} ,
- . obtaining the final times $t_{final\ n}$ of all the coffees C_n part of the customised blend, and
- . identifying the smallest final time $t_{final\ low}$,

- for times inferior or equal to the lowest final time $t_{final\ low}$, determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I),

- above the smallest final time $t_{final\ low}$, :

- 5 . calculating one time $t_{final\ global}$ from all the final times $t_{final\ n}$ of all the coffees C_n part of the customised blend, as follows :

$$t_{final\ global} = \sum(f_n * S_n * t_{final\ n})$$

. limiting the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber to said time $t_{final\ global}$, and

- 10 . determining the temperature of the roasting recipe (R_{blend}) to be applied at said time $t_{final\ global}$ to said blend of coffee beans introduced inside the chamber from the roasting recipes $R_{m_n'}$ of all the coffee beans C_n presenting a final time superior or equal to $t_{final\ global}$, according to following formula (II) :

$$T_{blend@t_{final\ global}} = \sum_{n'} f_{n'} \cdot K_{n'} \cdot T_{m_{n'}@t_{final\ global}} \quad (II)$$

15

Preferably, $T_{m_{n'}@t_{final\ global}}$ corresponds to interpolated values extracted from the recipes $R_{m_{n'}}$.

Determination of the roasting recipe R_{m_n} from one pre-determined roasting recipe R_{M_n}

- 20 In one first mode of the step of determining, for at least one coffee C_n , the roasting recipe R_n adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , the method comprises the steps of :

- getting access, for at least one coffee C_n , to one roasting recipe R_{M_n} of coffee beans, said
25 recipe being adapted to the roasting of one pre-determined quantity M_n of beans,

- for said at least one coffee C_n part of the customised blend, determining the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , (providing the temperatures $T_{m_n@t_i}$ respectively to be applied at time t_i respectively) from said
30 one accessible recipe R_{M_n} adapted to the roasting of one pre-determined quantity M_n of beans of type C_n and providing the temperatures $T_{M_n@t_i}$ to be applied at discrete successive times t_i respectively, as follows :

$$\text{. if } m_n > M_n, \text{ then } T_{m_n@t_i} = T_{M_n@t_i} + [T_{M_n@t_i} \cdot D \cdot (m_n - M_n)/M_n] \quad (\text{IIIa})$$

$$\text{. if } m_n < M_n, \text{ then } T_{m_n@t_i} = T_{M_n@t_i} - [T_{M_n@t_i} \cdot D \cdot (M_n - m_n)/M_n] \quad (\text{IIIb})$$

5

with $D \leq 1$

- from said determined roasting recipes R_{m_n} , determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to following formula (I) or (II).

10

With this first mode, there is access to a limited number of roasting recipes, in particular one roasting recipe R_{M_n} for each type of coffee beans C_n , this roasting recipe being defined for the roasting a pre-determined quantity M_n of beans.

15

In addition, from said roasting recipe R_{M_n} defined for the roasting a pre-determined quantity M_n of beans, the roasting recipe R_{m_n} for another quantity m_n of beans according to the formulas (IIIa) and (IIIb) is calculated

Then, this roasting recipe R_{m_n} is used to determine the temperature to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to following formula (I) or (II)

20

In one mode by default, D equals 1.

In a particular embodiment of this first mode, based on the obtained type C_n of the coffee beans, the method comprises the steps of :

25

- getting access to a coefficient D_n specific to said type C_n of coffee beans, and
- determining the roasting recipe R_{M_n} defined for the roasting a pre-determined quantity M_n of beans C_n by determining the temperature T_m to be applied to the obtained quantity m_n of beans at each of said discrete successive times t_1 , t_2 , ... as follows :

30

$$\text{. if } m_n > M_n, \text{ then } T_{m_n@t_i} = T_{M_n@t_i} + [T_{M_n@t_i} \cdot D_n \cdot (m_n - M_n)/M_n] \quad (\text{IIIa})$$

$$\text{. if } m_n < M_n, \text{ then } T_{m_n@t_i} = T_{M_n@t_i} - [T_{M_n@t_i} \cdot D_n \cdot (M_n - m_n)/M_n] \quad (\text{IIIb})$$

Selection of the roasting recipe R_{m_n} from a series of pre-determined roasting recipes R_{M_n}

In one second mode of the step of determining, for at least one coffee C_n , the roasting recipe R_n adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , the method comprises the steps of :

- getting access, for at least one type of coffee beans C_n , to at least one series of roasting recipes ($R_{M_{ny}}$, $R_{M_{nyi+1}}$, ...) adapted to the roasting of different successive pre-determined quantities (M_{ny} , M_{nyi+1} , ...) of beans of type C_n respectively and to said pre-determined quantities M_{ny} , M_{nyi+1} , ..., and

- for said at least one coffee C_n part of the customised blend, determining roasting recipe $R_{m_{ny}}$ adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , by selecting one of the recipes of the at least one accessible series of roasting recipes, said selection comprising identifying the roasting recipe adapted to the roasting of a pre-determined quantity M_{ny} of beans, said pre-determined quantity of beans presenting the smallest difference of quantity M_{ny} with the obtained quantity m_n .

- from said determined roasting recipe $R_{m_{ny}}$, determining the temperature $T_{blend@t1}$, $T_{blend@t2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to formula (I) or (II).

Within this second mode, for at least one type of beans, there is access to a series of multiple roasting recipes ($R_{M_{ny}}$, $R_{M_{nyi+1}}$, ...) adapted to different pre-determined quantities (M_{ny} , M_{nyi+1} , ...) of beans of the specific type C_n . These different pre-determined quantities can be set to cover different quantities between a minimum quantity and a maximum quantity able to be roasted inside the apparatus. Preferably, the differences between two different successive pre-determined quantities are the same from said minimum quantity to said maximum quantity.

Accordingly, for one type of beans, there is access to a series of roasting recipes adapted to the roasting of different successive pre-determined quantities (M_{ny} , M_{nyi+1} , ...).

The different roasting recipes adapted to the roasting of different pre-determined quantities of beans are usually defined by experimentation.

Based on the obtained quantity m_n of coffee beans C_n introduced inside the blend, the accessible roasting recipe R_{ny} to be applied on said obtained quantity M_{ny} of coffee beans introduced inside the chamber is selected.

Determination of the roasting recipe R_{m_n} from a series of pre-determined roasting recipes R_{M_n}

In another third mode of the step of determining, for at least one coffee C_n , the roasting recipe R_n adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , the method comprises the steps of :

- getting access, for at least one type of coffee beans C_n , to at least one series of roasting recipes ($R_{M_{ny}}$, $R_{M_{ny+1}}$, ...) adapted to the roasting of different successive pre-determined quantities (M_{ny} , M_{ny+1} , ...) of beans of type C_n respectively, and

- for said at least one coffee C_n part of the customised blend, determining the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n by :

. identifying in said at least one series of roasting recipes the two accessible roasting recipes $R_{M_{ny}}$ and $R_{M_{ny+1}}$ adapted to the roasting of two successive pre-determined quantities M_{ny} and M_{ny+1} of beans respectively, wherein the quantity m_n is comprised between said two successive pre-determined quantities M_{ny} and M_{ny+1} ,

. from said two identified roasting recipes $R_{M_{ny}}$ and $R_{M_{ny+1}}$, said roasting recipes providing the temperatures $T_{M_{ny}@t_1}$, $T_{M_{ny}@t_2}$, ... and $T_{M_{ny+1}@t_1}$, $T_{M_{ny+1}@t_2}$, ... respectively applied at discrete successive times t_1 , t_2 , ..., determining the temperature $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... to be applied to the obtained quantity m_n of beans at each of said discrete successive times t_1 , t_2 , ... as follows :

$$T_{m_n@t_i} = T_{M_{ny}@t_i} + [(T_{M_{ny+1}@t_i} - T_{M_{ny}@t_i}) \cdot E \cdot (m_n - M_{ny}) / (M_{ny+1} - M_{ny})] \quad (IV)$$

with $E \leq 1$,

- from said determined roasting recipe R_{m_n} , determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to formula (I) or (II).

This third mode provides a more accurate determination of the roasting recipe R_n to be applied on said quantity m_n of coffee beans C_n compared to the previous modes since a specific roasting profile is determined for each specific quantity.

By default, E equals 1.

In a particular embodiment of this third mode, based on the obtained type C_n of the coffee beans, the method can comprise the steps of :

- getting access to a coefficient E_n specific to said type C_n of coffee beans, and
- determining the roasting recipe RM_n defined for the roasting a pre-determined quantity M_n of beans C_n by determining the temperature T_m to be applied to the obtained quantity m_n of beans at each of said discrete successive times $t_1, t_2, \dots$ as follows :

$$T_{mn@ti} = T_{Mny@ti} + [(T_{Mny+1@ti} - T_{Mny@ti}) \cdot E_n \cdot (m_n - M_{ny}) / (M_{ny+1} - M_{ny})] \quad (IV).$$

In another fourth mode of the step of determining, for at least one coffee C_n , the roasting recipe R_n adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , the method can comprise the steps of :

- getting access, for at least one type of coffee beans C_n , to at least one series of roasting recipes ($RM_{ny}, RM_{nyi+1}, \dots$) adapted to the roasting of different successive pre-determined quantities ($M_{ny}, M_{nyi+1}, \dots$) of beans of type C_n respectively, and

- for said at least one coffee C_n part of the customised blend, determining the roasting recipe RM_n adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n by :

- identifying in said at least one series of roasting recipes the two accessible roasting recipes RM_{ny} and RM_{nyi+1} adapted to the roasting of two successive pre-determined quantities M_{ny} and M_{ny+1} of beans respectively, wherein the quantity m_n is comprised between these two successive pre-determined quantities M_{ny} and M_{ny+1} ,

- from said two identified roasting recipes RM_{ny} and RM_{nyi+1} , said roasting recipes providing the temperatures $TM_{ny@t1}, TM_{ny@t2}, \dots$ and $TM_{ny+1@t1}, TM_{ny+1@t2}, \dots$ respectively applied at discrete successive times $t_1, t_2, \dots$, determining the temperature $T_{mn@t1}, T_{mn@t2}, \dots$ to be applied to the obtained quantity m_n of beans at each of said discrete successive times $t_1, t_2, \dots$ as follows :

. if m_n is closer to M_{ny} , then $T_{mn@ti} = TM_{ny@ti} + [(TM_{ny+1@ti} - TM_{ny@ti}) \cdot E \cdot (m_n - M_{ny}) / (M_{ny+1} - M_{ny})]$

. if m_n is closer to M_{ny+1} , then $T_{mn@ti} = TM_{ny+1@ti} - [(TM_{ny+1@ti} - TM_{ny@ti}) \cdot E \cdot (M_{ny+1} - m_n) / (M_{ny+1} - M_{ny})]$

with $E \leq 1$,

- from said determined roasting recipe R_{m_n} , determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to formula (I) or (II).

This fourth mode provides a more accurate determination of the roasting recipe R_n to be applied on said quantity m_n of coffee beans compared to the third mode.

By default, E equals 1.

In a particular embodiment of this third mode, based on the obtained type C_n of the coffee beans, the control system can be configured :

- to get access to a coefficient E_n specific to said type C_n of coffee beans, and
- to determine the roasting recipe R_{m_n} defined for the roasting a pre-determined quantity M_n of beans C_n by determining the temperature T_{m_n} to be applied to the obtained quantity m_n of beans at each of said discrete successive times t_1 , t_2 , ... as follows :

. if m_n is closer to M_{ny} , then $T_{m_n@t_i} = T_{M_{ny}@t_i} + [(T_{M_{ny+1}@t_i} - T_{M_{ny}@t_i}) \cdot E_n \cdot (m_n - M_{ny}) / (M_{ny+1} - M_{ny})]$

. if m_n is closer to M_{ny+1} , then $T_{m_n@t_i} = T_{M_{ny+1}@t_i} - [(T_{M_{ny+1}@t_i} - T_{M_{ny}@t_i}) \cdot E_n \cdot (M_{ny+1} - m_n) / (M_{ny+1} - M_{ny})]$

In a second aspect, there is provided a method of roasting a customised blend of coffee beans C_A , C_B , ... using the apparatus such as described above and applying a roasting recipe R_{blend} providing the temperature $T@t_1$, $T@t_2$, ... to be applied at discrete successive times t_1 , t_2 , ..., respectively, the method comprising :

- obtaining for each type of coffee beans C_n comprised in said blend at least :

- . the type C_n of said type of coffee beans, and
- . the quantity m_n of said type of coffee beans C_n introduced in the chamber,

and

- based on the obtained type C_n , getting access at least to :

- . roasting recipes R_{M_A} , R_{M_B} , ... of the different types of coffee beans C_A , C_B , ... respectively, each recipe R_{M_n} being adapted to the roasting of one pre-determined quantity M_n of beans of same type C_n and providing the temperatures $T_{M_n@t_i}$ to be applied at discrete successive times t_i respectively,

and

. temperature adaptation factors K_A , K_B , ... of different types of coffee beans C_A , C_B , ... respectively,

and

- based on the obtained quantities m_n of the different coffee beans C_n and the accessible roasting recipes RM_n and temperature factors K_n , determining the roasting recipe R_{blend} to be applied to said customised blend of coffee beans introduced inside the chamber.

In a third aspect, there is provided an apparatus for roasting coffee beans comprising :

- a chamber to contain coffee beans,
- a heating device to heat coffee beans contained in the chamber,
- a control system operable to control the heating device and configured to apply a roasting recipe R providing the temperature $T_{@t1}$, $T_{@t2}$, ... $T_{@tfinal}$ to be applied at discrete successive times t_1 , t_2 , ..., t_{final} respectively,

wherein, for a customised blend of coffee beans C_A , C_B , ... introduced inside the chamber, the control system is configured to determine the recipe R_{ym} for roasting said blend in the roasting apparatus according to the method such as described above.

In a fourth aspect, there is provided a computer program which, when executed by a computer, processor or control unit, cause the computer, processor or control unit to perform the method such as described above.

Generally, this computer program can be executed by the processing unit of the roasting apparatus.

In one embodiment, the computer program can be executed at least in part by the processing unit of a device external to the apparatus for roasting coffee beans.

By external device, it is meant a device that is physically separated from the apparatus for roasting coffee beans. Such an external device can be a device to obtain the type and/or the quantity of beans, such as a scale and/or a code reader, or a mobile device, like a tablet or smartphone, to get input about the type and/or the quantity of beans and remote access to roasting recipes, temperature and/or time adaptation factors.

The computer program can be executed by the processing unit of the roasting apparatus and the processing unit of said external devices, all said processing units communicating together. The processing unit of the mobile device can be configured to apply all the steps of the method and finally provide the determined roasting recipe of the blend to the processing unit of the roasting apparatus so that said apparatus roasts the blend. Alternatively the processing unit of the mobile device can be configured to implement some steps only of the method such as

obtaining the type and/or the quantity of beans and/or getting access to pre-determined pieces of information such as roasting recipes, temperature and/or time adaptation factors and supplying them the processing unit of the roasting apparatus, that can determine the roasting recipe of the blend from said pieces of information.

- 5 The computer program can be provided as an app inside the processing unit of the mobile device.

In a fifth aspect, there is provided a computer readable storage medium comprising instructions which, when executed by a computer, processor or control unit cause the
10 computer, processor or control unit to carry out the method such as described above.

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
15 advantageous features of the invention will be apparent from the claims, from the detailed description, and annexed drawings.

Brief description of the drawings

- 20 Specific embodiments of the invention are now described further, by way of example, with reference to the following drawings in which :
- Figure 1 is a schematic view of a roasting apparatus according to the invention,
 - Figure 2 shows a block diagram of a control system of the apparatus according to Figure 1,
 - Figure 3 illustrates the calculation of the roasting profile of a blend of coffees derived from
25 the roasting profiles of said coffees,
 - Figure 4 illustrates the process of interpolation of roasting profiles curves,
 - Figure 5 illustrates the calculation of the roasting profile of a blend of coffees derived from the roasting profiles of said coffees presenting different timelines,
 - Figure 6 illustrates the determination of the roasting recipe of a quantity m_A of coffee beans
30 C_A from a roasting recipe adapted for a quantity M_A of coffee beans C_A ,
 - Figure 7 illustrates the calculation of the roasting profile of specific quantity of a particular type of coffee derived from roasting profiles of pre-determined quantities of said type of coffee beans,
 - Figure 8 schematically illustrates the use of measuring device to communicate quantities of
35 beans introduced inside the roasting apparatus,

- Figure 9 shows the block diagram an alternative embodiment of the control system of the apparatus of Figure 1.

Detailed description of exemplary embodiments

5

Roasting Apparatus

Figure 1 shows an illustrative side view part of a roasting apparatus 10. Functionally, the roasting apparatus 10 is operable to roast coffee beans hold in a chamber 1 by means of a flow of hot air introduced inside this chamber. At a first level, the apparatus comprises : a housing 4, a roasting unit and a control system 80. These components will now be sequentially described.

15

Roasting Unit of Roasting Apparatus

The roasting unit is operable to receive and roast coffee beans.

The roasting unit typically comprises at a second level of the roasting apparatus 10 : a chamber 1 and a heating device 2, which are sequentially described.

20 The chamber 1 is configured to receive and hold the coffee beans introduced by the operator. In the preferred embodiment, the chamber 1 is removable from the housing 4. The chamber can be put aside the roasting apparatus :

- for the introduction or the removal of coffee beans, or
- for cleaning and maintenance of the chamber once it is removed, or
- 25 - for cleaning of the vertical housing part 43 behind the chamber.

The bottom opening 11 of the chamber is configured to enable air to pass through, specifically it can comprise a perforated plate on which the beans can lie and through which air can flow upwardly. The chamber 1 comprises a handle in order to enable the user to remove the chamber from the housing and hold it outside the housing.

30

A chaff collector (no illustrated) is in flow communication with the chamber 1 to receive chaffs that progressively separate from the beans and due to their light density are blown off to the chaff collector.

35

The heating device 2 comprises an air flow driver 21 and a heater 22.

The air flow driver 21 is operable to generate a flow of air (dotted lines arrows) in direction of

the bottom of the chamber. The generated flow is configured to heat the beans and to agitate and lift the beans. As a result the beans are homogenously heated. Specifically, the air flow driver can be a fan powered by a motor. Air inlets 42 can be provided inside the base of the housing in order to feed air inside the housing, the air flow driver blowing this air upwardly
 5 though a passage 23 to an air outlet hole 41 in direction of the chamber 1 as illustrated by dotted lines arrows.

The heater 22 is operable to heat the flow of air generated by the air flow driver 21. In the specific illustrated embodiment, the heater is an electrical resistance positioned between the
 10 fan 21 and the bottom opening 11 of the chamber with the result that the flow of air is heated before it enters the chamber 1 to heat and to lift the beans. Other types of heater can be used such as infrared heating, gas burner, ...

The heater 22 and/or the air flow driver 21 is/are operable to apply a roasting profile to the beans, this roasting profile being defined as a curve of temperature against time.

15 When the chamber is mounted to the housing, the bottom of the chamber is tightly connected to the air outlet hole 41 to avoid that the flow of hot air flow leaks at the connection.

The top opening 12 of the chamber is connected to a smoke and particulates evacuation device (not illustrated).

20 Although the invention is described with a roaster implementing a fluidized bed of hot air, the invention is not limited to this specific type of roasting apparatus. Drum roasters and other kinds of roasters can be used.

The roasting apparatus 10 usually comprises a user interface 6 enabling the display and the
 25 input of information.

The roasting apparatus can comprise a code reader 7 to read a code associated to a type of coffee beans, for example present on the package of coffee beans. Preferably, this code reader is positioned in the apparatus so that the operator is able to easily position a code in front of it. It is preferably positioned at the front face of the apparatus, for example close to a
 30 user interface 6 of the apparatus. Accordingly, information provided by the code can be immediately displayed through the display of the user interface 6 positioned aside.

Control System of Roasting Apparatus

35 With reference to **Figures 1 and 2A**, the control system 80 will now be considered : the control system 80 is operable to control the components of the apparatus to roast coffee beans. The

control system 80 typically comprises at a second level of roasting apparatus : the user interface 6, a processing unit 8, temperature probe 5, a power supply 9, a memory unit 13, optionally a database 12, sensors 10, optionally a communication interface 11 for remote connection, optionally a code reader 7, optionally a measuring device 3.

5

The user interface 6 comprises hardware to enable a user to interface with the processing unit 8, by means of user interface signal. More particularly, the user interface receives commands from a user, the user interface signal transfers the said commands to the processing unit 8 as an input. The commands may, for example, be an instruction to execute a roasting process and/or to adjust an operational parameter of the roasting apparatus 10 and/or to power on or off the roasting apparatus 10. The processing unit 8 may also output feedback to the user interface 6 as part of the roasting process, e.g. to indicate the roasting process has been initiated or that a parameter associated with the process has been selected or to indicate the evolution of a parameter during the process or to create an alarm.

10

15 In particular, the user interface can be used :

- to provide the types C_n of the different coffee beans introduced inside the chamber by the user by manual input such as selection of an identification type in a list of pre-selected coffee beans or by entering a digital reference of the coffee, for example read from a coffee beans package or a user's manual.

- 20 - to provide the quantities m_n of the different coffee beans forming the customised blend introduced inside the chamber by manual input.

The hardware of the user interface may comprise any suitable device(s), for example, the hardware comprises one or more of the following : buttons, such as a joystick button, knob or press button, joystick, LEDs, graphic or character LDCs, graphical screen with touch sensing and/or screen edge buttons. The user interface 20 can be formed as one unit or a plurality of discrete units.

25

A part of the user interface can also be on a mobile app when the apparatus is provided with a communication interface 11 as described below. In that case at least a part of input and output can be transmitted to the mobile device through the communication interface 11.

30

The sensors 10 are operable to provide an input signal to the processing unit 8 for monitoring of the roasting process and/or a status of the roasting apparatus. The input signal can be an analogue or digital signal. The sensors 10 typically comprise at least one temperature sensor 5 and optionally one or more of the following sensors : level sensor associated with the chamber 1, air flow rate sensor, position sensor associated with the chamber and/or the chaff

35

collector.

If the apparatus or the system comprises a measuring device 3 (for example as illustrated in Figure 8), this measuring device is operable to provide the input that is the quantity of coffee beans introduced inside the chamber 1. This input can be the weight of the beans measured by a scale or a volume of beans or a level measured by a level sensor associated with the chamber 1.

A code reader 7 can be provided and operable to read a code, for example on coffee beans package, and automatically provide an input that is the identification of the type C_n coffee beans introduced in the chamber 1 and optionally operation conditions for roasting a specific quantity M_n of said coffee beans.

The processing unit 8 generally comprise memory, input and output system components arranged as an integrated circuit, typically as a microprocessor or a microcontroller. The processing unit 8 may comprise other suitable integrated circuits, such as : an ASIC, a programmable logic device such as a PAL, CPLD, FPGA, PSoC, a system on a chip (SoC), an analogue integrated circuit, such as a controller. For such devices, where appropriate, the aforementioned program code can be considered programmed logic or to additionally comprise programmed logic. The processing unit 8 may also comprise one or more of the aforementioned integrated circuits. An example of the later is several integrated circuits arranged in communication with each other in a modular fashion e.g. : a slave integrated circuit to control the user interface 6 in communication with a master integrated circuit to control the roasting apparatus 10.

The power supply 9 is operable to supply electrical energy to the said controlled components and the processing unit 8. The power supply 9 may comprise various means, such as a battery or a unit to receive and condition a main electrical supply. The power supply 9 may be operatively linked to part of the user interface 6 for powering on or off the roasting apparatus 10.

The processing unit 8 generally comprises a memory unit 13 for storage of instructions as program code and optionally data. To this end the memory unit typically comprises : a non-volatile memory e.g. EPROM, EEPROM or Flash for the storage of program code and operating parameters as instructions, volatile memory (RAM) for temporary data storage. The memory unit may comprise separate and/or integrated (e.g. on a die of the semiconductor) memory. For programmable logic devices the instructions can be stored as programmed logic.

The instructions stored on the memory unit 13 can be idealised as comprising a coffee beans roasting program.

The control system 80 is operable to apply this coffee beans roasting program by controlling the heating device 2 – that is, in the particular illustrated embodiment of Figure 1, the air flow driver 21 and/or the heater 22 – usually using signal of the temperature probe 5.

The coffee beans roasting program can effect control of the said components using extraction information encoded on the code and/or other information that may be stored as data on the memory unit 13 or from a remote source through the communication interface 11 and/or input provided via the user interface 6 and/or signal of the sensors 10.

In particular, the control system 80 is configured to apply a roasting recipe (R) providing the temperature $T_{@t_1}$, $T_{@t_2}$, ... $T_{@t_{final}}$ to be applied at discrete successive times t_1 , t_2 , ..., t_{final} respectively.

With that aim, the processing unit 8 is operable to :

- receive an input of the temperature probe 5,
- process the input according to roasting recipe R,
- provide an output, which is the roasting recipe R. More specifically the output comprises the operation of at least the heater 22 and the air flow driver 21.

The temperature measured by the temperature probe 5 is used to adapt the power of the heater 22 and/or the power of the air driver 21 in a feedback loop in order to apply the roasting recipe R to the beans.

Depending on the type of control applied in the roaster, the heater 22 can be powered at one pre-determined power, meaning its temperature is constant, and in that case the power of the air driver 21 can be controlled based on the temperature monitored at the probe 5 in order to vary the time of contact of the flow air through the heater during its movement.

Alternatively, the air driver 21 can be powered at one pre-determined power, meaning the flow rate of air is constant, and in that case the power of the heater 22 can be controlled based on the temperature monitored at the probe 5 in order to heat more or less air during its passage through the heater.

In a last alternative, both heater 22 and air driver 21 can be controlled based on the monitoring of the temperature by probe 5.

The control system 80 can comprise a communication interface 11 for data communication of the roasting apparatus 10 with another device and/or system, such as a server system, a mobile device and/or a physically separated measuring apparatus 3. The communication interface 11 can be used to supply and/or receive information related to the coffee beans roasting process, such as roasting process information, type of the beans, quantity of beans.

The communication interface 11 may comprise first and second communication interface for data communication with several devices at once or communication via different media.

5 The communication interface 11 can be configured for cabled media or wireless media or a combination thereof, e.g. : a wired connection, such as RS-232, USB, I2C, Ethernet define by IEEE 802.3, a wireless connection, such as wireless LAN (e.g. IEEE 802.11) or near field communication (NFC) or a cellular system such as GPRS or GSM. The communication interface 11 interfaces with the processing unit 8, by means of a communication interface signal. Generally the communication interface comprises a separate processing unit
10 (examples of which are provided above) to control communication hardware (e.g. an antenna) to interface with the master processing unit 8. However, less complex configurations can be used e.g. a simple wired connection for serial communication directly with the processing unit 8.

15 The processing unit 8 enables access to different roasting recipes ($RM_A, RM_B, \dots$) adapted to the roasting of pre-determined quantities ($M_A, M_B, \dots$) of beans of different natures ($C_A, C_B, \dots$).

These recipes and the pre-determined quantities can be stored in the memory 13 of the processing unit 8. Alternatively, these data can be stored in a remote server and the
20 processing unit 8 can be supplied with access to this remote server through the communication interface 11, directly or indirectly through a mobile device establishing connection between the remote server and the processing unit.

The control system 80 can comprise a database 12 storing information about coffee beans, in particular about the operation conditions for roasting specific coffee beans as described
25 hereunder. The database 12 can be stored locally in the memory 13 of the control system of the roasting apparatus or remotely in a server accessible through the communication interface 13.

In one alternative embodiment, the control system can be provided with the roasting recipes RM_n , and depending on the embodiment with their associated pre-determined quantities M_n ,
30 during a code reading operation, these pieces of information being encoded inside the code and decoded by the control system.

The roasting apparatus 10 and the control system 80 are configured for roasting a customised blend of different coffee beans introduced inside the chamber 1. This customised blend is
35 defined by the types C_n of beans part of the blend and the respective quantities m_n of said types of beans.

In the present invention, the customised blend can be a mixture created from :

- different beans of single origin only,

or

- different types of pre-existing blends of beans only. In that case, pre-existing blends of coffee beans can be used and mixed together to create new customised and more complex blends.

or

- at least one bean of single origin and at least one pre-existing blend of beans.

In the description the types C_A , C_B ... C_n relate indifferently to beans of single origin or pre-existing blends of beans.

When a customised blend of different types of coffee beans, like for example C_A and C_B in quantities m_A and m_B respectively, is introduced inside the chamber 1 in order to be roasted, the processing unit 8 of the apparatus of the present invention is configured to implement several steps.

First, the processing unit 8 of the apparatus of the present invention is configured to obtain for each type of coffee beans C_n comprised in said blend :

- the type C_n of coffee beans, and

- the quantity m_n of said type of coffee beans C_n introduced in the chamber.

As mentioned earlier, information about identification and quantity can be provided through the user interface 6 of the roasting apparatus, the display of the user interface guiding the user to enter information for each types of coffee.

Alternatively, for the type of the coffee types, information about the types of coffee introduced inside the chamber can be obtained by means of a code reader 7, the user being able or incited to scan the code of the different beans in front of the code reader 15.

Alternatively, for the quantity of the beans of each type, the quantity of each type of coffee can be measured and automatically communicated to the control system 80, for example by the use a measuring device 3 either directly connected to the apparatus or indirectly through the communication interface 11, as illustrated in Figure 8.

In a particular embodiment, the control system can be configured :

- to obtain the input that is the global weight composition of the customised blend, that is the types C_n of coffee beans and the corresponding weight fraction f_n ,

- to obtain the total weight of said customised blend to roasted, for example 500 g,

- to calculate the weight of each type of coffee C_n corresponding to the fraction f_n for said global weight,
- as an output, to request the operator to introduce each calculated weight m_n of coffee C_n in the chamber.

5

Then, in a further step, the control system of the roasting apparatus is configured to get access to information related to the roasting of these specific types of coffee beans C_n , for example C_A and C_B , part of the customised blend, and in particular to :

- the roasting recipes R_A , R_B of the different identified types of coffee beans C_A , C_B respectively.

10

Each of said recipes R_n is usually adapted to the roasting of one pre-determined quantity m_n of beans of same type C_n and provides the temperatures $T_{m_n@t_i}$ to be applied to this quantity of beans C_n at discrete successive times t_i respectively.

and

- temperature adaptation factors K_A , K_B of the different identified types of coffee beans C_A , C_B

15

respectively,

and optionally :

- time adaptation factors S_A , S_B of different identified types of coffee beans C_A , C_B respectively.

In one embodiment, the control system comprises a memory or database 12 storing these roasting recipes R_A , R_B , the temperature adaptation factors K_A , K_B of said different types of coffee beans C_A , C_B and optionally the time adaptation factors S_A , S_B of said different types of coffee beans C_A , C_B and the processing unit 8 of the control system is configured to get access to said database.

20

This database 12 can be stored locally in the memory unit 13 of the processing unit or in a remote server accessible through the communication interface 11 of the control system. This remote database can be accessible through remote connection with a mobile device or through connection with a modem.

25

Based on the first step where identification and quantities of each of the different coffee beans part of the customised blend are obtained, the control system 80 is configured to get access to the above roasting recipes and factors in the database 12.

30

In one alternative embodiment, the control system 80 can be provided with the roasting recipes, the temperature adaptation factors and the time adaptation factors during the code reading operation, these pieces of information being encoded inside the code and decoded by the control system 80.

35

Then, in a further step, the control system is configured to calculate the roasting recipe R_{blend} to be applied to the customised blend of coffee beans introduced inside the chamber based on at least :

- the quantities m_A and m_B of each type of beans C_A and C_B respectively that are part of the blend,
- the accessible roasting recipes R_A , R_B of these beans part of the blend, and
- the accessible temperature factors K_A , K_B of these beans part of the blend.

This roasting recipe can be used to roast the customised blend of coffees introduced in the chamber. This recipe takes into account the properties of each types of coffees and, when applied, provides a roasting of the blend that prevents over-roasting of the more fragile beans and yet sufficient roasting of the denser beans.

This roasting recipe can be calculated for any customised blend of beans in an automatic manner and guarantees a safe roasting of the blend meaning no spill of the blend.

The only condition is that the control system is able to get access to roasting recipes R_A , R_B , ... of the different types of coffee beans C_A , C_B , ... respectively, and to the temperature adaptation factors K_A , K_B , ... of said coffee beans C_A , C_B , ... respectively. In case that a new type of coffee beans is used in the customised blend, it is sufficient that at least one roasting recipe of said new type of beans to be applied for one pre-determined quantity is uploaded in the memory or database of the control system or provided through a readable code.

At each time t_i , the calculation is generally based on a average of the temperatures $T_{m_A@t_i}$ and $T_{m_B@t_i}$, said average being weighted with the quantity fractions ($f_A = m_A/m_A+m_B$, $f_B = m_B/m_A + m_B$) of coffees C_A and C_B respectively and modulated with the temperature factors K_A and K_B respectively.

More precisely, the roasting profile to be applied to the blend of coffee beans can be determined by the following formula (I) :

$$T_{blend@t_i} = \sum_{n=A}^C f_n \cdot K_n \cdot T_{m_n@t_i}$$

Although one type of beans may be present inside the blend with a small quantity fraction, the sensitivity of this type of beans to temperature may be high ; in particular in terms of profile aroma, colour and/or generation of acrylamides. For example, final properties of one type of beans may easily deviate from usual expected properties with a roasting profile differing too much from its own optimal roasting profile. Accordingly, in order to avoid such deviation in the

roasted blend, the temperature adaption factor for this type of sensitive coffee beans is set relatively high to keep the profile of this specific type of beans in the blend close to the optimal roasting profile of this type of beans when roasted alone and in order compensate a low fraction quantity in the roasting profile formula (I) of the blend.

5

As an example, **Figure 3** illustrates the calculation of the roasting profile of a blend of three coffees A, B and C derived from the roasting profiles of each of said coffee A, B and C.

For a blend comprising :

- 50 % in weight of coffee A, said coffee presenting a temperature factor K_A of 1 and a roasting temperature at time t_i of 220°C, and

10

- 30 % in weight of coffee B, said coffee presenting a temperature factor K_B of 0,9 and a roasting temperature at time t_i of 205°C, and

- 20 % in weight of coffee C, said coffee presenting a temperature factor K_C of 1 and a roasting temperature at time t_i of 185°C,

15

the roasting temperature to be applied to the blend at time t_i is :

$$\begin{aligned} T_{\text{blend}} @ t_i &= (0,5 \times 1 \times 220) + (0,3 \times 0,9 \times 205) + (0,2 \times 1 \times 185) \\ &= 110 + 55,35 + 37 \\ &= 202,35^\circ\text{C} \end{aligned}$$

20

Curves interpolation

Often the roasting recipes R_n of the coffee beans are defined by discrete sets of points $(t_i, T@t_i)$ rather than with a complete continuous curve.

25

In a customised blend of different coffees, it can happen that the roasting recipes of the different coffee beans are not defined by discrete sets of points set at the same abscissas t_i .

In that case, the calculation of the roasting profile of the blend preferably comprises an intermediate additional step to interpolate the different accessible curves of the roasting recipes R_n so that all the accessible roasting recipes R_n provide the temperatures $T_{m_n}@t_1$,

30

$T_{m_n}@t_2, \dots T_{m_n}@t_{\text{final}}$ to be applied at the same discrete successive abscissa times $t_1, t_2, \dots t_{\text{final}}$ and to be able to calculate the roasting profile of the blend by means of the formula (I) applied at each of said discrete successive abscissa times $t_1, t_2, \dots t_{\text{final}}$.

Figure 4 illustrates the process of interpolation of two roasting profiles curves of one coffee CA and one coffee CB. The first diagram shows the roasting profile curves of CA and CB such as provided to the control system, through database, memory or code. It appears that the curves do not present points at common abscissa. The second diagram shows the roasting

35

profile curves of CA and CB after a process step of interpolation : both roasting profile curves provide temperatures $T_{mA}@t_i$ and $T_{mB}@t_i$ at the same abscissas t_i .

Interpolation is a process that can be automatically implemented by an algorithm applied by the control system. The choice of the new abscissa t_i at which interpolation is executed can be defined at regular times, for example at every 10 seconds or 20 seconds, or at particular periods in the timeline, for example every 10 seconds during the period covering the first crack periods of all the coffee beans part of the blend, and then every 10 seconds until and during the second crack periods of all the coffee beans part of the blend.

10 **Determination of the roasting recipe R_{m_n} from pre-determined roasting recipes RM_n with different final times**

It can happen that the different roasting recipes R_n of the different coffee beans are defined by curves or discrete sets of points wherein the last abscissa t_{final} is different from one type of coffee to another for at least two of the coffees part of the blend as illustrated in **Figure 5A**.

In that case, the processing unit can be configured to implement additional steps to determine the roasting recipe R_{blend} of the blend.

In particular, the control system can be configured to obtain additional information about the coffee beans of the blend that is time adaptation factors $S_A, S_B, \dots S_n$ for each identified type of coffee beans $C_A, C_B, \dots C_n$ respectively.

In addition, the processing unit is configured to obtain the final times $t_{final\ n}$ of all the coffees C_n part of the customised blend (for example through the different roasting recipes R_n of the identified coffees or alternatively by direct access to that piece of information) and to sort said obtained final times in a series of time $t_{final\ y}$ in an ascending order from the smallest final time $t_{final\ low}$, $t_{final\ low+1}$ up to the highest $t_{final\ high}$.

Then, the processing unit is configured to determine the roasting recipe R_{blend} of the blend as follows :

- for times inferior or equal to the smallest final time $t_{final\ low}$, the processing unit determines the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to above defined formula (I),

- for times superior to the smallest final time $t_{final\ low}$, the processing unit determines the roasting recipe R_{blend} to be applied to said blend of coffee beans introduced inside the chamber by setting temperatures to be applied at new calculated times t_y , as follows :

* each of said new calculated times t_y is calculated from each corresponding obtained final time $t_{\text{final } y}$, from $t_{\text{final low}+1}$ up to $t_{\text{final high}}$, as follows :

5 $t_y = t_{\text{final } y-1} + [(t_{\text{final } y} - t_{\text{final } y-1}) * \Sigma(f_{n'} \cdot S_{n'})]$ with n' corresponding to the coffees presenting a final time superior or equal to $t_{\text{final } y}$,

* up to $t_{\text{final high}-1}$, temperature is determined at each of said calculated time t_y from all the roasting recipes $R_{m_{n'}}$ of the coffee beans $C_{n'}$ presenting a final time superior or equal to $t_{\text{final } y}$ according to following formula (II) :

$$10 \quad T_{\text{blend}@t_y} = \sum_{n'} f_{n'} \cdot K_{n'} \cdot T_{m_{n'}@t_y}$$

Preferably the values of the temperatures $T_{m_{n'}@t_y}$ are interpolated values extracted from the recipes $R_{m_{n'}}$ at the new calculated times t_y .

15 * at $t_{\text{final high}}$:

20 . if only one coffee C_z presents a roasting recipe that presents a final time equal to $t_{\text{final high}}$, then the temperature of the blend is the temperature of the roasting recipe of the quantity m_z of said coffee C_z part of the blend at said final time : $T_{\text{blend}@t_{\text{final high}}} = T_{m_z@t_{\text{final } z}}$,
or

. if at least two coffees present roasting recipes that present the same final time equal to $t_{\text{final high}}$, then the temperature of the blend is determined according to formula II.

25 This determination of the roasting recipe for a blend comprising coffees with different final times is illustrated in **Figure 5A**. In the case related to this figure, the blend comprises three coffees C_A , C_B and C_C with respective quantities m_A , m_B and m_C and the figure represents the roasting curves R_{m_A} , R_{m_B} , R_{m_C} . It can be noticed that these roasting curves present different final time abscissa. Coffee C presents the smallest $t_{\text{final low}}$ and coffee A the highest $t_{\text{final high}}$,
30 whereas coffee B presents an intermediate $t_{\text{final } 2}$.

The roasting curve of the blend can be determined as follows.

First up to $t_{\text{final low}}$, the temperature to be applied to the blend is determined by the above mentioned formula (I) calculated at different times t_i . For example, at the time $t_{\text{final low}}$ the temperature to be applied to the blend is :

$$T_{\text{blend}}@t_{\text{final low}} = f_A.K_A.T_A@t_{\text{final low}} + f_B.K_B.T_B@t_{\text{final low}} + f_C.K_C.T_C@t_{\text{final low}}$$

5

Then, for times between $t_{\text{final low}}$ and $t_{\text{final high}}$, new abscissa times are calculated from the final times of the different recipes :

- a new abscissa time t_2 is calculated from $t_{\text{final 2}}$ as follows : $t_2 = t_{\text{final 1}} + [(t_{\text{final 2}} - t_{\text{final 1}}) * (f_B S_B + f_A S_A)]$ that is $t_{\text{final low}} + [(t_{\text{final 2}} - t_{\text{final low}}) * (f_B S_B + f_A S_A)]$

10 - a new abscissa time t_3 is calculated from $t_{\text{final high}}$ as follows : $t_3 = t_{\text{final 2}} + [(t_{\text{final 3}} - t_{\text{final 2}}) * (f_A S_A)]$ that is $t_2 = t_{\text{final 2}} + [(t_{\text{final high}} - t_{\text{final 2}}) * (f_A S_A)]$

Then at these new calculated times t_2 and t_3 , the temperature of the blend is determined as follows.

15 At the new calculated time t_2 , the temperature to be applied to the blend is determined by the above mentioned formula (II) calculated at time t_2 and only for the coffee beans presenting a final time abscissa superior or equal to $t_{\text{final 2}}$ that is to say in the present case for coffees A and B only, as follows :

$$T_{\text{blend}}@t_2 = f_A.K_A.T_{m_A}@t_2 + f_B.K_B.T_{m_B}@t_2$$

20

At the new calculated time t_3 , the temperature to be applied to the blend corresponds to $T_{m_A}@t_3$ since only coffee A presents a roasting recipe with a final time abscissa superior or equal to $t_{\text{final 3}}$.

25 Figure 5A makes clear that, up to the time $t_{\text{final low}}$, the roasting recipe of the blend of coffees A, B and C can be calculated at whatever abscissa t_i common to the three curves interpolated or not. But, for time abscissa greater than $t_{\text{final low}}$, the roasting curve of the blend is determined by calculating new time abscissas t_2 and t_3 from $t_{\text{final 1}}$, $t_{\text{final 2}}$ and $t_{\text{final 3}}$ and then by calculating the temperatures of the blend at these new time abscissas respectively.

30

Based on the same blend of coffees C_A , C_B and C_C , **Figure 5B** illustrates an alternative method to determine the roasting recipe of the blend.

In that embodiment, the smallest final time $t_{\text{final low}}$ is identified that is here $t_{\text{final 1}}$ of coffee C.

Then the temperature to be applied to the blend is determined by limiting the recipe to times

35 inferior or equal to this smallest final time $t_{\text{final low}}$ and for times t_i inferior or equal to this smallest

final time t_{final} low determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I), that is :

$$T_{\text{blend}} @t_i = f_A \cdot K_A \cdot T_{m_A} @t_i + f_B \cdot K_B \cdot T_{m_B} @t_i + f_C \cdot K_C \cdot T_{m_C} @t_i$$

5

Whatever the embodiment, the control system such as described above is based on the access of the pre-determined roasting recipes R_A , R_B , ... of the different types of coffee beans C_A , C_B , ..., or eventually pre-determined roasting recipes $R_{\text{Blend}\alpha}$, $R_{\text{Blend}\beta}$, ... ($R_{\text{Blend}x}$) of pre-determined blends $\text{Blend}\alpha$, $\text{Blend}\beta$, and the use of at least said pre-determined roasting recipes to define the roasting recipe of the new customised blend.

10

The roasting recipes R_A , R_B , ... or $R_{\text{Blend}\alpha}$, $R_{\text{Blend}\beta}$, ... can be provided more or less precisely as explained below.

15

Determination of the roasting recipe R_{m_n} from one pre-determined roasting recipe R_{M_n}

In one first mode, the accessible roasting recipe R_n of coffee beans of types C_n can correspond to the roasting recipe of one single pre-determined quantity M_n of beans of type C_n . This roasting recipe is usually defined by experimentation by defining the optimal profile for a pre-determined quantity of beans C_n . It is generally linked to the roasting in a type of roaster too. If the quantity m_n of beans C_n introduced in the customised blend is different from this quantity M_n corresponding to the accessible roasting recipe, the control system can be configured to adapt this roasting profile for the quantity m_n of the beans of type C_n used in the customised blend before determining the roasting profile of the blend as illustrated in **Figure 6**.

20

Accordingly, based on the access to the recipe R_{M_A} for the pre-determined quantity M_A , for a quantity m_A of coffee C_A part of the customised blend, the control system is configured to determine the roasting recipe R_{m_A} providing the temperatures $T_{m_A} @t_i$ to be applied at time t_i respectively as follows :

25

30

$$\text{. if } m_A > M_A, \text{ then } T_{m_A} @t_i = T_{M_A} @t_i + [T_{M_A} @t_i \cdot D \cdot (m_A - M_A) / M_A] \quad (\text{IIIa})$$

$$\text{. if } m_A < M_A, \text{ then } T_{m_A} @t_i = T_{M_A} @t_i - [T_{M_A} @t_i \cdot D \cdot (M_A - m_A) / M_A] \quad (\text{IIIb})$$

with $C \leq 1$.

For example, if for coffee CA, the pre-determined quantity MA of the roasting recipe RMA accessible by the control system is set to 150 g and if the quantity mA of coffee beans CA in the customised blend is 160 g, then, at time t₁, the temperature to be applied T_{mA@t1} is :

$$T_{mA@t1} = [T_{MA@t1} \times D \times (160 - 150)/150]$$

Alternatively, if the pre-determined quantity MA is set to 150 g and if the quantity mA of coffee beans A in the customised blend is 135 g, then, at time t₁, the temperature to be applied T_{mA@t1} is :

$$T_{mA@t1} = [T_{MA@t1} \times D \times (150 - 135)/150]$$

The calculation is reproduced for the different time abscissas of the roasting recipe RMA in order to determine the roasting recipe R_{mA} for the quantity m_A of beans as illustrated in Figure 6 corresponding to the situation where m_A is greater than M_A.

These discrete successive times of the pre-determined recipe R_{M_n} can be pre-defined to provide a final roasting recipe with enough points to be implemented by the roasting apparatus. For example, successive time may differ by about 20 to 40 seconds.

In the above formula, the coefficient D is usually fixed experimentally and can vary depending on the roaster specifications (power, chamber size, type of heater, ...) and/or the type of the beans.

In one embodiment, the coefficient D can be set according to the roaster specifications only. In another embodiment, the coefficient D can be set according to the type of beans. In that case, coefficient D can be set :

- generally at a high level of definition of the beans such as the big common botanical varieties of the beans, e.g. Arabica or Robusta providing a coefficient D_A when Arabica beans are roasted and a coefficient D_R when Robusta beans are roasted, or the usual origins, e.g. Colombia, Ethiopia, ...

- or more precisely for each type of beans C_n by defining the corresponding coefficient D_n specifically adapted to this type of beans with more precise criteria than the two general origins.

Based on the obtained type of beans (Arabica, Robusta or C_n) introduced in the chamber, the control system is configured to get access to the coefficient D_n corresponding to that type of beans.

Preferably, the coefficient D is set according to the roaster specifications and the type of beans.

In absence of information about the roaster or the type of beans or the further use, by default, the coefficient D equals 1.

In a further step, this new determined roasting recipe R_{m_n} adapted to the quantity m_n of coffee C_n part of the blend can be used to determine the roasting recipe of the customised blend according to above mentioned formulas (I) or (II).

Selection of the roasting recipe R_{m_n} from a series of pre-determined roasting recipes

R_{m_n}

In other modes, the control system can get access to a series of roasting recipes $R_{M_{ny}}$, $R_{M_{ny}+1}$, ... of coffee beans C_n adapted to the roasting of different successive pre-determined quantities M_{ny} , $M_{ny}+1$, ... respectively of beans of type C_n . These temperature profiles are usually defined by experimentation by defining the optimal profile for a pre-determined quantity of beans. It is usually linked to the type of roaster too.

Figure 7 schematically illustrates the series of roasting recipes $R_{M_{n0}}$, $R_{M_{n1}}$, $R_{M_{n2}}$, $R_{M_{n3}}$, $R_{M_{n4}}$ of coffee beans C_n adapted to the roasting of different successive pre-determined quantities M_{n0} , M_{n1} , M_{n2} , M_{n3} , M_{n4} . Each of the illustrated roasting recipes provides the temperature profile to be applied to a corresponding dedicated quantity of beans respectively in function of time. For example, the different pre-determined quantity of beans that are M_{n0} , M_{n1} , M_{n2} , M_{n3} , M_{n4} can be discrete weights such as : 50 g, 100 g, 150 g, 200 g and 250 g of the same type of beans C_n .

If the quantity m_n of beans C_n introduced in the customised blend is identical to one of these pre-determined quantities M_{ny} , $M_{ny}+1$, ... then the roasting recipe can be directly used in the determination of the roasting recipe of the blend.

If the quantity m_n of beans C_n introduced in the customised blend is different from these pre-determined quantities M_{ny} the control system can be configured to adapt this roasting profile for the quantity m_n of the beans of type C_n used in the customised blend before determining the roasting profile of the blend, in particular according to one of the below modes.

In one **second mode**, based on the quantity m_n of coffee beans introduced inside the chamber, the control system is configured to determine the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , by selecting in the series the roasting recipe $R_{M_{ny}}$ corresponding to the pre-determined quantity of beans C_n presenting the smallest difference of quantity M_{ny} with the obtained quantity m_n used in the blend.

Then this roasting recipe $R_{M_{ny}}$ adapted to the quantity m_n of coffee C_n part of the blend can be used to determine the roasting recipe of the customised blend according to above formula (I) or (II).

For illustration of the second mode, based on the series of recipes of Figure 7 to be applied to different pre-determined weights of beans such as : 50 g, 100 g, 150 g, 200 g and 250 g, if the input for the quantity m_n of beans is 210 g, then the processing unit 8 is operable to select the roasting recipe corresponding to the pre-determined quantity of beans 200 g because the smallest difference between 210 and the five pre-determined quantities 50 g, 100 g, 150 g, 200 g, 250 g is the difference between 210 g and 200 g.

In another **third mode**, based on the quantity m_n of coffee beans introduced inside the chamber, the control system is configured to determine the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , by :

- identifying in the series of roasting recipes the two roasting recipes $R_{M_{ny}}$ and $R_{M_{ny+1}}$ adapted to the roasting of two successive pre-determined quantities M_{ny} and M_{ny+1} of beans respectively, wherein the quantity m_n is comprised between said two successive pre-determined quantities M_{ny} and M_{ny+1} ,

- from said two identified roasting recipes $R_{M_{ny}}$ and $R_{M_{ny+1}}$, determining the temperature $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... to be applied to the obtained quantity m_n of beans C_n at each of said discrete successive times t_1 , t_2 , ... as follows :

$$T_{m_n@t_i} = T_{M_{ny}@t_i} + [(T_{M_{ny+1}@t_i} - T_{M_{ny}@t_i}) \cdot E \cdot (m_n - M_{ny}) / (M_{ny+1} - M_{ny})]$$

with $E \leq 1$.

Then the temperatures $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... adapted to the quantity m_n of coffee C_n part of the blend can be used to determine the roasting recipe of the customised blend according to above formula (I) or (II).

For example, based on Figure 7, if the obtained quantity m_n is 160 g, then roasting recipes R_{150} and R_{200} corresponding respectively to 150 g and 200 g of coffee beans of type C_n are identified.

In a second step, at discrete successive times t_1 , t_2 , ..., t_6 , the temperature T_{m_n} to be applied to the obtained quantity m_n of beans C_n at each of said discrete successive times t_1 , t_2 , ..., t_6 is calculated from the roasting recipes R_{150} and R_{200} as follows :

$$T_{m_n@t_i} = T_{150@t_i} + [(T_{200@t_i} - T_{150@t_i}) \cdot E \cdot (160 - 150) / (200 - 150)]$$

with $E \leq 1$.

The calculation is reproduced at each time t_1 to t_6 determining the full roasting recipe R_{m_n} for the quantity m_n of beans.

These discrete successive times of the pre-determined recipe RM_n can be pre-defined to provide a final roasting recipe with enough points to be implemented by the roasting apparatus. For example, successive time may differ by about 20 to 40 seconds.

- 5 In the above formula, the coefficient E is usually fixed experimentally and can vary depending on the roaster specifications (power, chamber size, type of heater, ...) and/or the type of the beans.

In one embodiment, the coefficient E can be set according to the roaster specifications only. In another embodiment, the coefficient E can be set according to the type of beans. In that

- 10 case, coefficient E can be set :

- generally at a high level of definition of the beans such as the big common botanical varieties of the beans, e.g. Arabica or Robusta providing a coefficient E_A when Arabica beans are roasted and a coefficient E_R when Robusta beans are roasted, or the usual origins, e.g. Colombia (coefficient E_C), Ethiopia (coefficient E_E), ...

- 15 - or more precisely for each type of beans C_n by defining the corresponding coefficient E_n specifically adapted to this type of beans with more precise criteria than the two general origins.

Based on the obtained type of beans (Arabica, Robusta or C_n) introduced in the chamber, the control system is configured to get access to the coefficient E_n corresponding to that type of

- 20 beans.

Preferably, the coefficient E is set according to the roaster specifications and the type of beans.

In absence of information about the roaster or the type of beans or the further use, by default, the coefficient E equals 1.

- 25

In a further step, this new determined roasting recipe R_{m_n} adapted to the quantity m_n of coffee C_n part of the blend can be used to determine the roasting recipe of the customised blend according to above mentioned formulas (I) or (II).

- 30 In another **fourth mode**, based on the quantity m_n of coffee beans introduced inside the chamber, the control system is configured to determine the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , by :

- identifying in the series of roasting recipes the two roasting recipes RM_{nY} and RM_{nY+1} adapted to the roasting of two successive pre-determined quantities M_{nY} and M_{nY+1} of beans respectively, wherein the quantity m_n is comprised between said two successive pre-

- 35

determined quantities M_{nY} and M_{nY+1} ,

- from said two identified roasting recipes $R_{M_{ny}}$ and $R_{M_{ny}+1}$, determining the temperature $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... to be applied to the obtained quantity m_n of beans at each of said discrete successive times t_1 , t_2 , ... as follows :

. if m_n is closer to M_{ny} , then $T_{m_n@t_i} = T_{M_{ny}@t_i} + [(T_{M_{ny}+1@t_i} - T_{M_{ny}@t_i}) \cdot E \cdot (m_n - M_{ny}) / (M_{ny}+1 - M_{ny})]$

. if m_n is closer to $M_{ny}+1$, then $T_{m_n@t_i} = T_{M_{ny}+1@t_i} - [(T_{M_{ny}+1@t_i} - T_{M_{ny}@t_i}) \cdot E \cdot (M_{ny}+1 - m_n) / (M_{ny}+1 - M_{ny})]$

with $E \leq 1$,

Then the temperatures $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... adapted to the quantity m_n of coffee C_n part of the blend can be used to determine the roasting recipe of the customised blend according to above formula (I) or (II).

For example, based on Figure 7, if the obtained quantity m_n is 160 g, then then roasting recipes R_{150} and R_{200} corresponding respectively to 150 g and 200 g of coffee beans of type C_n are identified. Then, since 160 g is closer to 150 g, the temperature T_{m_n} to be applied to said 160 g of beans C_n at each of discrete successive times t_1 , t_2 , ... t_6 is calculated from these roasting recipes R_{150} and R_{200} as follows :

$$T_{160@t_i} = T_{150@t_i} + [(T_{200@t_i} - T_{150@t_i}) \cdot E \cdot (160 - 150) / (200 - 150)]$$

with $E \leq 1$.

But, if the obtained quantity m_n had been 180 g, m_n would be closer to 200 g and the temperature to be applied at t_1 would have been $T_{200@t_i} - [(T_{200@t_i} - T_{150@t_i}) \cdot E \cdot (200 - 180) / (200 - 150)]$.

The coefficient E is defined in the same manner as in the third mode.

Generally, in the step of determining the recipe R_{blend} to be applied to a customised blend of different coffee beans introduced inside the chamber from the quantities m_A , m_B , ... and roasting recipes R_{MA} , R_{MB} , ... of said different types of coffee beans C_A , C_B , ... any of the different above described modes enabling the determination of roasting recipes R_{m_A} , R_{m_B} , ... can be used. In particular, different modes can be used for different coffees.

Figure 8 illustrates the use of a measuring device 3 to communicate quantities of beans introduced inside the roasting apparatus to the processing unit of the control system.

The measuring device 3 is connected to the processing unit 8 of the roasting apparatus 10.

When a blend of coffees is customised, different coffees are introduced inside the chamber 1 positioned in relation to the measuring device 3. For example if the measuring device is a scale, the chamber 1 can be positioned on the scale.

In a step 1, a first quantity of coffee C_A is introduced inside the chamber. The scale detects the introduction of beans and provides the information to the control system 80 of the apparatus. The control system can be configured to display a message through the user interface 6 to require the operator enters the identification of the beans C_A . In the operation of identification, the operator can input the type of the beans like a SKU reference, a trademark or a more general level description like Arabica green beans or Robusta pre-roasted beans. Then or simultaneously, in step 2, the measuring device provides the quantity m_A of beans C_A present in the chamber. A further step, not illustrated, can happen where the control system asks the operator to confirm the introducing of beans C_A in the chamber is finished.

In step 3, the scale detects the introduction of beans again and provides the information to the control system 80 of the apparatus, which implements the steps 4 and 5 identical the previous steps 1 and 2 of requiring identification of the beans being introduced, here C_B , and getting access to the measured quantity m_B of said beans C_B in the chamber.

In step 6, the chamber 1 is positioned inside the apparatus 10 finishing the steps of obtaining the identification and quantities of the different coffee beans part of the customised blend.

Alternative implementations can be used : the measuring device can be part of the chamber which does not require the withdrawal of the chamber from the apparatus.

Usually the measured quantity is the weight of the beans. Alternatively, it can be the volume.

If the quantity provided by the measuring device is a volume and not a weight, the weight can be deduced indirectly from an average density of coffee beans or more preferably, the identification of the nature of the beans provides access to the exact density of said beans enabling the calculation of the weight of beans introduced in the chamber.

Figure 9 illustrates the block diagram of an alternative embodiment of the control system 80 of a roasting apparatus 1.

In this embodiment, the control system is implemented through two processing units, one processing unit 8 being part of the roasting apparatus 1 and the other processing unit 81 being part of an external command device like a tablet or a smartphone.

The processing unit 8 of the roasting apparatus can provide less functions than the processing unit illustrated in Figure 2 and is limited essentially to the core functions of the roasting apparatus that is applying a determined recipe by control of the air flow driver and the heater. The presence of a user interface can even be optional.

The determined roasting recipe for the new customized blend can be provided through the communication interface 11 establishing communication with the communication interface 111 of the processing unit 81 of the external device. The processing unit 81 is configured to receive

input about the types and quantities of the beans introduced inside the chamber of the roasting apparatus through the user interface 61 of the external device and/or through a measuring device 3 and/or through a code reader 71.

The processing unit 81 of the external device is configured to execute the program enabling the determination of the roasting recipe of the blend, this program being stored in the memory unit 131 of the processing unit or accessible in a remote server 15 through the communication interface 111. Once the roasting recipe of the blend is determined, it can be communicated to the processing unit 8 of the roasting apparatus 1 for execution of the roasting operation.

The present invention provides the advantage of enabling the rapid and easy determination of the roasting recipe of a customized blend from the at least one existing recipe of each of the coffee beans part of the blend. Once at least one roasting recipe of a type of beans is accessible, it becomes possible to use this existing roasting recipe to determine the roasting recipe of a blend comprising said type of beans.

Another advantage is that, when the roasting recipes of existing commercialized blends of coffee beans are defined by this method and the sourcing of one type of the beans of the blend is no more possible for various reasons, it becomes possible to replace this type of beans by another one and to define rapidly and automatically the new roasting recipe of the blend based on the recipe of this new type of coffee beans and the recipes of the other types of beans already present in the blend.

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 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 :

roasting apparatus	10
chamber	1

	bottom opening	11
	top opening	12
	heating device	2
	air flow driver	21
5	heater	22
	passage	23
	measuring device	3
	housing	4
	air outlet hole	41
10	air inlets	42
	temperature probe	5
	user interface	6, 61
	code reader	7, 71
	processing unit	8, 81
15	control system	80
	power supply	9, 91
	sensor	10
	communication interface	11, 111
	database	12
20	memory unit	13, 131
	coffee beans	14
	server	15

CLAIMS

1. A method to determine the roasting recipe R_{blend} for roasting a customised blend of coffee beans $C_A, C_B, \dots$ introduced in a chamber of a roasting apparatus, said recipe R_{blend} providing the temperature $T@t_1, T@t_2, \dots$ to be applied at discrete successive times $t_1, t_2, \dots$, respectively, said method comprising the steps of :

- obtaining for each type of coffee beans C_n comprised in said blend at least :

. the type C_n of said type of coffee beans, and

. the quantity m_n of said type of coffee beans C_n introduced in the chamber,

and

- based on the obtained type C_n , getting access at least to :

. roasting recipes $RM_A, RM_B, \dots$ of the different types of coffee beans $C_A, C_B, \dots$ respectively, each recipe RM_n being adapted to the roasting of one pre-determined quantity M_n of beans of same type C_n and providing the temperatures $TM_n@t_i$ to be applied at discrete successive times t_i respectively,

and

. temperature adaptation factors $K_A, K_B, \dots$ of said different types of coffee beans $C_A, C_B, \dots$ respectively of the customised blend,

and

- based on the obtained quantities m_n of the different coffee beans C_n and the accessible roasting recipes RM_n and temperature factors K_n , determining the roasting recipe R_{blend} to be applied to said customised blend of coffee beans introduced inside the chamber.

2. A method according to Claim 1, wherein the roasting recipe R_{blend} to be applied to the customised blend of coffee beans is determined by at least the following steps :

- for each type C_n of coffee beans respectively selecting or determining the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said obtained type C_n , said roasting recipe R_{m_n} providing the temperature $T_{m_n}@t_i$ respectively to be applied at time t_i respectively, and

- from said selected and/or determined roasting recipes R_{m_n} and from said accessible temperature adaptation factors K_n , and based on the obtained quantities m_n of beans of type C_n introduced inside the chamber, determining the temperature $T_{blend}@t_1, T_{blend}@t_2, \dots$ to be applied to the customised blend of beans at each of discrete successive times $t_1, t_2, \dots$ respectively according to following formula (I) :

$$T_{blend@t_i} = \sum_{n=A}^N f_n \cdot K_n \cdot T_{m_n@t_i} \quad (I)$$

wherein n corresponds to all the types of coffee beans C_A to C_N present in the blend and f_n represents the fraction in weight of coffee beans of type C_n in the customised blend of coffee beans.

3. A method according to Claim 2, wherein :

- in at least two of the selected or determined roasting recipes R_{m_n} of coffees C_n , said recipes providing temperatures $T_{m_n@t_i}$, to be applied at discrete successive times t_i , at least a part of said discrete successive times t_i are set differently, and
- from the selected or determined roasting recipes R_{m_n} for each coffee C_n of the customised blend, interpolated roasting recipes curves R_{m_n} are determined by interpolating the curves of the accessible roasting recipes so that all the selected or determined roasting recipes provide the temperatures $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... $T_{m_n@t_{final}}$ respectively to be applied at the same discrete successive times t_1 , t_2 , ... t_{final}

4. A method according to Claim 2 or 3, comprising the steps of :

- selecting or determining :
 - . the roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} , ... of the different identified types of coffee beans of different types C_A , C_B , ... C_n ... respectively, each recipe being adapted to the roasting of the quantity m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$ to be applied at discrete successive times t_i up to a final time $t_{final\ n}$ respectively, and said final time $t_{final\ n}$ being set differently in at least two of said different roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} ..., and
- getting access to :
 - . time adaptation factors S_A , S_B , ... S_n for each type of coffee beans C_A , C_B , ... C_n respectively,
- and
- determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by implementing the following steps :
 - based on the obtained roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} , ...,
 - . obtaining the final times $t_{final\ y}$ of all the coffees C_n part of the customised blend, and

. sorting said obtained final times $t_{final\ y}$ in an ascending order from the lowest final time $t_{final\ low}$ up to the highest $t_{final\ high}$

- for times inferior or equal to the lowest final time $t_{final\ low}$, determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I),

- for times superior to the smallest final time $t_{final\ low}$, determining the roasting recipe R_{blend} to be applied to said blend of coffee beans introduced inside the chamber by setting temperatures to be applied at calculated times t_y ,

* each of said calculated times t_y being calculated from each corresponding obtained final time $t_{final\ y}$, from $t_{final\ low+1}$ up to $t_{final\ high}$, as follows :

$t_y = t_{final\ y-1} + [(t_{final\ y} - t_{final\ y-1}) * \sum(f_{n'} * S_{n'})]$ with n' corresponding to the coffees presenting a final time superior or equal to $t_{final\ y}$,

* up to $t_{final\ high-1}$, temperature being determined at each of said calculated time t_y from the roasting recipes $R_{m_{n'}}$ of all the coffee beans $C_{n'}$ presenting a final time superior or equal to $t_{final\ y}$, according to following formula (II) :

$$T_{blend@t_y} = \sum_{n'} f_{n'} \cdot K_{n'} \cdot T_{m_{n'}@t_y} \quad (II)$$

* at $t_{final\ high}$:

. if only one coffee C_z presents a roasting recipe that presents a final time equal to $t_{final\ high}$, then the temperature of the blend is the temperature of the roasting recipe of the quantity m_z of said coffee C_z part of the blend at said final time : $T_{blend@t_{final\ high}} = T_{m_z@t_{final\ z}}$, or

. if at least two coffees presents roasting recipes that present the same final time equal to $t_{final\ high}$, then the temperature of the blend is determined according to formula (II).

5. A method according to Claim 2 or 3, comprising the steps of :

- selecting or determining the roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} of the different identified types of coffee beans of different types C_A , C_B , ... C_n ... respectively, each recipe being adapted to the roasting of the qaunttiy m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$ to be applied at discrete successive times t_i up to a final time $t_{final\ n}$ respectively, and said final

time $t_{\text{final } n}$ set differently in at least two of said different roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} , and

- determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by implementing the following steps :

- 5 - based on the selected or determined roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} ,
 - . obtaining the final times $t_{\text{final } n}$ of all the coffees C_n part of the customised blend, and
 - . identifying the smallest final time $t_{\text{final low}}$,
- limiting the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber to times inferior to the smallest final time $t_{\text{final low}}$, and
- 10 - determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I).

6. A method according to Claim 2 or 3, comprising the steps of :

- selecting or determining the roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} of the different identified types
- 15 of coffee beans of different types C_A , C_B , ... C_n ... respectively, each recipe being adapted to the roasting of the quantity m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$ to be applied at discrete successive times t_i up to a final time $t_{\text{final } n}$ respectively, and said final time $t_{\text{final } n}$ set differently in at least two of said different roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} , and
- 20 - determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by implementing the following steps :
 - based on the selected or determined roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} ,
 - . obtaining the final times $t_{\text{final } n}$ of all the coffees C_n part of the customised blend, and
 - . identifying the smallest final time $t_{\text{final low}}$,
 - 25 - for times inferior or equal to the lowest final time $t_{\text{final low}}$, determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I),
 - for times superior to the smallest final time $t_{\text{final low}}$, determining the roasting recipe R_{blend} to be applied to said blend of coffee beans introduced inside the chamber by setting
 - 30 temperatures to be applied at each $t_{\text{final } n}$, as follows :

* up to $t_{\text{final high}-1}$, temperature being determined at each of said time $t_{\text{final } n}$ from the roasting recipes R_{m_n} of all the coffee beans C_n presenting a final time superior or equal to $t_{\text{final } y}$, according to following formula (II) :

$$T_{blend@t_{final\ n}} = \sum_{n'} f_{n'} \cdot K_{n'} \cdot T_{m_{n'}@t_{final\ n}} \quad (II)$$

* at $t_{final\ high}$:

- . if only one coffee Cz presents a roasting recipe that presents a final time equal to $t_{final\ high}$, then the temperature of the blend is the temperature of the roasting recipe of the quantity m_z of said coffee Cz part of the blend at said final time : $T_{blend@t_{final\ high}} = T_{m_z@t_{final\ z}}$, or
- . if at least two coffees presents roasting recipes that present the same final time equal to $t_{final\ high}$, then the temperature of the blend is determined according to formula (II).

7. A method according to Claim 2 or 3, comprising the steps of :

- selecting or determining the roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} of the different identified types of coffee beans of different types C_A , C_B , ... C_n ... respectively, each recipe being adapted to the roasting of the quantity m_n of beans of same type C_n and providing the temperatures $T_{m_n@t_i}$ to be applied at discrete successive times t_i up to a final time $t_{final\ n}$ respectively, and said final time $t_{final\ n}$ set differently in at least two of said different roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} , and

- getting access to time adaptation factors S_A , S_B , ... S_n for each type of coffee beans C_A , C_B , ... C_n respectively,

and

- determining the roasting recipe (R_{blend}) to be applied on the blend of coffee beans by implementing the following steps :

- based on the selected or determined roasting recipes R_{m_A} , R_{m_B} , ... R_{m_n} ,

- . obtaining the final times $t_{final\ n}$ of all the coffees C_n part of the customised blend, and

- . identifying the smallest final time $t_{final\ low}$,

- for times inferior or equal to the lowest final time $t_{final\ low}$, determining the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber according to formula (I),

- above the smallest final time $t_{final\ low}$, :

- . calculating one time $t_{final\ global}$ from all the final times $t_{final\ n}$ of all the coffees C_n part of the customised blend, as follows :

$$t_{final\ global} = \sum (f_n \cdot S_n \cdot t_{final\ n})$$

- . limiting the roasting recipe (R_{blend}) to be applied to said blend of coffee beans introduced inside the chamber to said time $t_{final\ global}$, and
- . determining the roasting recipe (R_{blend}) to be applied at said time $t_{final\ global}$ to said blend of coffee beans introduced inside the chamber according to formula (I).

5

8. A method according to any one of Claims 2 to 7, comprising the steps of :

- getting access, for at least one coffee C_n , to one roasting recipe RM_n of coffee beans, said recipe being adapted to the roasting of one pre-determined quantity M_n of beans,

10

- for said at least one coffee C_n part of the customised blend, determining the roasting recipe RM_n adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n (providing the temperatures $T_{m_n@t_i}$ respectively to be applied at time t_i respectively) from said one accessible recipe RM_n adapted to the roasting of one pre-determined quantity M_n of beans of type C_n and providing the temperatures $TM_n@t_i$ to be applied at discrete successive times t_i respectively, as follows :

15

$$\text{. if } m_n > M_n, \text{ then } T_{m_n@t_i} = T_{M_n@t_i} + [T_{M_n@t_i} \cdot D \cdot (m_n - M_n)/M_n] \quad (IIIa)$$

20

$$\text{. if } m_n < M_n, \text{ then } T_{m_n@t_i} = T_{M_n@t_i} - [T_{M_n@t_i} \cdot D \cdot (M_n - m_n)/M_n] \quad (IIIb)$$

with $D \leq 1$

- from said determined roasting recipe R_{m_n} , determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to formula (I) or (II).

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9. A method according to any one of Claims 2 to 8, comprising the steps of :

- getting access, for at least one type of coffee beans C_n , to at least one series of roasting recipes (RM_{n0} , RM_{n1} , ... RM_{ny} ...) adapted to the roasting of different successive pre-determined quantities (M_{n0} , M_{n1} , ..., M_{ny} ...) of beans of type C_n respectively and to said pre-determined quantities M_{n0} , M_{n1} , ... M_{ny} ..., and

30

- for said at least one coffee C_n part of the customised blend, determining roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n , by selecting one of the recipes of the at least one accessible series_of roasting recipes, said selection comprising identifying the roasting recipe adapted to the roasting of a pre-determined quantity M_{ny} of beans, said pre-determined quantity of beans presenting the smallest difference of quantity M_{ny} with the obtained quantity m_n .

- from said determined roasting recipe $R_{m_{ny}}$, determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to formula (I) or (II).

10. A method according to any one of Claims 2 to 9, comprising the steps of :

- getting access, for at least one type of coffee beans C_n , to at least one series of roasting recipes ($R_{m_{n0}}$, $R_{m_{n1}}$, ... $R_{m_{ny}}$...) adapted to the roasting of different successive pre-determined quantities (M_{n0} , M_{n1} , ..., M_{ny} ...) of beans of type C_n respectively and to said pre-determined quantities M_{n0} , M_{n1} , ... M_{ny} ..., and

- for said at least one coffee C_n part of the customised blend, determining the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n by :

. identifying in said at least one series of roasting recipes the two accessible roasting recipes $R_{m_{ny}}$ and $R_{m_{ny+1}}$ adapted to the roasting of two successive pre-determined quantities M_{ny} and M_{ny+1} of beans respectively, wherein the quantity m_n is comprised between said two successive pre-determined quantities M_{ny} and M_{ny+1} ,

. from said two identified roasting recipes $R_{m_{ny}}$ and $R_{m_{ny+1}}$, said roasting recipes providing the temperatures $T_{m_{ny}@t_1}$, $T_{m_{ny}@t_2}$, ... and $T_{m_{ny+1}@t_1}$, $T_{m_{ny+1}@t_2}$, ... respectively applied at discrete successive times t_1 , t_2 , ..., determining the temperature $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... to be applied to the obtained quantity m_n of beans at each of said discrete successive times t_1 , t_2 , ... as follows :

$$T_{m_n@t_i} = T_{m_{ny}@t_i} + [(T_{m_{ny+1}@t_i} - T_{m_{ny}@t_i}) \cdot E \cdot (m_n - M_{ny}) / (M_{ny+1} - M_{ny})] \quad (IV)$$

with $E \leq 1$,

- from said determined roasting recipe R_{m_n} , determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to formula (I) or (II).

5 11. A method according to any one of Claims 2 to 10, comprising the steps of : :

- getting access, for at least one type of coffee beans C_n , to at least one series of roasting recipes (R_{m_0} , R_{m_1} , ...) adapted to the roasting of different successive pre-determined quantities (M_{n0} , M_{n1} , ...) of beans of type C_n respectively and to said pre-determined quantities
10 M_{n0} , M_{n1} , ..., and

- for said at least one coffee C_n part of the customised blend, determining the roasting recipe R_{m_n} adapted to the roasting of the obtained quantity m_n of beans of said identified type C_n by :

15 - identifying in said at least one series of roasting recipes the two accessible roasting recipes $R_{m_{ny}}$ and $R_{m_{ny+1}}$ adapted to the roasting of two successive pre-determined quantities M_{ny} and M_{ny+1} of beans respectively, wherein the quantity m_n is comprised between these two successive pre-determined quantities M_{ny} and M_{ny+1} ,

20 - from said two identified roasting recipes $R_{m_{ny}}$ and $R_{m_{ny+1}}$, said roasting recipes providing the temperatures $T_{m_{ny}@t_1}$, $T_{m_{ny}@t_2}$, ... and $T_{m_{ny+1}@t_1}$, $T_{m_{ny+1}@t_2}$, ... respectively applied at discrete successive times t_1 , t_2 , ..., determining the temperature $T_{m_n@t_1}$, $T_{m_n@t_2}$, ... to be applied to the obtained quantity m_n of beans at each of said discrete successive times t_1 , t_2 , ... as follows :

25 . if m_n is closer to M_{ny} , then $T_{m_n@t_i} = T_{m_{ny}@t_i} + [(T_{m_{ny+1}@t_i} - T_{m_{ny}@t_i}) \cdot E \cdot (m_n - M_{ny}) / (M_{ny+1} - M_{ny})]$

30 . if m_n is closer to M_{ny+1} , then $T_{m_n@t_i} = T_{m_{ny+1}@t_i} - [(T_{m_{ny+1}@t_i} - T_{m_{ny}@t_i}) \cdot E \cdot (M_{ny+1} - m_n) / (M_{ny+1} - M_{ny})]$

with $E \leq 1$,

35 - from said determined roasting recipe R_{m_n} , determining the temperature $T_{blend@t_1}$, $T_{blend@t_2}$, ..., to be applied to the customised blend of beans at each of said discrete successive times t_1 , t_2 , ... according to formula (I) or (II).

12. An apparatus (10) for roasting coffee beans comprising :

- a chamber (1) to contain coffee beans,
 - a heating device (2) to heat coffee beans contained in the chamber,
 - a control system (80) operable to control the heating device and configured to apply a
- 5 roasting recipe R providing the temperature $T_{@t_1}$, $T_{@t_2}$, ... $T_{@t_{final}}$ to be applied at discrete successive times t_1 , t_2 , ..., t_{final} respectively,

wherein, for a customised blend of coffee beans C_A , C_B , ... introduced inside the chamber, the control system is configured to determine the recipe R_{ym} for roasting said blend in the roasting apparatus according to the method of any one of Claims 1 to 11.

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13. A computer program which, when executed by a computer, processor or control unit, cause the computer, processor or control unit to perform the method of any one of Claims 1 to 11.

14. A computer program according of the precedent claim, wherein said computer program is

15 executed at least in part by the processing unit of a device external to the apparatus for roasting coffee beans.

15. A computer readable storage medium comprising instructions which, when executed by a computer, processor or control unit cause the computer, processor or control unit to carry out

20 the method of any one of Claims 1 to 11.

Abstract**METHOD FOR ROASTING COFFEE BEANS**

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The invention concerns a method to determine the roasting recipe R_{blend} for roasting a customised blend of coffee beans $C_A, C_B, \dots$ introduced in a chamber of a roasting apparatus, said recipe R_{blend} providing the temperature $T@t_1, T@t_2, \dots$ to be applied at discrete successive times $t_1, t_2, \dots$, respectively, said method comprising the steps of :

- 10 - obtaining for each type of coffee beans C_n comprised in said blend at least :
- . the type C_n of said type of coffee beans, and
 - . the quantity m_n of said type of coffee beans C_n introduced in the chamber,
- and
- based on the obtained type C_n , getting access at least to :
- 15 . roasting recipes $RM_A, RM_B, \dots$ of the different types of coffee beans $C_A, C_B, \dots$ respectively, and
- . temperature adaptation factors $K_A, K_B, \dots$ of said different types of coffee beans $C_A, C_B, \dots$ respectively of the customised blend,
- and
- 20 - based on the obtained quantities m_n of the different coffee beans C_n and the accessible roasting recipes RM_n and temperature factors K_n , determining the roasting recipe R_{blend} to be applied to said customised blend of coffee beans introduced inside the chamber.

Figure 1