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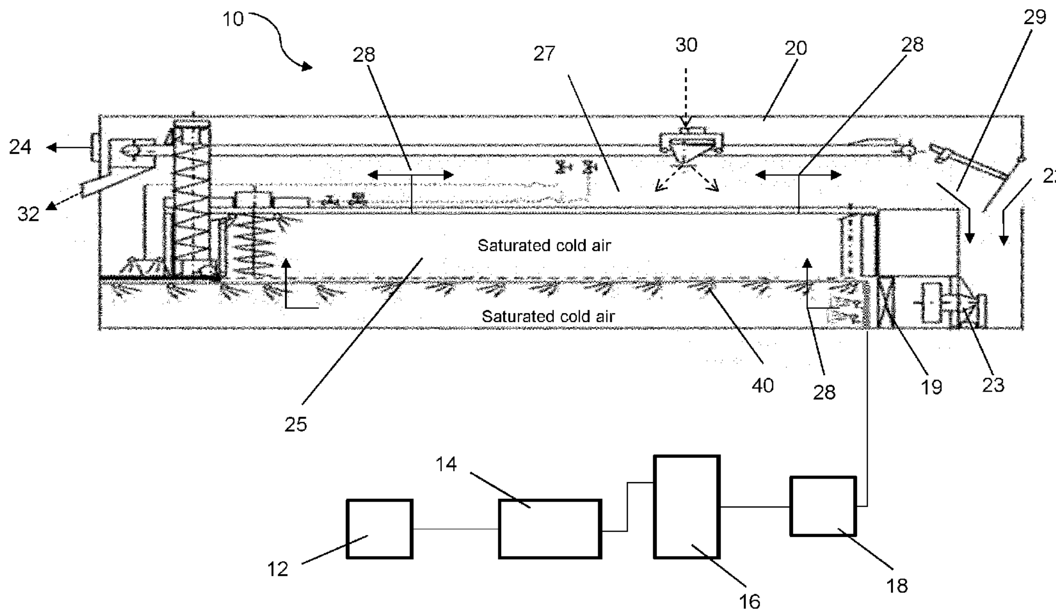

Figure 1

(57) Abstract: The present invention provides a method of germinating grains in a germination system, the germination system comprising: a germination housing comprising an air inlet, an air outlet, an air flow path defined between the air inlet and air outlet, and grains to be germinated, wherein said grains are located within the air flow path; and a plurality of nozzles configured to spray water into the air flow path, the plurality of nozzles having a nozzle arrangement; and the method comprises: supplying unsaturated air to the germination housing via the air inlet, and cooling and humidifying the unsaturated air using water sprayed from the plurality of nozzles configured to spray water within the air flow path so that the air in the air flow path is a fog, and is preferably maintained at a temperature of 16-18 °C.

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Germination Method and Malted Grains

INTRODUCTION

The present invention relates to a germination system for the malting of grains, and methods of germination using the germination system. The present invention also relates to malted barley obtained by the methods of the invention and using the system of the invention. The malted barley has less batch to batch variability as well as advantageous properties compared to malted barley prepared by conventional malting processes.

BACKGROUND

The malting process within the brewing industry typically involves three stages: steeping, germination and drying. These stages occur within a malthouse and is typically applicable to the preparation of malted barley for the purposes of brewing, for example, beer based beverages. However, other grains and feedstocks such as oats, wheat, rye can also undergo a malting process for use in brewing and food production.

The malting process allows the development of malt enzymes within the grains. These enzymes modify the physical structure of the grain, producing a product that is ready for use in subsequent brewing stages.

The germination stage within the malting process is therefore important as this stage promotes the growth of the required malt enzymes. During the germination stage, a constant airflow is required to keep the germ oxygenated, permit respiration and to remove the carbon dioxide produced by the respiration process. Humidity and temperature have significant effects on the germination process. Typically, the air has to be saturated in order to stabilise the moisture of the grain kernel, without it drying out. Germination also produces large quantities of heat and therefore cooling is required to maintain the germination process at the optimum/required temperatures.

The germination stage can be energy intensive. For example, cooling of unsaturated air to the optimum temperature for use in the germination stage can account for 15% of electricity consumption of the entire malthouse.

SUMMARY OF INVENTION

Aspects of the present invention relate to a germination system, a method of germination and the resulting malted grain, e.g. malted barley.

According to an aspect of the present invention, there is provided a method of germinating grains in a germination system, the germination system comprising:

a germination housing comprising an air inlet, an air outlet, an air flow path defined between the air inlet and air outlet and grains to be germinated, wherein said grains are located within the air flow path; and

a plurality of nozzles configured to spray water into the air flow path, the plurality of nozzles having a nozzle arrangement;

and the method comprises:

supplying unsaturated air to the germination housing via the air inlet, and cooling and humidifying the unsaturated air using water sprayed from the plurality of nozzles configured to spray water within the air flow path so that the air in the air flow path is a fog, and is preferably maintained at a temperature of 16-18 °C

According to another aspect of the present invention, there is provided a germination system for the malting of grains, the system comprising

a germination housing comprising an air inlet, an air outlet, an air flow path defined between the air inlet and air outlet, a grains inlet, a grains outlet and grains to be germinated, wherein said grains are located within the air flow path; and

a plurality of nozzles configured to spray water into the air flow path, the plurality of nozzles having a nozzle arrangement;

wherein the plurality of nozzles are configured to provide a mean water droplet diameter of between about 20 μm to 90 μm, or about 20 μm to 30 μm.

According to another aspect of the present invention, there is provided malted barley obtainable by, or obtained by, the methods of the present invention.

According to another aspect, the present invention provides use a germination system as hereinbefore described to prepare malted grain, preferably malted barley.

According to a further aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:

an amount of PUGs;

an amount of WUGs;

an amount of beta-glucans;

a friability; and

a diastatic power,

wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the control limit range for the amount of PUGs is less than 7 wt%, preferably less than 5 wt%;
(ii) the control limit range for the amount of WUGs is less than 3.5 wt%, preferably less than 3 wt%;
(iii) the control limit range for the amount of beta-glucans is less than 300 ppm, preferably less than 250 ppm;
(iv) the control limit range for friability is less than 20 %, preferably less than 18 %; and
(v) the control limit range for diastatic power is less than 50 °WK, preferably less than 40 °WK.

According to a further aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:
an amount of PUGs;
an amount of WUGs;
an amount of beta-glucans;
a friability; and
a diastatic power,
wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the standard deviation for the amount of PUGs is less than 1.4 wt%, preferably less than 1.0 wt%;
(ii) the standard deviation for the amount of WUGs is less than 0.6 wt%, preferably less than 0.5 wt%;
(iii) the standard deviation for the amount of beta-glucans is less than 50 ppm, preferably less than 40 ppm;
(iv) the standard deviation for friability is less than 3.5%, preferably less than 3.0%; and
(v) the standard deviation for diastatic power is less than 8.0 °WK, preferably less than 6.0 °WK.

According to a further aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:
an amount of PUGs;
an amount of WUGs;
an amount of beta-glucans;
a friability; and

a diastatic power,

wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the mean amount of PUGs is less than 2.2 wt%;

(ii) the mean amount of WUGs is less than 1.0 wt%;

(iii) the mean amount of beta-glucans is less than 100 ppm;

(iv) the mean friability is greater than 85 %;

(v) the mean diastatic power is greater than 290 °WK; and

(vi) the mean extract is greater than 81.0 wt%.

According to a further aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:

an amount of PUGs;

an amount of WUGs;

an amount of beta-glucans;

a friability; and

a diastatic power,

wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the mean amount of PUGs is less than the mean amount of PUGs present in malted barley prepared by a conventional malting process;

(ii) the mean amount of WUGs is less than the mean amount of WUGs present in malted barley prepared by a conventional malting process;

(iii) the mean amount of beta-glucans is less than the mean amount of beta-glucans present in malted barley prepared by a conventional malting process;

(iv) the mean friability is higher than the mean friability of the malted barley prepared by a conventional malting process; and

(v) the mean diastatic power is higher than the mean friability of the malted barley prepared by a conventional malting process.

DEFINTIONS

As used herein, the term “fog” refers to air comprising suspended water droplets. Fog tends to form when the air has a relative humidity of greater than 100%. Some of the moisture in the air condensates to form water droplets that are suspended in the air.

As used herein, the term “adiabatic cooling” refers to the cooling which arises from evaporation of water from the surface of water droplets. Since evaporation is an endothermic process, it cools the air (i.e. the air supplies the necessary energy). As the temperature of the air decreases, more water droplets condense.

As used herein, the term “plurality of batches of malted barley” refers to at least two batches of malted barley, wherein each batch has been separately germinated and dried. A batch of malted barley is therefore a quantum of barley that has been germinated and dried and has a set of characteristics. The characteristics of every batch germinated and dried by the same process are ideally the same. In other words, the extent of variation between different batches is ideally minimised. This ensures the product is of a consistent quality. A batch of malted barley is different to malted barley per se because it refers to a certain quantum of barley that has been germinated and dried together and has a set of characteristics.

As used herein, the term “green barley” refers to barley that has been germinated. Often it is characterised by its moisture content.

As used herein, the term “PUGs” refers to partially unconverted grains.

As used herein, the term “WUGS” refers to wholly unconverted grains.

As used herein the amount of PUGs (wt%) is determined by Analytica EBC Malt 4.15 friability methodology.

As used herein the amount of WUGs (wt%) is determined by Analytica EBC Malt 4.15 friability methodology.

As used herein the amount of beta-glucans (ppm) is determined by is determined by Analytica EBC Malt 4.15 friability methodology.

As used herein the diastatic power (°WK) is determined by is determined by Analytica EBC Malt 4.15 friability methodology.

As used herein extract (%wt), which refers to the total mass that can be extracted or obtained from the malted grain, is determined by Analytica EBC 4.5.1 extract of malt.

As used herein, green malt moisture (%) is determined by is determined by Analytica EBC Malt 4.15 friability methodology.

As used herein, the term mean refers to the arithmetic mean across a plurality of batches. The mean and standard deviation were calculated by the methodology described in the examples.

As used herein the terms Upper Control Limit (UCL) and Lower Control Limit (LCL) are calculated as the mean + 3 times the standard deviation (UCL) and the mean – 3 times the standard deviation (LCL) respectively.

As used herein the control limit range is defined as the difference between the UCL and the LCL, wherein UCL and LCL are calculated on the basis of at least 20 batches of a given variety of barley. Preferably each batch contains at least 75 tons of barley (dry weight).

DETAILED DESCRIPTION OF THE INVENTION

The germination method and system of the present invention provides efficient cooling and humidification of air, and specifically the formation of fog, to promote effective germination of grains within the germination housing. The germination method and system of the present invention has also been shown to result in improved malted grain quality that requires less further processing in subsequent brewing stages. The germination method and system may contribute to energy savings throughout the germination process, the malting process and subsequent brewing stages.

The principle upon which the germination method and system of the present invention is based is the utilisation of evaporative cooling and humidification of the air flow within the germination housing. Evaporative cooling may be considered an adiabatic process, wherein droplets of water from the nozzles are evaporated using thermal energy from the air within the airflow path. This in turn cools the air, and provides for humidification, and specifically formation of a fog in the air. As such, the requirement to cool air entering the germination housing may be reduced or eliminated. Furthermore, in comparison to conventional germination methods and systems for the malting of grains, the germination method and system of the present invention may reduce or eliminate the requirement for a separate irrigation system within the germination housing.

<u>Process/Methods</u>

The invention provides a method of germinating grains in a germination system, the germination system comprising:

a germination housing comprising an air inlet, an air outlet, an air flow path defined between the air inlet and air outlet grains to be germinated, wherein said grains are located within the air flow path; and a plurality of nozzles configured to spray water into the air flow path, the plurality of nozzles having a nozzle arrangement;

and the method comprises:

supplying unsaturated air to the germination housing via the air inlet, and

cooling and humidifying the unsaturated air using water sprayed from the plurality of nozzles configured to spray water within the air flow path so that the air in the air flow path is a fog.

The air supplied to the inlet of the germination housing preferably has a temperature of 14 to 24 °C, and more preferably 16 to 22 °C.

The method may comprise cooling the air within the air flow path to between about 16 to 18 °C. The method may comprise maintaining the air temperature at between about 16 to 18 °C throughout the air flow path.

The method of the present invention operates at atmospheric pressure, i.e. 101,325 Pa.

The method comprises forming a fog within the air flow path, preferably prior to the air contacting the grain. The fog then passes through, and around, the grain. Preferably the cooling and humidifying of the unsaturated air maintains the air in the air flow path in a fog throughout the germination process. The fog is a suspension of water droplets in the air flow path. This may contribute to hydration of the grains to be germinated, improving the germination process while reducing or eliminating the need for a separate irrigation system.

The formation of fog may be explained with reference to the Mollier diagram shown in Figure 6. The curved lines extending upwards from the x axis show points of equal relative humidity. The limit is the saturation line. The region to the right of this line is called the “fog region” and is where fog is formed. When air with a relatively high humidity (e.g. about 100%) is cooled, condensation occurs because the saturation line is crossed. The condensate is the water droplets in the fog.

Preferably the fog formed in the method of the present invention reduces visibility to 10 m or less, more preferably to 5 m or less and still more preferably to 3 m or less. This represents a very dense fog. It is noted here that a fog is differentiated from a mist by the reduction in visibility caused. A mist reduces visibility to no less than 1000 m.

Preferably the cooling is adiabatic cooling. Thus the unsaturated air supplied via the air inlet is cooled by evaporation occurring from the surface of the water droplets sprayed by the nozzles. Since evaporation is an endothermic process, the air is cooled and passes through the saturation point. The air forms a fog comprising a suspension of water droplets. The droplets remain suspended in the air due to their small size, and weight.

The method may comprise supplying water to each of the plurality of nozzles at a pressure of between 30 to 50 bar (3 to 5 MPa). The method may comprise spraying water from the plurality of nozzles, wherein the mean water droplet diameter is between about 20 μm to 90 μm, preferably between about 20 μm to 30 μm. The mean water droplet diameter may be about 30 μm or less.

The method may comprise germinating the grains for a total germination time of at least 90 hours. The method may comprise allowing the grains to germinate at 18 °C for at least 24 hours. The method may comprise allowing the grains to germinate at 16 °C for at least 48 hours. The method may comprise allowing the grains to germinate at 18 °C for 24 hours, followed by germinating at 16 °C for 48 hours and germinating at 18 °C for a further 18 °C.

The method may comprise rotating the grains at least once during the germination time, for example using a mechanical turning arrangement provided within the germination housing.

The grains may comprise barley, oats, wheat, rye or any suitable cereal grain for malting.

In preferred methods of the invention, the grains are barley, and the moisture content of the green barley produced is < 2 wt% higher than the steeped barley introduced into the germination housing at the start of the process (i.e. compared to the cast steep moisture content). This is an advantage of the process of the invention. In conventional processes, the moisture content of the green barley is typically 3-5 wt% higher than the barley introduced into the germination housing. This is because the barley is exposed to too much water. The method of the present invention provides the germinating barley with sufficient water to stop it drying out, but does not significantly increase its water content. This is beneficial in the subsequent drying (kilning) process as much less energy is needed to dry the barley.

<u>System</u>

The invention provides a germination system for the malting of grains, the system comprising a germination housing comprising an air inlet, an air outlet, an air flow path defined between the air inlet and air outlet, a grains inlet, a grains outlet, and grains to be germinated, wherein said grains are located within the air flow path; and

a plurality of nozzles configured to spray water into the air flow path, the plurality of nozzles having a nozzle arrangement;

wherein the plurality of nozzles are configured to provide a mean water droplet diameter of between about 20 μm to 90 μm, or about 20 μm to 30 μm.

The germination housing may be any appropriate shape and capacity. For example, the germination housing may comprise a vessel having a rectangular or square cross-section. For example, the germination housing may be a cylindrical vessel. For example, the germination housing may comprise a vessel having a circular cross-section.

The germination housing may comprise a saladin box having at least one mechanical turning arrangement for the rotation of grains within the housing.

The germination housing may comprise a means to direct air from the air inlet to the air outlet, along the air flow path. An example of a suitable means is a fan.

The germination housing may comprise a grains inlet and a grains outlet. The housing may comprise a volume for housing the grains. The volume for housing the grains may be within the air flow path. In use, grains housed within the volume may be cooled and hydrated by air, i.e. fog, within the air flow path. The grains may comprise barley, oats, wheat, rye or any suitable cereal grain for malting.

The germination housing may comprise an evaporative cooling section. The evaporative cooling section may comprise the plurality of nozzles. The germination housing may comprise a germination section. The germination section may comprise the volume for housing the grains. The evaporative cooling section may be arranged downstream of the germination section within the air flow path. In use, air may pass through the evaporative cooling section where the air is cooled and humidified to form a fog, the cooled and humidified air (i.e. fog) may then flow through the germination section where the cooled and humidified air (i.e. fog) may maintain the grains at a desired temperature and humidity for germination. Alternatively, or additionally, the germination section may comprise the evaporative cooling section. In use, air may be cooled and humidified to form a fog, by the plurality of nozzles as air flows through the germination section.

The housing may comprise at least one fan configured to direct air along the air flow path from the air inlet to the air outlet. The housing may be configured such that at least some of the air within the air flow path is recirculated within the germination housing prior to passing through the air outlet. A fan may be provided to re-direct the air for recirculation within the housing.

Nozzle arrangement

The plurality of nozzles may be interconnected by a network of piping configured to supply water to each of the plurality of nozzles.

The nozzle arrangement may be configured to humidify the air within the air flow path. This ensures that the air within the air flow path remains at or above the relative humidity and temperature required for fog formation as well as germination. For example, the relative humidity may be 100 %. The temperature of the air may be 16 to 18 °C. Humidifying the air within the air flow path allows the formation of a fog of finely dispersed and suspended water droplets. This may contribute to hydration of the grains to be germinated, improving the germination process while reducing or eliminating the need for a separate irrigation system. This may also result in a green malt (the grains from the grain outlet) having a reduced moisture content which in turn can reduce the drying time required during subsequent processing stages.

The number of nozzles may be determined by at least one of the following: the size of the germination housing, the batch size of the grains to be germinated, the target humidity of the air within the air flow path, the inlet air temperature, the temperature of ambient air fed to the air inlet, the flow rate of air supplied to the air inlet, a water supply temperature, and water flow rate to the plurality of nozzles.

The nozzle arrangement may comprise a minimum spacing between each nozzle provided within the housing. For example, the minimum spacing may be between about 0.5 m to about 4 m. The plurality of nozzles may be spaced about 0.01 m to 0.5 m from the side walls of the housing.

The minimum spacing may be dependent upon at least one of: the number of nozzles required, the flow rate of water required, the flow capacity of each nozzle, the volume of the germination housing, the distribution of grain within the germination housing and the length of the air flow path. The minimum spacing may be provided for even distribution of the nozzles along the air flow path.

The plurality of nozzles may be evenly distributed throughout the housing. The nozzle arrangement may comprise a plurality of nozzles that are unevenly distributed throughout the housing. For example, a greater number of nozzles may be provided adjacent to or closer to the air inlet compared to the number of nozzles adjacent to or closer to the air outlet.

The nozzle arrangement may comprise a grid pattern. The nozzle arrangement may comprise a ring pattern. The nozzle arrangement may comprise a series of concentric circles of nozzles. The nozzle arrangement may comprise a semi-circular arrangement.

Nozzle type and size

The plurality of nozzles may comprise hollow cone spray nozzles. The hollow cone spray nozzles may be configured for atomisation of water. Accordingly, the nozzles allow for efficient evaporative cooling and humidification of the air within the air flow path to form a fog. Furthermore, the atomisation of water assists in the formation of a fog of water droplets. The hollow cone spray nozzles may comprise a ceramic spray orifice. The hollow cone spray nozzles may comprise a built-in strainer or filter.

Each nozzle of the plurality of nozzles may be configured to provide a mean water droplet diameter of between about 20 μm to about 90 μm, preferably between about 20 μm to 30 μm. The mean water droplet diameter may be about 30 μm or less. The smaller the mean water droplet diameter, the larger the surface area of the total spray from the nozzle. Therefore, a smaller mean water droplet diameter may be more effective for evaporative cooling and humidification of the air to form a fog. The mean water droplet diameter for each nozzle may be, at least in part, a function of pressure. Each nozzle of the plurality of nozzles may be pressure rated up to 100 bar (10 MPa), preferably 50 bar (5MPa). Each nozzle of the plurality of nozzles may be configured to be operated at a pressure of between about 30 bar (3 MPa) to about 50 bar (5 MPa). Each nozzle of the plurality of nozzles may comprise an orifice diameter of about 0.1 to 0.2 mm. The orifice diameter may be adjustable. The plurality of nozzles may comprise a number of nozzles, each of which are configured to have same flow capacity and mean water droplet diameter or different flow capacities and mean water droplet diameters.

Further components

The germination system may comprise a water supply system. The water supply may be arranged to provide water to the plurality of nozzles. The water supply may comprise a high pressure pump. The pump may be rated up to about 50 bar (5 MPa) to 100 bar (10 MPa), preferably about 50 bar (5 MPa). The high pressure pump may be configured to supply water to the plurality of nozzles at a desired flow rate and pressure to achieve a desired mean water droplet diameter. The water supply may further comprise at least one water cooler. For example, a heat exchanger, a refrigeration system or similar

The water supply system may further comprise a water filtration system. The water filtration system may be provided upstream of the germination housing and may be arranged to filter water from the water supply before the water is supplied to the plurality of nozzles. The water filtration system may comprise a reverse osmosis system. The water filtration system may be provided to minimise the likelihood of impurities clogging the nozzles, this may reduce the frequency of cleaning required and any subsequent impact on the overall effectiveness and efficiency of the germination system. Where a reverse osmosis system is used, the resulting water that is supplied to the air flow path may have a lower osmotic pressure compared to water that has not been passed through a reverse osmosis system. The lower osmotic pressure may allow for water to be more easily absorbed by the grains which may in turn contribute to maintaining or stabilising the moisture content of the grains during the germination process.

The germination system may comprise an air supply. The air supply may comprise at least one cooler. For example, a refrigeration system, a heat exchanger or similar.

The germination system may comprise at least one sensor, for example a temperature sensor and/or a humidity sensor. The at least one sensor may provide an output relating to the temperature and/or humidity of at least one of the grains during the germination process and/or the air within the air flow path. The provision of at least one sensor may allow for process conditions to be adjusted to ensure that the desired temperatures and relative humidity are maintained throughout the germination process.

Preferably the germination system does not comprise an irrigation system for hydration of the germinating grains. An irrigation system is not necessary because the fog ensures that the germinating grains are adequately hydrated. Advantageously the germinating grains do not absorb excess water.

The disclosed systems and methods have been shown to provide for effective germination of grains while providing a number of energy savings. For example, the use of evaporative cooling and humidification may reduce or eliminate the need for additional cooling of unsaturated air supplied to the germination housing.

Furthermore, it has been shown that the above systems and methods are effective at hydrating the grains without the need for an additional irrigation system. The end moisture content of the grains may also be reduced which in turn reduces the drying time required during the subsequent drying stage, typically involving kiln drying.

<u>Improved Malted Barley</u>

The present invention also provides malted barley obtainable by, or obtained by, the methods of the present invention.

Barley malted according to the disclosed germination methods and using the disclosed systems, has been shown to require less drying time. This may result in improved energy efficiency within the malting process, for example, as less kiln time is required to dry the malted barley.

Barley malted according to the disclosed germination methods and using the disclosed systems, has also been shown to have a number of improved properties, including but not limited to reduced beta-glucans; reduced partial unmodified grains, reduced whole unmodified grains, increased friability and increased diastatic power.

The barley used in the malting process is a natural product. As such, there are variations in the composition and form of the barley entering the process as a starting material, depending on amongst other things, the variety of the barley, the conditions used to grow the barley, and the harvesting process. A batch of barley preferably consists of a single variety of barley.

Prior to malting, the barley is preferably cleaned to remove impurities and steeped. These steps are carried out in a conventional manner. The moisture content of the barley after steeping is called the cast steep moisture content.

The malted barley obtainable by, or obtained from, the methods and system herein described is advantageous because, for a given type of barley, it produces a higher quality malted barley than a conventional malting process. The higher quality malted barley is manifested in a reduced amount of PUGs, WUGs and/or beta-glucans, increased friability, and/or increased diastatic power compared to malted barley of the same variety, but produced under conventional malting conditions. Of course, the absolute values of PUGs, WUGs, beta-glucans, friability, and diastatic power is partially dependent on the variety of the barley used as the starting material in the process.

Another advantage of the malted barley obtainable by, or obtained from, the methods and system herein described is that, for a given variety of barley, a much higher level of batch-to-batch consistency is achieved. This improved batch-to-batch consistency may be reflected in two ways. First, in a reduced control limit range, across a plurality of batches, for each of amount of PUGs, amount of WUGs, amount of beta-glucans, friability, and/or diastatic power compared to malted barley of the same variety, but produced under conventional malting conditions. Second, in a reduced standard deviation, across a plurality of batches, for each of amount of PUGs, amount of WUGs, amount of beta-glucans, friability, and/or diastatic power compared to malted barley of the same variety, but produced under conventional malting conditions. A still further advantage of the malted barley obtainable by, or obtained from, the methods and system of the invention is that despite having reduced control limit ranges for a number of parameters, the majority of batches produced are inside the control limit ranges.

Thus, according to another aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:
an amount of PUGs;
an amount of WUGs;
an amount of beta-glucans;
a friability; and
a diastatic power,
wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the control limit range for the amount of PUGs is less than 7 wt%, preferably less than 5 wt%;
(ii) the control limit range for the amount of WUGs is less than 3.5 wt%, preferably less than 3 wt%;
(iii) the control limit range for the amount of beta-glucans is less than 300 ppm, preferably less than 200 ppm;
(iv) the control limit range for friability is less than 25 %, preferably less than 18 %; and
(v) the control limit range for diastatic power is less than 50 ^{o}WK, preferably less than 40 ^{o}WK.

In criteria (i), preferably the control limit range for the amount of PUGs is 0-7 wt%, more preferably 0-6 wt% and still more preferably 0-5 wt%.

In criteria (ii), preferably the control limit range for the amount of WUGs is 0-3.5 wt%, and more preferably 0-3 wt%.

In criteria (iii), preferably the control limit range for the amount of beta-glucans is 0-300 ppm, more preferably 0-250 ppm and still more preferably 0-200 ppm.

In criteria (iv), preferably the control limit range for friability is 0-25 %, more preferably 0-20 % and still more preferably 0-18 %.

In criteria (v), preferably the control limit range for diastatic power is 0-50 °WK and more preferably 0-40 °WK.

Preferably the plurality of batches of malted barley satisfies criteria (i).

Preferably the plurality of batches of malted barley satisfies criteria (ii).

Preferably the plurality of batches of malted barley satisfies criteria (iii).

Preferably the plurality of batches of malted barley satisfies criteria (iv).

Preferably the plurality of batches of malted barley satisfies criteria (v).

Still more preferably the plurality of batches of malted barley satisfies at least three of criteria (i)-(v), still more preferably satisfies at least four of criteria (i)-(v) and yet more preferably satisfies all of criteria (i)-(v).

In a preferred plurality of batches of malted barley of the present invention, each of said batches of malted barley produces an extract (%), and the control limit range for the amount of extract is less than 4.5 wt%, preferably less than 4 wt%. In this criteria, preferably the control limit range for extract is 0-4.5 wt% and more preferably 0-4 wt%.

In another aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:
an amount of PUGs;
an amount of WUGs;
an amount of beta-glucans;
a friability; and
a diastatic power,
wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the standard deviation for the amount of PUGs is less than 1.4 wt%, preferably less than 1.0 wt%;

(ii) the standard deviation for the amount of WUGs is less than 0.6 wt%, preferably less than 0.5 wt%;

(iii) the standard deviation for the amount of beta-glucans is less than 50 ppm, preferably less than 40 ppm;

(iv) the standard deviation for friability is less than 3.5%, preferably less than 3.0%; and

(v) the standard deviation for diastatic power is less than 8.0 °WK, preferably less than 6.0 °WK.

In criteria (i), preferably the standard deviation for the amount of PUGs is 0-1.4 wt%, more preferably 0-1.0 wt% and still more preferably 0-0.9 wt%.

In criteria (ii), preferably the standard deviation for the amount of WUGs is 0-0.6 wt%, and more preferably 0-0.5 wt%.

In criteria (iii), preferably the standard deviation for the amount of beta-glucans is 0-50 ppm, more preferably 0-40 pppm and still more preferably 0-30 ppm.

In criteria (iv), preferably the standard deviation for friability is 0-3.5 % and more preferably 0-3.0 %.

In criteria (v), preferably the standard deviation for diastatic power is 0-8.0 °WK and more preferably 0-6.0 °WK.

Preferably the plurality of batches of malted barley satisfies criteria (i).

Preferably the plurality of batches of malted barley satisfies criteria (ii).

Preferably the plurality of batches of malted barley satisfies criteria (iii).

Preferably the plurality of batches of malted barley satisfies criteria (iv).

Preferably the plurality of batches of malted barley satisfies criteria (v).

Still more preferably the plurality of batches of malted barley satisfies at least three of criteria (i)-(v), still more preferably satisfies at least four of criteria (i)-(v) and yet more preferably satisfies all of criteria (i)-(v).

In a preferred plurality of batches of malted barley of the present invention, each of said batches of malted barley produces an extract (%), and the standard deviation for the amount of extract is less than 0.8 wt%, preferably less than 0.7 wt%. In this criteria, preferably the standard deviation for extract is 0-0.8 wt% and more preferably 0-0.7 wt%.

In another aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:

an amount of PUGs;

an amount of WUGs;

an amount of beta-glucans;

a friability; and

a diastatic power,

wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the mean amount of PUGs is less than the mean amount of PUGs present in malted barley prepared by a conventional malting process;

(ii) the mean amount of WUGs is less than the mean amount of WUGs present in malted barley prepared by a conventional malting process;

(iii) the mean amount of beta-glucans is less than the mean amount of beta-glucans present in malted barley prepared by a conventional malting process;

(iv) the mean friability is higher than the mean friability of the malted barley prepared by a conventional malting process; and

(v) the mean diastatic power is higher than the mean friability of the malted barley prepared by a conventional malting process.

As used herein, the term “conventional malting process” refers to a process wherein the air is cooled and humidified using a spinning disk and fan arrangement and/or nozzles configured to spray water droplets having an average droplet diameter of 900 μm into the air prior to the air entering the germination housing.

In the comparative conventional malting process, the variety of the barley and the size of the batch is the same as in batch being defined. Additionally the process steps prior to malting (including steeping) are identical to those used to obtain the malted barley being defined.

Preferably the plurality of batches of malted barley satisfies criteria (i).

Preferably the plurality of batches of malted barley satisfies criteria (ii).

Preferably the plurality of batches of malted barley satisfies criteria (iii).

Preferably the plurality of batches of malted barley satisfies criteria (iv).

Preferably the plurality of batches of malted barley satisfies criteria (v).

Still more preferably the plurality of batches of malted barley satisfies at least three of criteria (i)-(v), still more preferably satisfies at least four of criteria (i)-(v) and yet more preferably satisfies all of criteria (i)-(v).

In a preferred plurality of batches of malted barley of the present invention, each of said batches of malted barley produces an extract (%), and the mean amount of extract is higher than the mean extract of the malted barley prepared by a conventional malting process.

In another aspect, the present invention provides a plurality of batches of malted barley, wherein each of said batches of malted barley has:

an amount of PUGs;

an amount of WUGs;

an amount of beta-glucans;

a friability; and

a diastatic power,

wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the mean amount of PUGs is less than 2.2 wt%;

(ii) the mean amount of WUGs is less than 1.0 wt%;

(iii) the mean amount of beta-glucans is less than 100 ppm;

(iv) the mean friability is greater than 85 %;

(v) the mean diastatic power is greater than 290 °WK; and

(vi) the mean extract is greater than 81.0 wt%.

Preferably the plurality of batches of malted barley satisfies criteria (i) and (ii).

Preferably the plurality of batches of malted barley satisfies criteria (i) and (iii).

Preferably the plurality of batches of malted barley satisfies criteria (i) and (iv).

Preferably the plurality of batches of malted barley satisfies criteria (ii) and (iii).

Preferably the plurality of batches of malted barley satisfies criteria (i) and (v).

Preferably the plurality of batches of malted barley satisfies criteria (ii) and (v).

Preferably the plurality of batches of malted barley satisfies criteria (iii) and (v).

Still more preferably the plurality of batches of malted barley satisfies at least three of criteria (i)-(v), still more preferably satisfies at least four of criteria (i)-(v) and yet more preferably satisfies all of criteria (i)-(vi).

In a preferred plurality of batches of malted barley of the present invention each batch comprises at least 75 tons of barley. Preferably each batch comprises 75-500 tons of barley, more preferably 100-400 tons of barley.

In the present invention, a preferred plurality of batches of malted barley comprises at least 20 batches, and more preferably at least 25 batches. The upper limit to the number of batches may be, for example, 300 or 500 batches.

In the present invention, a preferred plurality of batches of malted barley undergo identical preparation steps prior to malting.

The malted barley produced by the method and system of the invention has reduced PUGs, WUGs and beta-glucans compared to malted barley produced using a conventional malting process. More specifically, the malted barley produced using the method and system of the invention achieves a more effective germination.

Futhermore, a significantly higher batch to batch consistency is achieved. This is seen in the reduced standard deviations and in the reduced control range limits for the various parameters used to characterise malted barley.

The malted barley produced by the method and system of the invention has improved friability. The improved friability of the malted barley means it is easier to crush during milling.

The malted barley produced by the method and system of the invention also has increased diastatic power. Without wishing to be bound by theory, it is thought that the increase in diastatic power of the malted barley is due to the more consistent humidity levels achieved during the germination process. It is thought that the method and system of the invention keep the majority of the grains hydrated, meaning that a greater amount of active enzymes are produced therein. This result correlates with the decreased PUGs, WUGs and beta-glucans discussed above.

The malted barley produced by the method and system of the invention also produces an increased amount of extract per unit weight of malted barley. This result corroborates the results discussed above, in particular increased mean diastatic power and decreased PUGs, WUGs and beta-glucans.

Overall the malted barley produced by the method and system of the present invention produces more beer per unit of weight of malted barley than malted barley prepared by conventional malting processes. This is due to more complete germination, increased friability, and increased diastatic power. It is also believed that the more consistent hydration levels achieved during the germination process may lead to a better distribution of enzymes in the kernels, and in turn, improved conversion of starch to fermentable sugars during subsequent processing.

For the purposes of the present invention, it should be understood that the features defined above or described below may be utilised, either alone or in combination with any other defined feature, in any other aspect, embodiment, or example or to form a further aspect, embodiment or example of the invention.

BRIEF DESCRIPTION OF DRAWINGS

These and other aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a schematic drawing of a germination system according to the present invention;

Figure 2 shows a schematic drawing of a nozzle arrangement for use in a germination system of the present invention; and

Figure 3 shows a schematic drawing of an alternative nozzle arrangement for use in a germination system of the present invention.

Figures 4a-h each show the properties of a plurality of batches of malted barley produced by a method and system of the invention compared to the same malted barley prepared by a conventional malting process;

Figure 5 compares the key properties of malted barley produced by a method and system of the invention compared to the same malted barley prepared by a conventional malting process; and

Figure 6 shows a Mollier diagram for the method of the invention.

DETAILED DESCRIPTION OF DRAWINGS

Figure 1 shows a schematic drawing of a germination system 10 according to the present invention. The germination system 10 comprises a germination housing 20 comprising an air inlet 22, an air outlet 24, a grains inlet 30 and a grains outlet 34. Grains removed from the grains outlet 34 are known as green malt. At least one fan 23 is provided to direct air from the air inlet 22 along an air flow path 28 through the germination housing 20. The air entering the air inlet 22 is unsaturated air. This air is cooled and humidified by directing a spray of water from a plurality of nozzles 40 which are arranged within the housing 20 and along the air flow path 28. A heat exchanger 19 may be provided for additional cooling of the unsaturated air, if required.

Water is supplied to the plurality of nozzles 40 from a water supply system that comprises a water tank 12, a reverse osmosis system 14, a further buffer storage tank 16 for storage of filtered water. Water is supplied to the plurality of nozzles using a high-pressure pump 18. In some examples, water is supplied at a pressure of 50 bars. The use of the reverse osmosis system 14 is dependent upon water supply quality, the specification of the nozzles and/or the desired droplet diameter from the nozzles 40.

The germination housing 20 comprises an evaporative cooling section 25, wherein unsaturated air is cooled and humidified as it flow through the flow path 28. A fog is formed. The nozzles 40 are configured to spray finely atomised water into the air flow path 28. The mean water droplet diameter of the water spray can be between 20 to 90 µm, preferably between 20 to 30 µm. The nozzles are provided and arranged to humidify the air allowing for the formation of a water fog. This air and fog is then directed to a germination section 27, where it is used to cool and hydrate the grains, promoting effective germination.

The number of nozzles required and the distribution pattern of the nozzles throughout the housing will be dependent upon a number of factors. For example, the size of the germination housing, the batch size of the grains to be germinated, the distribution of grains in the germination housing, the target humidity of the air within the air flow path, the ambient air temperature, the flow rate of air supplied to the air inlet, water supply temperature, water flow rate to the plurality of nozzles.

An example nozzle distribution arrangement is shown in Figure 2. In Figure 2, a germination housing 120 is provided. The housing 120 is a rectangular saladin box arrangement having side walls 121. A plurality of nozzles 142 are arranged throughout the housing 120 in a grid pattern by a network of water supply piping 144 which is connected to a water supply 140. Air is supplied via an air inlet 122. In this particular example, the nozzles are arranged in four parallel rows each having a length B of 39.8 m. Each row is separated by a distance D of 2.612 m, and each nozzle within a row is separated by a distance C of 1.99 m. The rows of nozzles adjacent to the side walls 121 are spaced from the side walls 121 by distance A of 0.03 m. The nozzles are configured to have a mean water droplet diameter of between 20 µm to 30 µm, preferably about 30 µm or less. The example nozzle distribution may be used for the formation of a fog of suspended water in the air flow path.

Another example nozzle distribution arrangement is shown in Figure 3. A circular germination housing 220 is provided with two concentric rings 241 and 245 of nozzles connected by a network of water supply piping. An outer ring 241 comprises a diameter of 20 m and a length of 63 m. A nozzle is located at 1 m intervals around the length of the outer ring 241 totalling 63 nozzles. Each of these nozzles is configured to supply water at a flow rate of 3.9 l/h. The outer ring 241 therefore supplies a total water flow rate of 246 l/h.

An inner ring 245 comprises a diameter of 6 m and a length of 19 m. A nozzle is located every meter along the length of the inner ring 245, totalling 18 nozzles. The nozzles of the inner ring 245 are also configured to supply water at a flow rate of 3.9 l/h, and the total flow rate from the inner ring 245 arrangement is 70 l/h.

A semi-circular arrangement of nozzles 243 is provided between the outer ring 241 and inner ring 245. The semi-circular arrangement of nozzles 243 comprises a diameter of 14 m and a total length of 22 m. A nozzle is provided at every 0.5 m along this length and the nozzles are positioned to be staggered between the nozzles of the inside 245 and outside ring 241.There are 44 nozzles provided in the semi-circular arrangement 243 supplying a total water flow rate of 172 l/h, with each nozzle in the semi-circular arrangement being configured to have a flow rate of 3.9 l/h.

Adjacent the air inlet 222, there is provided a rectangular arrangement 247 of nozzles having a total perimeter length of 10m (for example, a 2 x 3m rectangle). The rectangular arrangement 247 comprises a nozzle every 0.5m around the perimeter, totalling 20 nozzles. Each nozzle is configured to supply a flow rate of 7.9 l/h and the total flow rate of water supplied from the rectangular arrangement is 156 l/h. The rectangular arrangement 247, the inner and outer rings 241, 245 and the semi-circular arrangement 243 are interconnected by a network of water supply piping and connections 250.

The provision of the rectangular arrangement 247 adjacent to the air inlet 222 provides for initial cooling and humidification of the air entering the germination vessel 220. The air passing through the rectangular arrangement 247 is in the form of a fog of water droplets 248. The nozzles of the outer and inner rings 241, 245 and the semi-circular arrangement 245 provide for further cooling and humidification of the air as it is passed through the germination housing 220, therefore ensuring that the air remains in the form of a fog. The nozzles are configured to produce a mean water droplet diameter of between 20 μm to 30 μm, preferably about 30 μm or less. The arrangement also ensures that the temperature of the grains within the germination housing 220 is maintained at 16 to 18 °C.

The disclosed germination method and system can eliminate the requirement for an additional irrigation system within the germination housing. In one example, it was possible to reduce the irrigation water consumption from 5 m^3 per batch to 0 m^3 per batch.

The disclosed germination method and system has also been shown to reduce the moisture of the green malt. This reduces the required drying time during the next stage of the malting process. In one example, compared with a typical germination method and system using conventional air cooling and saturation methods, the disclosed germination method and system resulted in a 2 % reduction in green malt moisture content and a 5 % reduction in kiln drying time (approximately 1 hour). A conventional germination system may typically comprise, for example, cooling and humidifying the air using a spinning disk and fan arrangement and/or nozzles configured to spray water droplets having an average droplet diameter of 900 μm into the air prior to the air entering the germination housing. These water droplets fall like "rain" in the germination housing.

In a further example, the disclosed germination system has been shown to reduce the energy consumption required for refrigeration by 43 %, requiring 6.198 kWh compared to 10.838 kWh used by a conventional germination method and system. The disclosed germination system and methods also resulted in a higher quality malted barley than in a conventional process. The higher quality barley is manifested in a reduced amount of PUGs, WUGs and/or beta-glucans, increased friability, and/or increased diastatic power compared to malted barley of the same variety, but produced under conventional malting conditions. It has also been shown that the disclosed germination system and methods result in a much higher level of batch-to-batch consistency.

EXAMPLES

Test methods

- Partially Unconverted Grain (PUGs, %wt), Wholly Unconverted Grain WUGs %wt) and Friability (%) were determined according to Analytica EBC/Malt/4.15 friability methodology.
- Beta-Glucans (ppm) were determined according to Analytica EBC/Malt/4.15 friability methodology.
- Diastatic power (°WK) was determined according to Analytica EBC/Malt/4.15 friability methodology.
- Extract (%wt) was determined by Analytica EBC 4.5.1 extract of malt.
- Green malt moisture (%) was determined according to Analytica EBC/Malt/4.15 friability methodology
- Kiln time was determined by conventional methodology, wherein the air temperature in and out is measured and drying is stopped when the temperatures are identical.

- A statistical analysis was applied to the results obtained for each of PUGs, WUGs, friability, beta-glucan, diastatic power, extract, green malt moisture and kiln time. The statistics methodology applied was Minitab 17 Statistical Software. The mean and standard deviation were calculated using the Software.

  The Upper Control Limit (UCL) and Lower Control Limit (LCL) were calculated as the mean + 3 times the standard deviation (UCL) and the mean – 3 times the standard deviation (LCL) respectively. The control limit range is defined as the difference between the UCL and the LCL, wherein UCL and LCL are calculated on the basis of at least 20 batches of a given variety of barley, each batch containing at least 75 tons of barley (dry weight).

Example 1

A germination system as shown in Figure 3 was installed in a malt house. The performance of the system was compared to the conventional system, which was running in the malt house prior to installation of the germination system described herein. The conventional system employed a process wherein the air is cooled and humidified using a spinning disk and fan arrangement and/or nozzles configured to spray water droplets having an average droplet diameter of 900 µm into the air prior to the air entering the germination housing,

The following standard conditions were utilised for germination and drying of barley according to the method claimed in the present invention as well as in the conventional malting process. Each batch was 100 tons. All barley underwent an identical preparation and steeping process.

Steeping temperature 17 °C	**Duration**
Steep 1 (with aeration)	9 hr
Air Rest 1	14 hr
Steep 2 (with aeration)	6 hr
Air Rest 2	4 hr
Germination (18°C)	24 hr
Germination (16°C)	48 hr
Germination (18°C)	18 hr
Kiln	6 h x 55 °C, 4 hrs x 60 °C, 2 hrs x 62 °C, 2 h x 65 °C , 2 hrs 72 °C 3 h x 82 °C, 1 h Cool

The specification of the barley required from the malting process is shown below:

Parameter	Units	Miniumum	Target	Maximum
Moisture VOP	%			5.5
Extract (dry matter)	%	80		
EBC colour				4.5
Beta-glucan	ppm		150.0	180.0
Total protein	%	9.7	10	12.5
Free amino nitrogen (FAN)	mg/l	165	175	190
Kolbach (s/t)		40		46
Diastatic power	°WK	250.0		360.0
DMS-precursor	ppm			5.0
N-Nitrosodimethylamine (NDMA)	ppb			2.5
Friability	%	80.0		
PUGs	%			4.0
WUGs	%			2.0
Minimum age of malt	Days, min	14.0		
DON	ppb	500.0		

Each batch of malted barley was assessed by the methods described above. The results are shown in Figures 4a-h and are summarised in the table below. In each of Figures 4a-h, the x-axis refers to the n^{th} batch through the process. In Figures 4a-h, the term “with foggy” refers to the barley malted according to the method and system described herein and the term “without foggy” refers to the barley malted according to the conventional malting process.

Parameter		Mean in Conventional process	Mean in Process according to the invention
PUGs (%wt)	Mean	2.6	2.0
	Standard deviation	1.5	0.8
	UCL	7.0	4.4

	LCL	-1.8	-0.3
	Control limit range	8.8	4.7
WUGs (%wt)	Mean	1.0	0.9
	Standard deviation	0.7	0.4
	UCL	3.2	2.2
	LCL	-1.1	-0.5
	Control limit range	4.3	2.7
Beta-Glucans (ppm)	Mean	120	61.8
	Standard deviation	76.7	28.6
	UCL	350	147.5
	LCL	-100	-23.8
	Control limit range	450	171.3
Friability (%)	Mean	85.05	86.76
	Standard deviation	3.7	2.7
	UCL	96.0	94.83
	LCL	75.0	78.69
	Control limit range	21.0	16.14
Diastatic power (^{o}WK)	Mean	290	298.7
	Standard deviation	10.0	5.8
	UCL	320	316.0
	LCL	260	281.3
	Control limit range	60	34.7
Extract (%wt)	Mean	80.9	81.3
	Standard deviation	0.9	0.6
	UCL	83.5	83.1
	LCL	78.2	79.4
	Control limit range	5.3	3.7
Green malt moisture (%)	Mean	40.2	40.9
	Standard deviation	1.4	1.0
	UCL	44.4	43.8
	LCL	38.0	38.0
	Control limit range	6.4	5.8
Kiln Time (hr)	Mean	16.30	14.52

Standard deviation		
UCL	20.00	18.30
LCL	13.15	11.15
Control limit range	6.45	7.15

Figure 4a shows that the mean amount of PUGs, across multiple batches, of malted barley produced by the method and system of the invention is less than the mean amount of PUGs, across multiple batches, produced by the conventional malting process. Figure 4a also shows that almost without exception, each of the batches of malted barley produced by the method and system of the invention are inside the control limits (UCL, LCL). In contrast, the batches produced by the conventional process show significantly more variation, with a number of batches exceeding the UCL for PUGs, despite the fact that the control limit range is significantly broader than for malted barley produced by the method and system of the invention.

Figure 4b shows the same trend in the results for WUGs as for PUGs. Thus the mean amount of WUGs, across multiple batches, of malted barley produced by the method and system of the invention is less than the mean amount of WUGs, across multiple batches, produced by the conventional malting process. Figure 4b also shows that the majority of batches of malted barley produced by the method and system of the invention are inside the relatively narrow control limits (UCL, LCL). In contrast, the batches produced by the conventional process show significantly more variation, with a number of batches exceeding the much greater UCL for WUGs.

Figure 4c shows the mean amount of beta-glucans, across multiple batches, of malted barley produced by the method and system of the invention is reduced compared to the mean amount of beta-glucans, across multiple batches, produced by the conventional malting process. As with PUGs and WUGs, the control limit range is significantly reduced compared to the batches produced by the conventional malting process and virtually all batches fall inside the narrow range. In contrast, the control limit range for beta-glucans present in malted barley produced by the conventional process is much broader, approximately two times broader.

The results shown in Figures 4a-4c show that the method and system of the invention produce malted barley with reduced PUGs, WUGs and beta-glucans compared to a conventional malting process. More specifically, the results indicate that the method and system now claimed achieves a more effective germination. The results also show that significantly higher batch to batch consistency is achieved. This is seen in the reduced standard deviations and in the reduced control limit range.

Figure 4d shows the mean friability, across multiple batches, of malted barley produced by the method and system of the invention is increased compared to the mean friability, across multiple batches, of malted barley produced by the conventional malting process. The improved friability of the malted barley means it is easier to crush during milling.

Figure 4e shows the mean diastatic power, across multiple batches, of malted barley produced by the method and system of the invention is increased compared to the mean diastatic power, across multiple batches, of malted barley produced by a conventional malting process. The control limit range (UCL, LCL) is also significantly narrowed. Without wishing to be bound by theory, it is thought that the increase in mean diastatic power of the malted barley produced by the method and system of the invention is due to the more consistent humidity levels achieved during the germination process. It is thought that the method and system of the invention keep the majority of the grains hydrated, meaning that a greater amount of active enzymes are produced therein. This result correlates with the decreased PUGs, WUGs and beta-glucans discussed above, and also with the increased extract achieved, which is discussed below.

Figure 4f shows the mean extract, across multiple batches, of malted barley produced by the method and system of the invention is increased compared to the mean extract, across multiple batches, of malted barley produced by a conventional malting process. The control limit range (UCL, LCL) is also narrowed compared to the control limit range for the conventional process. As mentioned above, this result corroborates the results discussed above, in particular increased mean diastatic power and decreased PUGs, WUGs and beta-glucans.

Figure 4g shows that the mean moisture level in green malt, across multiple batches, of malted barley produced by the method and system of the invention is decreased. Figure 4h shows that the resulting kiln time needed to dry the malted barley is corresponding decreased.

Overall the malted barley produced by the method and system of the present invention produces more beer per unit of weight of malted barley than malted barley prepared by conventional malting processes. This is due to more complete germination, increased friability, and increased diastatic power. It is also believed that the more consistent hydration levels achieved during the germination process may lead to a better distribution of enzymes in the kernels, and in turn, improved conversion of starch to fermentable sugars during subsequent processing.

Example 2

A germination system according to the invention was installed in a malt house. The performance of the system was compared to the conventional system as described above for Example 1. The same standard conditions were utilised for germination and drying of barley as set out above for Example 1. Each batch was 360 tons.

The results are shown in Figure 5 and summarised in the table below.

Parameter	Mean in Conventional Process	Mean in method according to the invention	Improvement (%)
PUGs (wt%)	5.1	2.7	49.7
WUGs (wt%)	1.5	0.7	22.6
beta-glucans (ppm)	172.5	149.6	13.4
Friability (%)	83.4	87.1	4.4
Extract (wt%)	81.2	82.5	1.7

CLAIMS:

1. A method of germinating grains in a germination system, the germination system comprising:

a germination housing comprising an air inlet, an air outlet, an air flow path defined between the air inlet and air outlet, and grains to be germinated, wherein said grains are located within the air flow path; and

a plurality of nozzles configured to spray water into the air flow path, the plurality of nozzles having a nozzle arrangement;

and the method comprises:

supplying unsaturated air to the germination housing via the air inlet, and

cooling and humidifying the unsaturated air using water sprayed from the plurality of nozzles configured to spray water within the air flow path so that the air in the air flow path is a fog, and is preferably maintained at a temperature of 16-18 °C.

2. The method as claimed in claim 1, wherein the cooling and humidifying the unsaturated air maintains the air in the airflow path as a fog throughout the germination process.

3. The method as claimed in claimed in claim 1 or 2, wherein the cooling is adiabatic cooling.

4. The method of any preceding claim, wherein the plurality of nozzles are configured to provide a mean water droplet diameter of between about 20 µm to 90 µm, or about 20 µm to 30 µm.

5. The method of any preceding claim, wherein the grains are barley, and the moisture content of the green barley produced by germination is less than 2 wt% higher than the moisture content of the steeped barley introduced into the germination housing at the start of the process.

6. A germination system for the malting of grains, the system comprising

a germination housing comprising an air inlet, an air outlet, an air flow path defined between the air inlet and air outlet, a grains inlet, a grains outlet and grains to be germinated, wherein said grains are located within the air flow path; and a plurality of nozzles configured to spray water into the air flow path, the plurality of nozzles having a nozzle arrangement;

wherein the plurality of nozzles are configured to provide a mean water droplet diameter of between about 20 µm to 90 µm, or about 20 µm to 30 µm.

7. The germination system of claim 6, wherein the nozzle arrangement comprises a minimum spacing of between 0.5 m to 4 m between each nozzle.

8. The germination system of claim 6 or 7, wherein each nozzle of the plurality of nozzles has an orifice diameter of 0.1 to 0.2 mm.

9. The germination system of any one of claims 6 to 8, wherein the nozzle arrangement comprises a greater concentration of nozzles adjacent to the air inlet compared to the air outlet.

10. The germination system of any one of claims 6 to 9, further comprising a water supply system, wherein the water supply system comprises a supply of water and a water filtration system.

11. The germination system of any one of claims 6 to 10, further comprising an additional refrigeration system configured to cool air prior to the air entering the air inlet of the germination housing.

12. The germination system of any one of claims 6 to 11, wherein there is no irrigation system present for hydration of the germinating grains.

13. A malted grain, preferably barley, obtainable by, or obtained by, the methods of any one of claims 1 to 5.

14. Use a germination system according to any one of claims 6 to 12 to prepare malted grain, preferably barley.

15. A plurality of batches of malted barley, wherein each of said batches of malted barley has:

an amount of PUGs;

an amount of WUGs;

an amount of beta-glucans;

a friability; and

a diastatic power,

wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the control limit range for the amount of PUGs is less than 7 wt%, preferably less than 5 wt%;

(ii) the control limit range for the amount of WUGs is less than 3.5 wt%, preferably less than 3 wt%;

(iii) the control limit range for the amount of beta-glucans is less than 300 ppm, preferably less than 250 ppm;

(iv) the control limit range for friability is less than 20 %, preferably less than 18 %; and

(v) the control limit range for diastatic power is less than 50 °WK, preferably less than 40 °WK.

16. A plurality of batches of malted barley as claimed in claim 15, wherein said plurality of batches of malted barley satisfies three or more of criteria (i), (ii), (iii), (iv) and (v).

17. A plurality of batches of malted barley as claimed in claim 15, wherein said plurality of batches of malted barley satisfies at least four of criteria (i)-(v) and yet more preferably satisfied all of criteria (i)-(v).

18. A plurality of batches of malted barley, wherein each of said batches of malted barley has:

an amount of PUGs;

an amount of WUGs;

an amount of beta-glucans;

a friability; and

a diastatic power,

wherein the plurality of said batches of malted barley satisfies as least two of the following criteria:

(i) the mean amount of PUGs is less than 2.2 wt%;

(ii) the mean amount of WUGs is less than 1.0 wt%;

(iii) the mean amount of beta-glucans is less than 100 ppm;

(iv) the mean friability is greater than 85 %;

(v) the mean diastatic power is greater than 290 °WK; and

(vi) the mean extract is greater than 81.0 wt%.

19. A plurality of batches of malted barley as claimed in claim 18, wherein said plurality of batches of malted barley satisfies three or more of criteria (i), (ii), (iii), (iv) and (v).

20. A plurality of batches of malted barley as claimed in claim 18, wherein said plurality of batches of malted barley satisfies at least four of criteria (i)-(v) and yet more preferably satisfied all of criteria (i)-(v).

21. A plurality of batches of malted barley as claimed in any of the preceding claims, wherein each batch comprises at least 75 tons of barley.

22. A plurality of batches of malted barley as claimed in any of the preceding claims, comprising at least 20 batches.

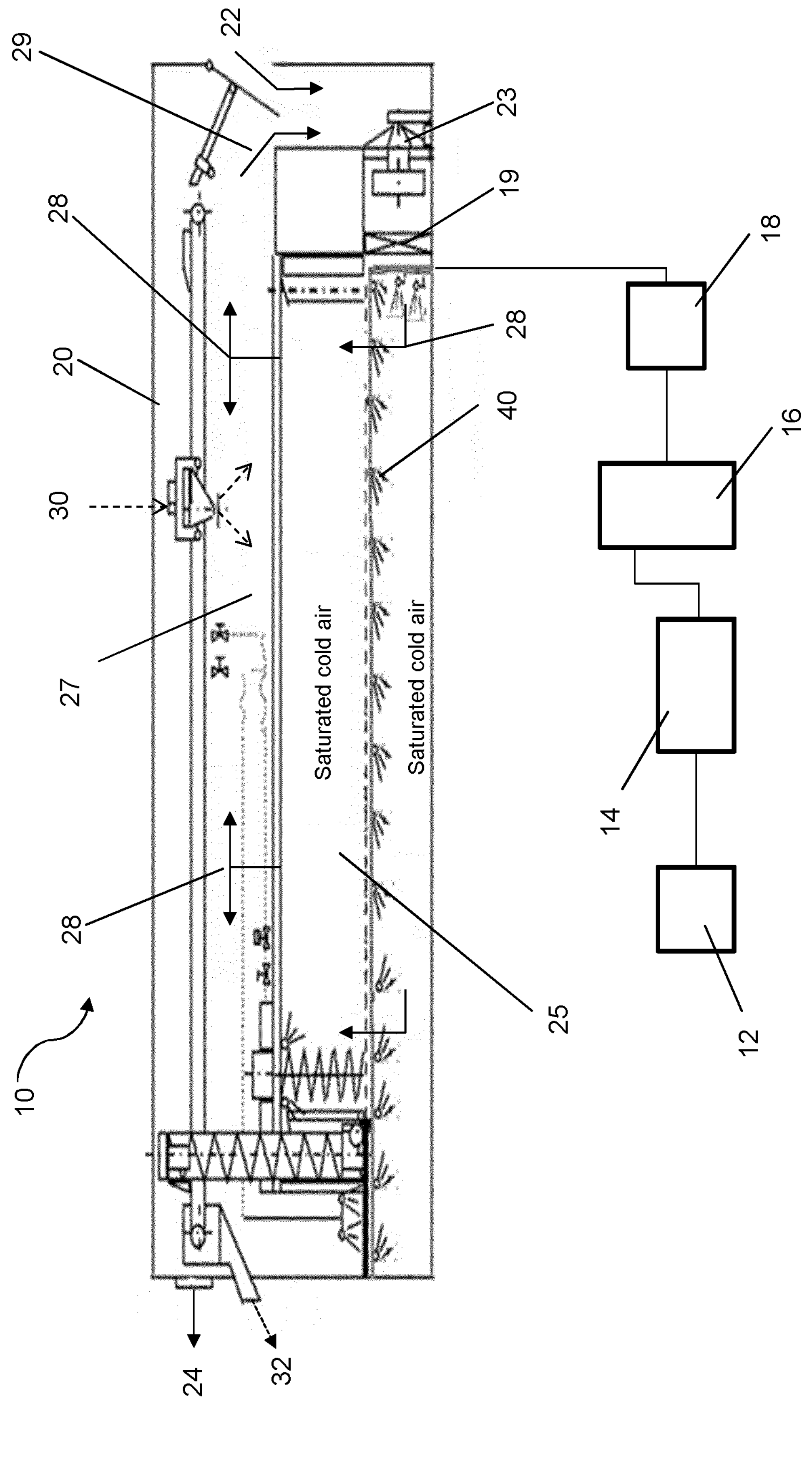
29
22
23
19
18
28
20
28
40
16
30
27
Saturated cold air
Saturated cold air
14
28
10
25
12
24
32

Figure 1

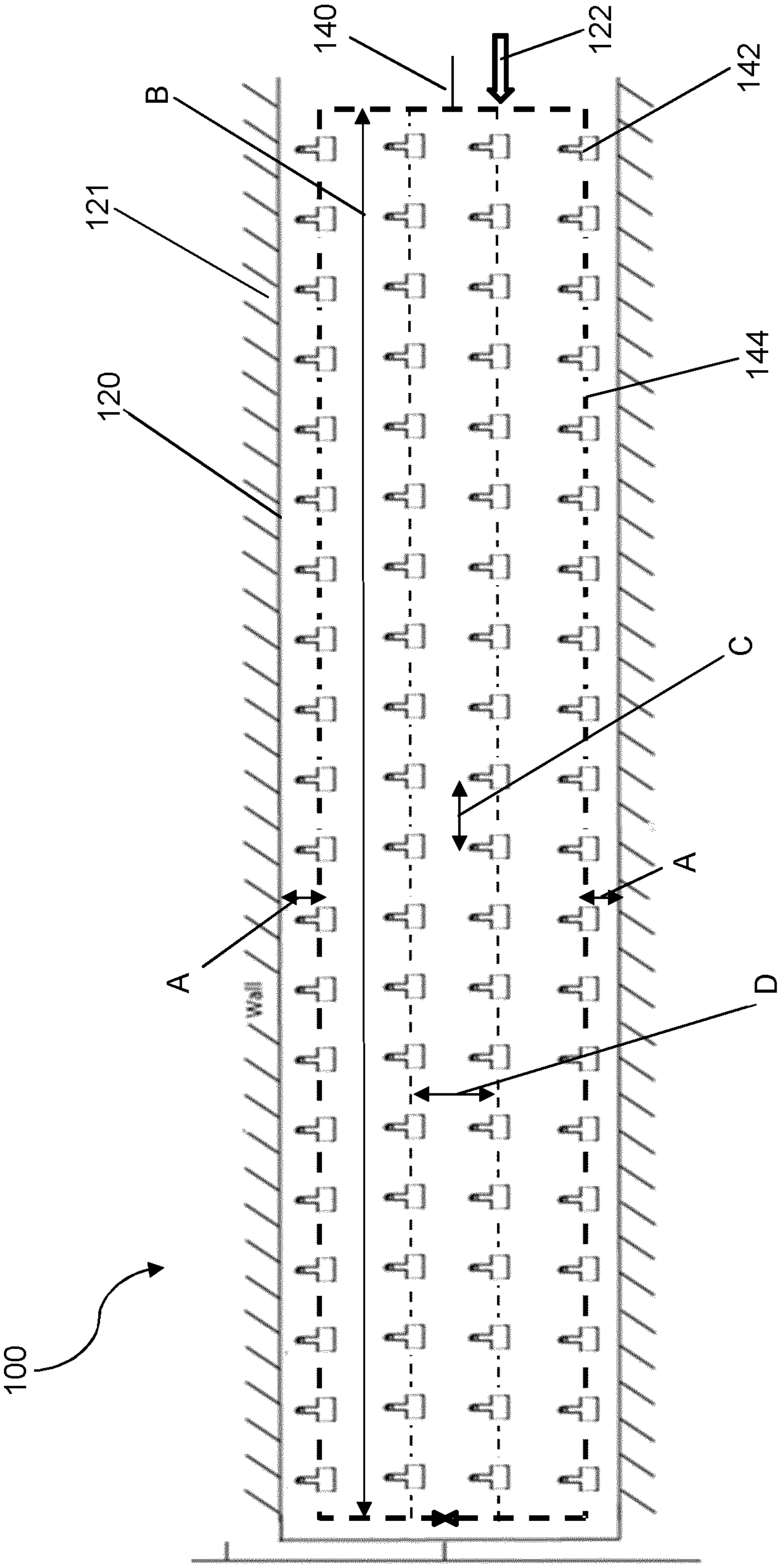

Figure 2

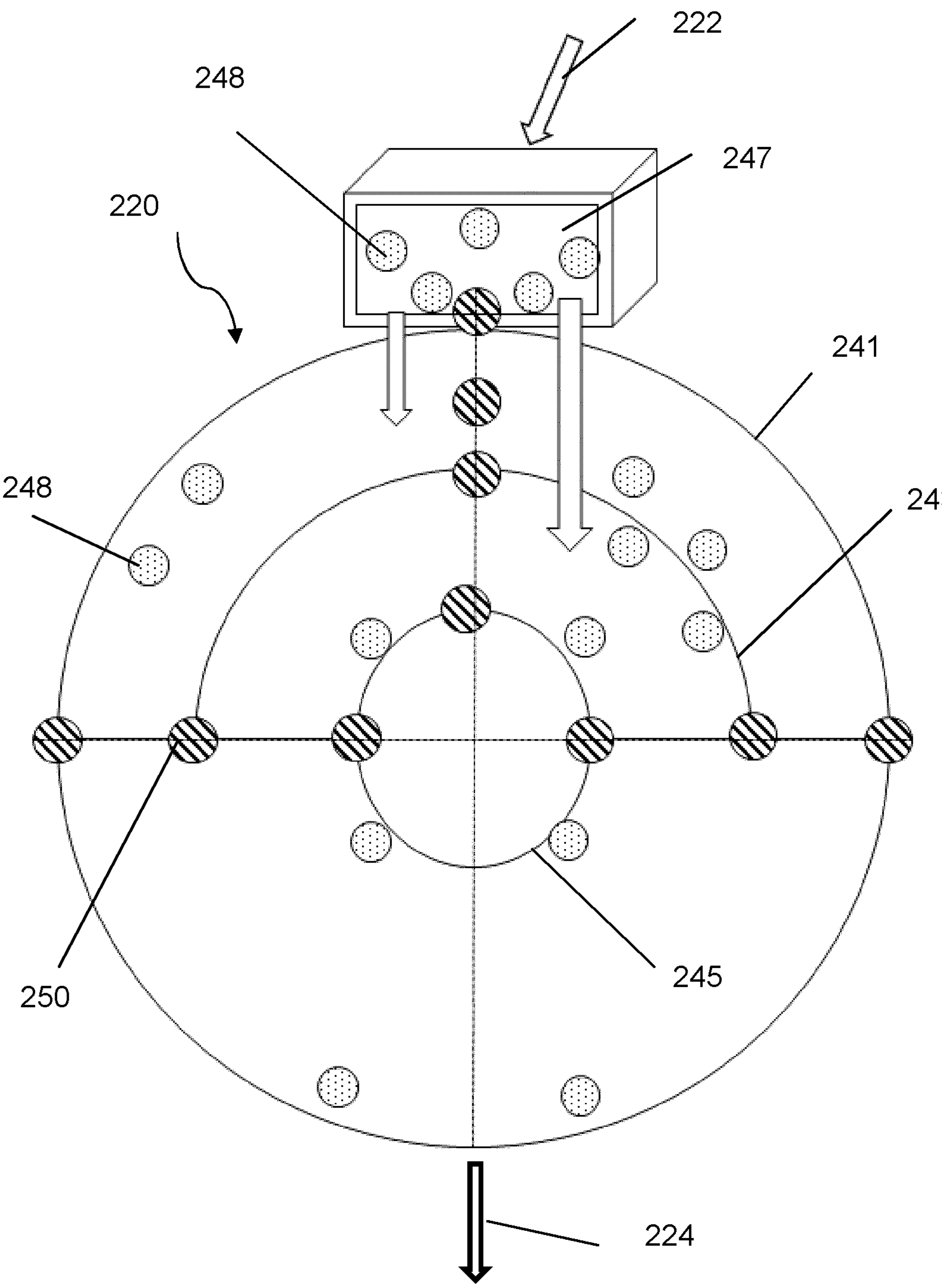

Figure 3

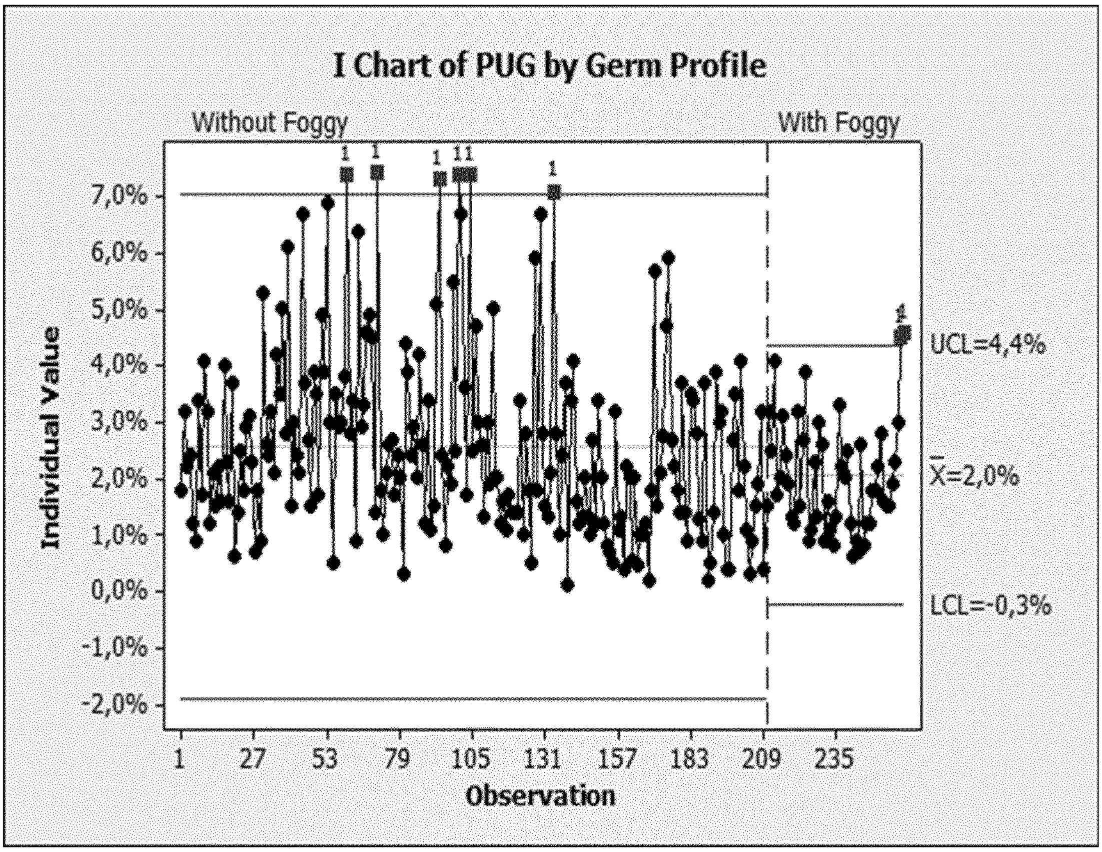

Figure 4a

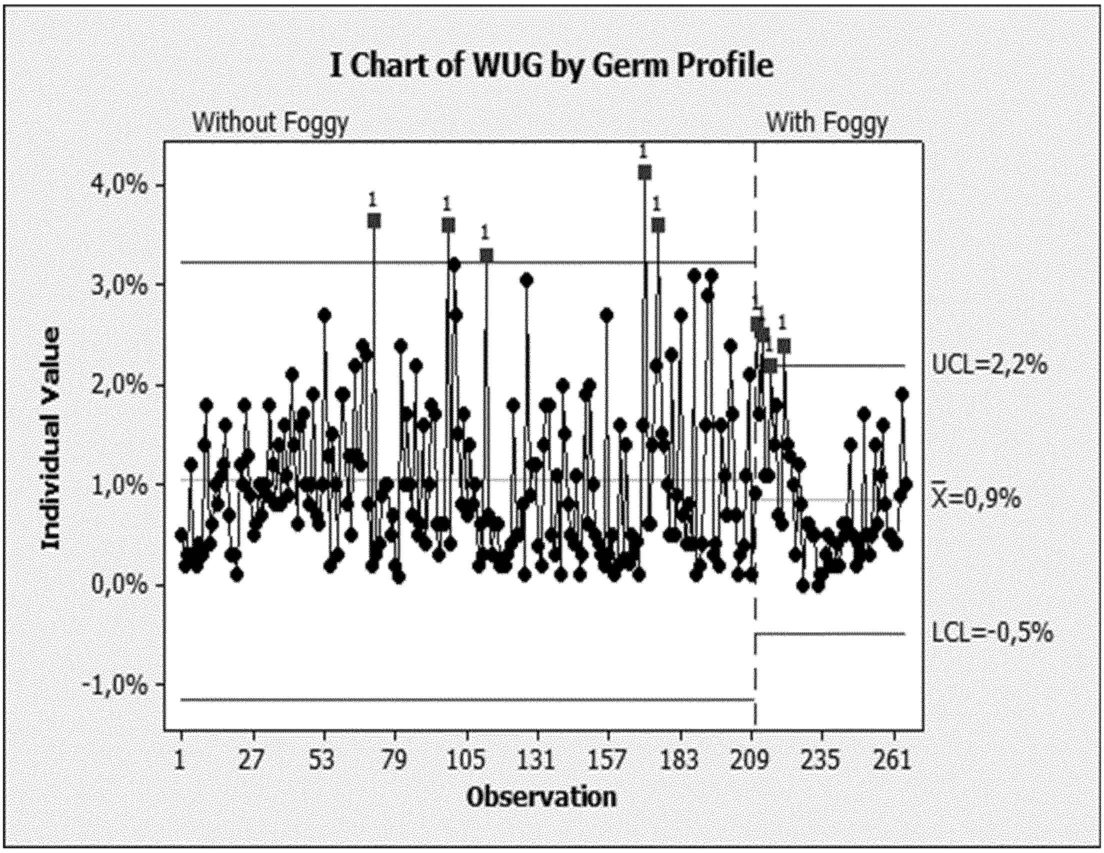

Figure 4b

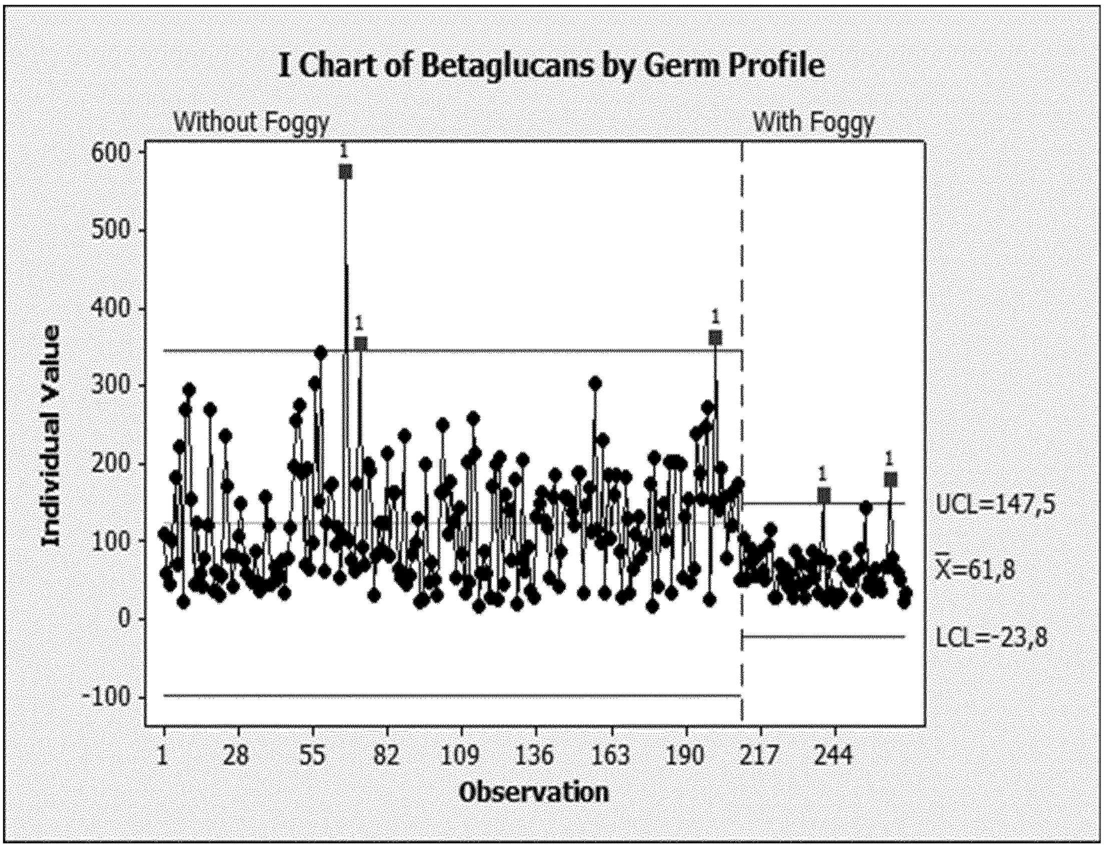

Figure 4c

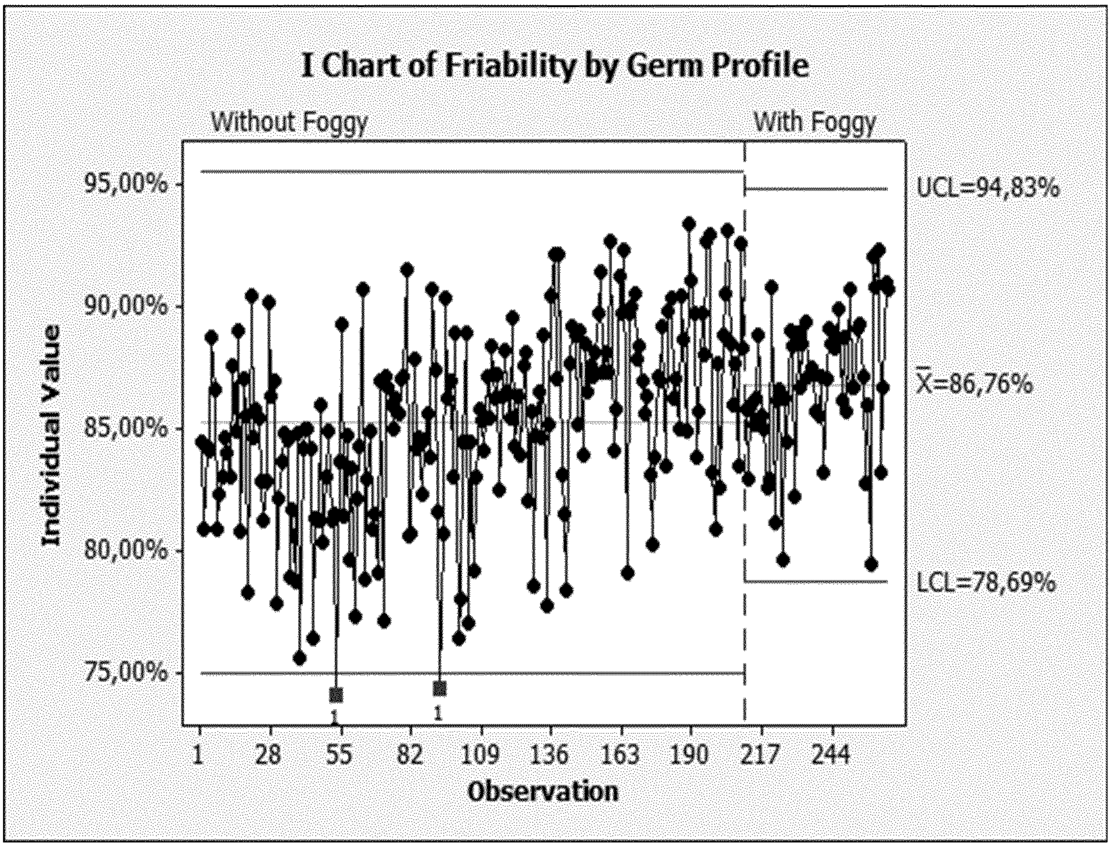

Figure 4d

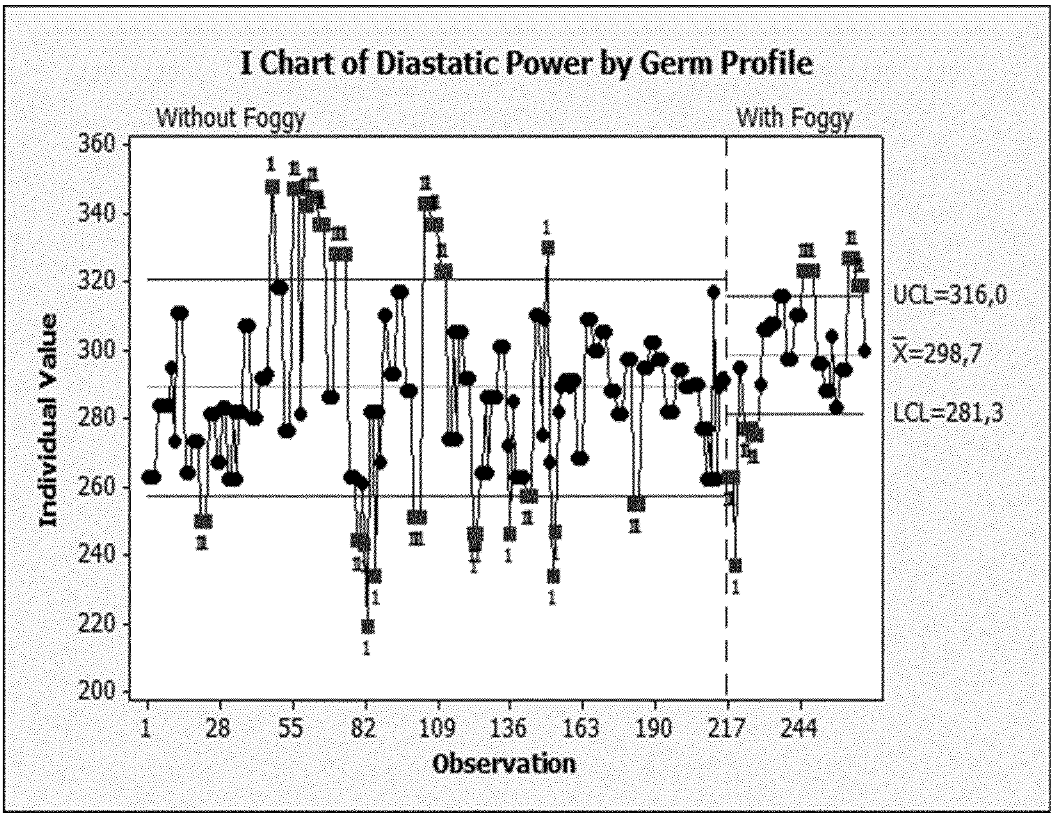

Figure 4e

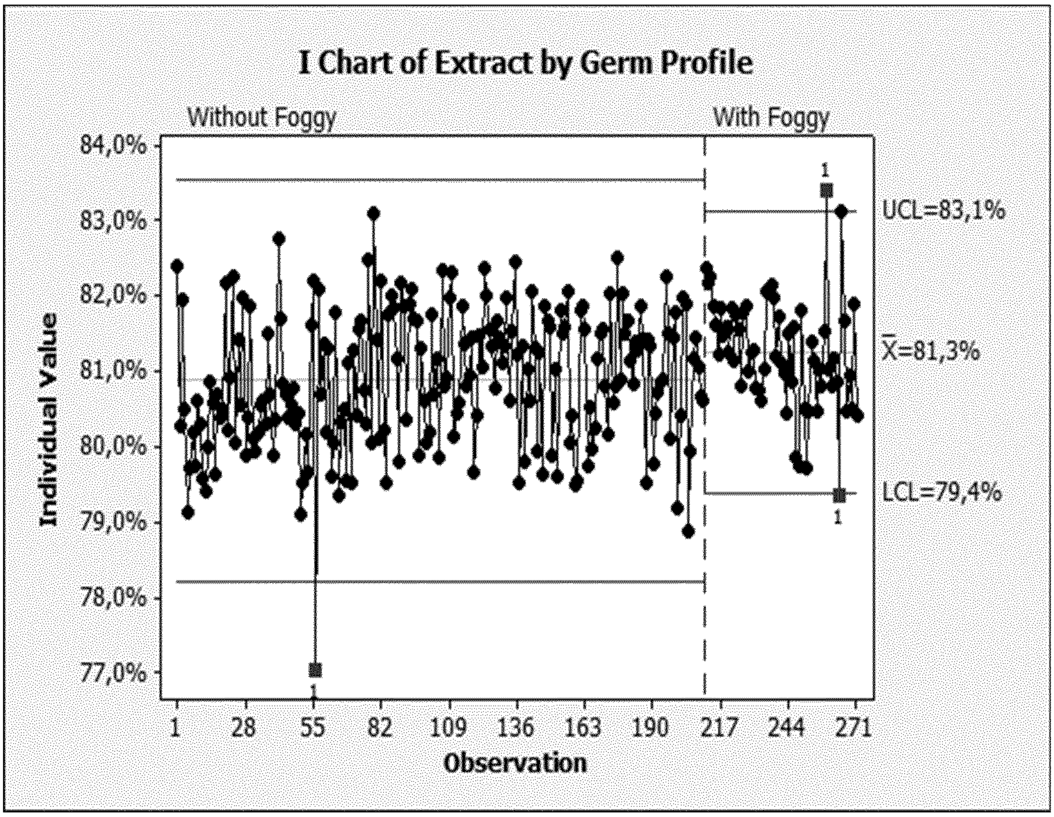

Figure 4f

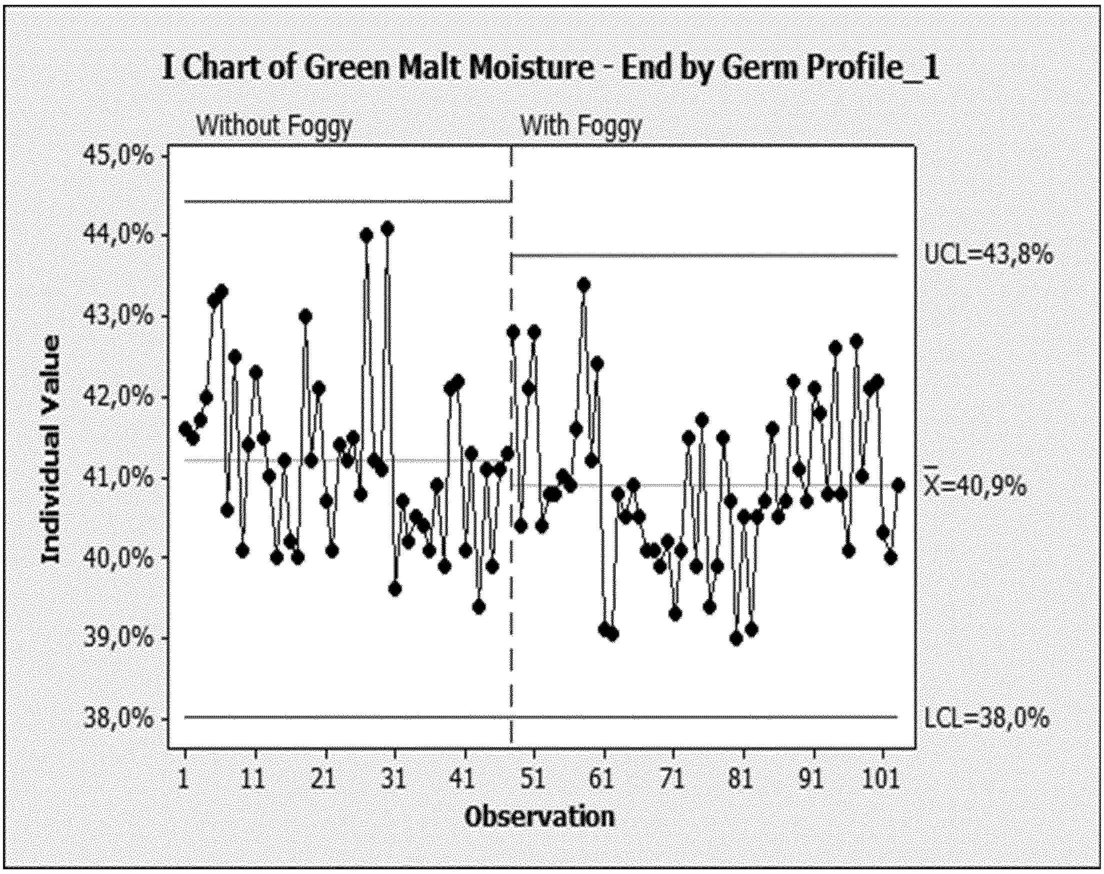

Figure 4g

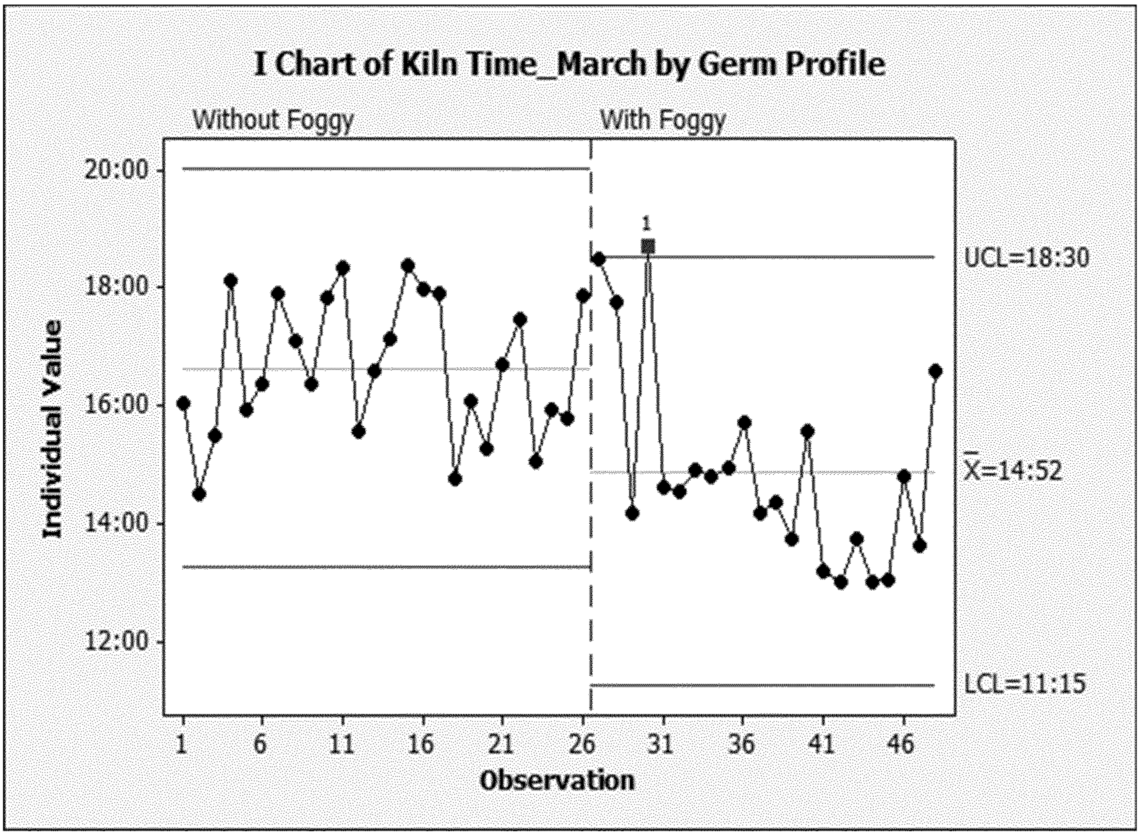

Figure 4h

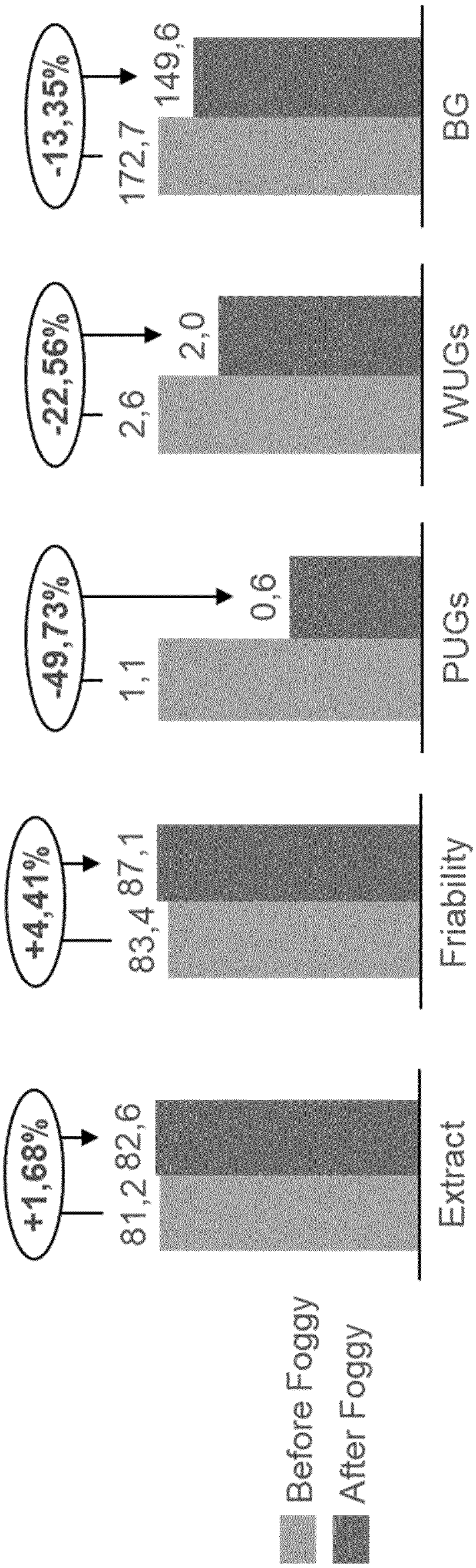
Before Foggy
After Foggy
Extract
81,2
82,6
+1,68%
Friability
83,4
87,1
+4,41%
PUGs
1,1
0,6
-49,73%
WUGs
2,6
2,0
-22,56%
BG
172,7
149,6
-13,35%

Figure 5

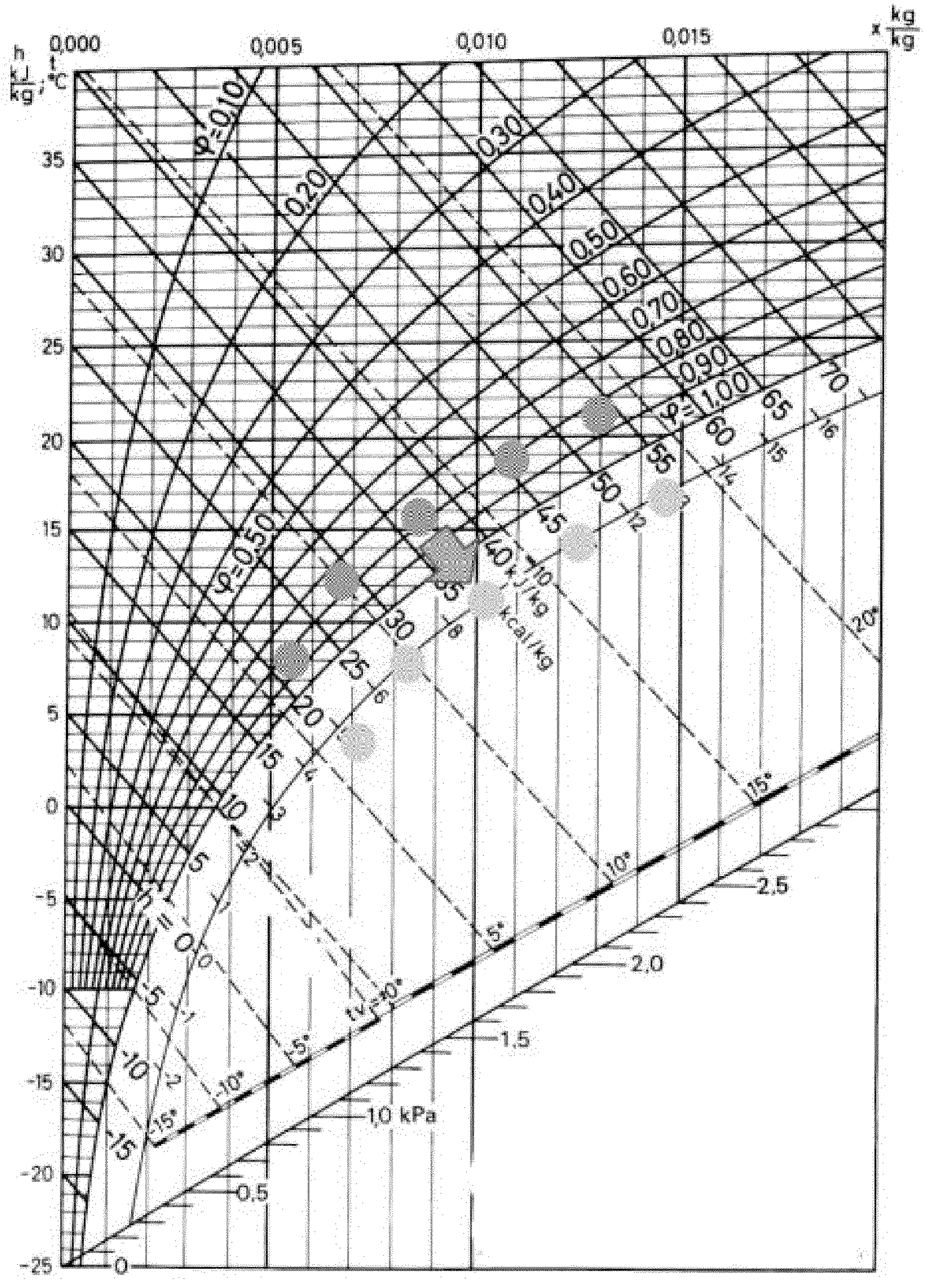
0,000
0,005
0,010
0,015
x kg/kg
h kJ/kg, t °C
φ=0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
φ=1,00
φ=0,50
kJ/kg
kcal/kg
tv=0°
1,0 kPa
0,5
1,5
2,0
2,5

Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/064415

A. CLASSIFICATION OF SUBJECT MATTER
INV. C12C1/047 C12C1/027 C12C1/125 C12C1/135
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C12C

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 405 155 A (MINCH NORTON LTD [IE]) 23 February 2005 (2005-02-23) page 5, line 29 - page 6, line 4; figure 1 -----	1-22
X	Anonymous: "MALTING BARLEY BREEDING GUIDELINES - IDEAL COMMERCIAL MALT CRITERIA", , 1 June 2019 (2019-06-01), pages 1-1, XP055894084, Retrieved from the Internet: URL:https://ambainc.org/wp-content/uploads/2019/10/Malting_Barley_Breeding_Guidelines_June_2019.pdf [retrieved on 2022-02-21] table 1 -----	13,15-22

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[x] Further documents are listed in the continuation of Box C. [x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 September 2022	16/09/2022
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Gzil, Piotr

2

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TURNER HANNAH M. ET AL: "Effect of Steeping Regime on Barley Malt Quality and Its Impacts on Breeding Program Selection", JOURNAL OF THE AMERICAN SOCIETY OF BREWING CHEMISTS. , vol. 77, no. 4 2 October 2019 (2019-10-02), pages 267-281, XP055894085, US ISSN: 0361-0470, DOI: 10.1080/03610470.2019.1629794 Retrieved from the Internet: URL:https://www.montana.edu/barleybreeding/documents/publications/Effect%20of%20Steeping%20Regime%20on%20Barley%20Malt%20Quality%20and%20Its%20Impacts%20on%20Breeding%20Program%20Selection.pdf table 2 -----	13,15-22
A	BE 1 026 272 A1 (ANHEUSER BUSCH INBEV SA [BE]) 5 December 2019 (2019-12-05) page 13, line 15 - line 30 -----	1-22

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2022/064415

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB 2405155	A	23-02-2005	EA	200400297 A1	26-08-2004
			GB	2405155 A	23-02-2005
BE 1026272	A1	05-12-2019	NONE		