

A method for the manufacture of an instant coffee powder

The present invention relates to a method for the manufacture of an instant coffee powder which has a reduced acrylamide content, or a different flavour profile without having an increased acrylamide content. In particular, the invention relates to an instant coffee powder comprising soluble coffee supplemented with roast and ground coffee particles.

The extraction of roast and ground coffee with water to obtain a high coffee-solids liquid coffee concentrate is well known. Moreover, it is well known to dry such a concentrate with, for example, spray- or freeze-drying to obtain a soluble beverage product. The soluble beverage product can then be reconstituted at the consumer's convenience with hot (or cold) water to obtain a coffee beverage. It is well known for these products to be supplemented with amounts of roast and ground coffee powder which serve to improve the mouthfeel and flavour of the product.

The industrial production of liquid coffee concentrates to make such soluble or "instant coffee" products is associated with higher temperatures and pressures than coffee shop brewing systems. This allows a higher yield to be obtained from the beans and a lower waste stream, but has a side-effect that the coffee can adopt undesirable processing flavour notes.

Food products that are subjected to high temperatures during processing often contain high levels of acrylamide. These temperatures can be reached during the first minutes of the coffee roasting process where the highest amount of acrylamide have been reported. Since acrylamide is a potentially carcinogenic substance, the food industry is unified in trying to reduce the levels of acrylamide in food. It is therefore desirable to implement measures to reduce the levels of acrylamide that accumulate during the coffee production.

Asparagine is converted to acrylamide, amongst other products, through chemical reaction at elevated temperatures. Unlike most other food products, coffee shows a decrease in acrylamide with increasing processing (roasting) time. All foods show this effect if heated sufficiently but under normal processing conditions most foods do not convert all their asparagine to acrylamide, hence longer processing times generally result in higher acrylamide levels. However, with coffee, all the asparagine is exhausted before processing is completed, and acrylamide levels then begin to fall. The most probable mechanisms for loss of acrylamide are polymerisation, degradation, or reaction with other food components.

Therefore, in roast and ground coffee the challenge is more acute with lighter roasts, since acrylamide degrades under the more severe roasting conditions. Lighter roasts can be associated with different flavour profiles and higher yields.

- 5 Accordingly, it is known that to provide roast and ground coffee with a low acrylamide content, it is necessary to ensure that the coffee has a relatively dark roast. The darker the roast, the lower the levels of acrylamide that are observed, but at the same time the flavour profile of the coffee suffers. The sale of coffee products is subject to strict health guidelines and it is necessary for commercial products to have low acrylamide content.

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The extent of roasting of coffee beans can be assessed by analysing the colour of the roasted beans. This is based on a colour reflectance, such that a darker bean is associated with a lower Colorette number (CMU). A CMU of less than 90 is associated with a relatively dark roast, whereas a CMU of about 120 would be a relatively light roast. The colour measurement system and values are discussed further below.

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It is known in the prior art that acrylamide levels fall very gradually during storage in roast and ground coffee; Guenther et al., Food Additives & Contaminants, Vol 24(sup1), p60 (2007). However, long term storage of coffee is associated with staling and flavour loss, so the product no longer meets the consumer expectations.

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Accordingly, it is desirable to provide a new coffee product with the required low levels of acrylamide but with a different flavour profile, or even a conventional flavour product with lower levels of acrylamide, and/or to tackle at least some of the problems associated with the prior art or, at least, to provide a commercially viable alternative thereto.

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GB2514138 relates to pre-extraction of coffee solids from a roast and ground coffee powder before using it as an additive in soluble coffee.

- 30 EP3087845 relates to a soluble coffee, including: a dried coffee extract; and a roasted coffee bean fine powder, in which the soluble coffee has a mass ratio of acetic acid (B) to malic acid (A), $[(B) / (A)]$, of 2.9 or less.

- GB2006603 relates to a coffee product consisting of free-flowing agglomerates comprising soluble coffee particles and finely ground roasted coffee, said finely ground roasted coffee being present in an amount of 2 to 20% by weight based on the weight of the two coffee

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constituents and having a particle size such that 90% by weight of the ground coffee passes a 75 micron mesh.

JP2008048728 relates to a method for producing coffee beans involving supplying a coffee
5 extracted solution which suppresses production of hydrogen peroxide in the body after drinking.

JP2011055716 relates to a method for producing purified roasted coffee beans, which
10 obtains a coffee extract which not only has a high content ratio of dimers of chlorogenic acid and a low content ratio of hydroxyhydroquinone to the chlorogenic acid but also excellent flavor.

According to a first aspect there is provided a method for the manufacture of an instant coffee powder, the method comprising:

- 15 (i) providing an aqueous coffee extract;
(ii) providing roasted coffee;
(iii) holding the roasted coffee in a substantially oxygen-free treatment-chamber at a temperature of from 70 to 120°C for at least 30 minutes to form acrylamide-depleted roasted coffee; and
20 (iv) drying the aqueous coffee extract to form a soluble coffee powder;
wherein, either:
a) the roasted coffee provided in step (ii) is a roasted coffee powder, whereby step (iii) provides an acrylamide-depleted roasted coffee powder; or
b) the method further comprises a step of grinding the acrylamide-depleted
25 roasted coffee obtained in step (iii) to form an acrylamide-depleted roasted coffee powder;
and, wherein, the method further comprises:
(v) adding the acrylamide-depleted roasted coffee powder to the aqueous coffee
extract before the drying step (iv), or adding the acrylamide-depleted roasted coffee powder
30 to the soluble coffee powder obtained in step (iv), to thereby form an instant coffee powder comprising soluble coffee and from 1wt% to 20wt% roast and ground coffee, by weight of the instant coffee powder.

Acrylamide is primarily produced during coffee roasting at temperatures between 140 and
35 180°C, whereas it begins to degrade at temperatures above 180°C. For coffee extraction processes (i.e. contacting roasted coffee with a hot aqueous solvent), a restriction to

temperatures below 140°C limit would lead to a low yield on the industrial processing. Equally, spending a long time at temperatures in excess of 180°C which might reduce the acrylamide content, would lead to over extraction and off-flavours.

- 5 For coffee roasting processes, below 140°C the acrylamide is not produced, nor is the coffee sufficiently roasted for flavour, and above 180°C the acrylamide levels start to decline. Conventional roasting profiles involve temperature gradients which pass through the acrylamide-forming range and then spend some time in the acrylamide-degradation range. The longer the coffee spends above the acrylamide-forming range, the darker the roast
10 colour.

- Roasting coffee to a darker roast is not always desirable because it affects the flavour and the associated temperatures lead to a roasting loss of material. Lighter roasts give a broader range of available flavours and actually extract better when contacted with hot water in a
15 conventional extraction process. Moreover, since a lighter roasted coffee has been subjected to lower roasting losses, a higher yield can subsequently be obtained (i.e. relative to the original weight of green beans). However, using a lighter roast means that there is more acrylamide present in the beans and this can lead to products having unacceptable acrylamide levels.

- 20 It is known to make instant coffee products that contain roast and ground coffee material, either mixed together with the soluble coffee granules or integrally within the soluble coffee granules. However, when making these products there are limits on the acrylamide content of the final coffee granules. In order to meet these requirements the roast and ground coffee
25 that is added is darker roasted, such as to colours of 80 to 90CMU.

- The inventors have now found that by performing the treatment process described herein, they can lower the acrylamide content of the roast and ground coffee component and, optionally, the soluble coffee component, such that the roast and ground coffee can be used
30 with a lighter roast. That is, decreasing the acrylamide content of the components of the product permits the use of lighter roast coffees which thereby opens up the flavour range and simultaneously increases the yield obtained from the roast and ground coffee used.

- In the context of a roast and ground coffee supplemented instant coffee, this is especially
35 key, since the roast and ground coffee contains unextracted coffee aroma components which are released only on reconstitution in water when making the beverage (compared to

a conventional soluble-coffee-only product). This means that the present invention allows additional flavour and aroma notes that are otherwise not observed in roasted-coffee-supplemented products due to the requisite dark roasts required for the low acrylamide regulations. Without the present invention, these flavour notes could only be observed if the products would also have undesirably high acrylamide levels, such as greater than 900mg/g.

As will be appreciated, the treatments described herein for reducing the acrylamide levels of the roast and ground, and soluble coffee components have an effect on the flavour of the final product. The desirability of the final flavours achieved in each case will influence the extent to which the treatment can be applied to the whole product, or to components thereof. While the present method certainly opens the door to a wider range of products, a balance is required of the acrylamide levels and the desired product characteristics.

According to a further aspect there is provided an instant coffee powder comprising soluble coffee and from 1wt% to 20wt% roast and ground coffee, by weight of the instant coffee powder, wherein the roast and ground coffee has a roasting CMU colour greater than 100, preferably greater than 120 and more preferably greater than 130, and wherein the instant coffee powder has an acrylamide content of less than 900mg/g; preferably wherein the roast and ground coffee is distributed homogeneously within the soluble coffee.

Detailed Description

The present invention relates to the production of an instant coffee powder. Instant coffee powders are very well known commercial coffee products produced by a range of different companies. The instant coffee powders are such that on addition of hot water, such as at a temperature of greater than 85°C, preferably 85 to 95°C, the instant coffee powder dissolves and forms a coffee beverage. An instant coffee powder comprises soluble coffee which is typically in the form of granules. Spray-dried soluble coffee is generally characterised by having round ball-shaped granules, whereas freeze-dried coffee is generally characterised by sharp, shard-shaped granules which tend to be a little larger than spray-dried coffee. Instant coffee powders may further comprise other components, such as insoluble ground coffee particles, or soluble components such as creamer and/or sweetener ingredients.

The instant coffee powder produced in the present method comprises soluble coffee and (insoluble) roast and ground coffee particles. The instant coffee powder comprises soluble

coffee and from 1wt% to 20wt% roast and ground coffee, by weight of the instant coffee powder. Preferably the instant coffee powder comprises from 12 to 18wt% roast and ground coffee. Preferably the instant coffee powder consists of soluble coffee and the roast and ground coffee particles. The roast and ground coffee particles can be homogenously distributed within the soluble coffee or can be dry mixed with the soluble coffee particles after they have been formed. The homogenous distribution is readily managed by having the roasted and ground coffee material present in the liquid coffee extract before it is dried.

The method comprises a step (i) of providing an aqueous coffee extract. Methods of obtaining an aqueous coffee extract are well known in the art with the most common commercial approach involving a plurality of sequential extraction columns. Hot water passing over roast and ground coffee beans extracts the soluble coffee matter into the hot water, providing a solution of soluble coffee solids. A preferred aqueous coffee extract comprises from 35 to 65wt% soluble coffee solids, more preferably from 45 to 55wt% soluble coffee solids. That is, if the extract were to be entirely dehydrated the remaining solids would be 45-55wt% of the original weight.

The method comprises a step (ii) of providing roasted coffee. Methods of roasting coffee beans are well known in the art and the method is suitable for all roasting extents. As discussed below, the roasted coffee may be provided as whole beans or as ground or milled coffee beans. Preferably the roasting process is conducted on whole beans, but the roasted beans can then be ground or milled before the subsequent steps of the process described herein. Preferably the roasted coffee provided in step (ii) has been roasted to a CMU colour greater than 100, preferably greater than 120 and more preferably greater than 130.

Preferably the roasted coffee provided in step (ii) is provided at a temperature of less than 50°C, preferably at room temperature. That is, it is preferred that the process is performed on a previously roasted and cooled roasted coffee. The treatment process described herein is a discrete processing step and is not part of the original roasting step.

Step (iii)

In order to reduce the acrylamide content of the roasted coffee, the method comprises a step (iii) of holding the roasted coffee in a substantially oxygen-free treatment-chamber at a temperature of from 70 to 120°C for at least 30 minutes to form acrylamide-depleted roasted coffee.

This heat-holding step is based on work undertaken by the inventors to mitigate the formation of acrylamide during the extraction process, seeking to understand the formation pathways and identify the critical pathways. By providing an understanding of the mechanisms that cause the reduction of acrylamide during later stages of roasting, during storage of roast and ground coffee and the observed increase in acrylamide occurring during the preparation of instant coffee from roast and ground coffee beans, the inventors have been able to develop strategies to minimise adverse changes in acrylamide during the production of instant coffee.

In the inventors' work, a series of precursors (free amino acids, reducing sugars), intermediates (3-aminopropionamide (3-APA)) and reaction products (acrylamide, pyrazines and pyrroles) were monitored during the extraction of five different roast and ground coffees: Robusta very light roast, light roast, medium roast and dark roast, and Arabica medium roast. Samples of the green beans, the roasted beans and samples taken from the primary, secondary and tertiary extractions were analysed.

Green beans contain sugars and free amino acids which react during roasting to form colour, flavour and acrylamide. After roasting these precursors are severely depleted and there is no evidence of significant amounts of the intermediate 3-APA. In the darker roasts there is no detectable asparagine. The more severe the roast the greater the depletion of Maillard precursors, the greater the formation of flavour compounds such as pyrazines and pyrroles, but the greater the degradation of acrylamide.

During the three extraction process stages, free amino acids, including asparagine, are generated at all stages, but by the end of the tertiary process asparagine is once again exhausted. Crucially, during the tertiary extraction, breakdown of galactomannans produces a substantial increase in the reducing sugars, glucose and mannose. At this stage, there is an accumulation of free amino acids, a significant increase in reducing sugars and a high temperature. This is where most of the acrylamide is generated in situ.

The results thus showed an increase in free amino acids during all extraction stages, and crucially asparagine, the key precursor of acrylamide, was detected in all the primary and secondary extracts. However, a source of reducing sugars is also required for the formation of acrylamide. The results showed that during the highest temperature stage, where the temperature is high enough to break up the galactomannans in the coffee, there was a

significant increase in glucose and mannose. Thus in the high temperature tertiary phase there are relatively high levels of sugars, and an accumulation of free amino acids, including asparagine, which also promote the formation of acrylamide. Under these conditions, there is a significant increase in acrylamide, with levels in accumulated extracts reaching 1200
5 ppb.

The direct correlations between the glucose content and the acrylamide formation is strong evidence that this is a major route to acrylamide formation during the production of instant coffee from roast and ground coffee. Key to mitigating the formation of new acrylamide
10 during the tertiary extraction process is preventing the breakdown of the galactomannans. Carrying out the bulk of the extraction at temperatures below those required to break down the galactomannans may be one way forward. Alternatively, the time of the high temperature extraction could be extended, but this would have an impact on the flavour of the final product, particularly the last two, where there is likely to be a significant increase in the burnt
15 character of the coffee.

However, the inventors also realised that the levels of acrylamide were higher than could be accounted for just by having conditions suitable for the formation of new acrylamide. They theorised that acrylamide which has been chemically or physically bound in the coffee may
20 be also being released. Without wishing to be bound by theory, it seems that the most likely candidate for this reversible trapping of acrylamide is thought to be melanoidins in the coffee. These heterogeneous, nitrogen-containing, brown pigments are produced in roast coffee and other cooked foods during the final stage of the Maillard reaction. They are formed by cyclisation, dehydration, rearrangement, and condensation of low molecular weight Maillard
25 products. The chemical composition of melanoidin structures is largely unknown, due to the complexity of the products. However, their composition will depend on polysaccharides (galactomannans and arabinogalactans), amino acids, proteins, and phenolic compounds (chlorogenic, caffeic, or ferulic acids) found in coffee beans. The nature of the binding could be physical, such as inclusion within the complex melanoidin structure (cf. inclusion of small
30 molecules in maltodextrins) or could involve covalent links between acrylamide and the melanoidins. Acrylamide is known to undergo Michael addition with thiol or amino groups and this is would lead to losses of acrylamide during thermal processing. Although this reaction was thought to be an irreversible route to acrylamide reduction the inventors found evidence that the reaction could be reversible. If the Michael addition is reversible under high pressure
35 and high moisture conditions used for coffee extraction during instant coffee processing, this would provide an explanation for the increased acrylamide in instant coffee.

The inventors realised that if the acrylamide was being released under the high temperatures then there could be method steps which could be undertaken to cause the acrylamide to be taken up again within the coffee melanoidins, trapping the acrylamide away within the beans and not within the coffee extract. It was theorised that the mechanism permitting re-uptake of the acrylamide could also be responsible for acrylamide that appears to be lost during storage of roast coffee beans and ground coffee. Consequently, they have arrived at a method for optimally causing uptake of the acrylamide into the coffee melanoidins causing a drop in the levels of acrylamide in the roast and ground coffee.

Without wishing to be bound by theory, it is understood that the heat treatment causes the acrylamide in the coffee beans to become bound with the melanodins within the beans. Thus the present invention lies in the realisation that acrylamide produced during roasting of coffee beans can be trapped in the material of the beans such that it is not released during conventional home or coffee shop extraction conditions (i.e. water at temperatures up to around 100°C). Thus the inventors have realised that they can conduct a heat treatment to increase the amount of acrylamide that is trapped naturally within the bean so that it is less readily released. This means that while the acrylamide is still strictly present, the amount of acrylamide that is released on extraction is reduced.

The method comprises holding roasted coffee in a substantially oxygen-free treatment-chamber at a temperature of from 70 to 120°C for at least 30 minutes to form acrylamide-depleted roasted coffee. They are preferably held dry in this step. Below 70°C the treatment time is too long to be commercially viable, whereas about 120°C the treatment may itself lead to the production of additional acrylamide. Preferably the treatment is conducted between 100 and 120°C, preferably 101 to 120°C, more preferably 110 to 120°C. Preferably the roasted coffee beans are held at the temperature of from 70 to 120°C (or the narrower ranges) for from 1 to 50 hours, preferably 2 to 10 hours.

By substantially oxygen-free it is meant that the levels of oxygen are kept below atmospheric levels such that the atmosphere contains less than 2v% oxygen, preferably 1v% oxygen and more preferably less than 0.1v% oxygen. The treatment chamber is preferably flushed with an inert gas, such as nitrogen, before use to remove oxygen and the beans can also be stored and filled into the chamber under the inert gas. Other suitable inert gases include carbon dioxide which can be obtained as a by-product of coffee roasting, and noble gases

such as argon. During treatment the beans are held in a gaseous environment. For the avoidance of doubt, the substantially oxygen-free treatment-chamber is devoid of added liquid water or coffee extract. That is, the beans are not submersed in water or coffee extract in the substantially oxygen-free treatment-chamber.

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The atmosphere can be supplemented with coffee aroma compounds to enhance the flavour of the beans and to mitigate against aroma loss from the beans. Suitable sources of coffee aroma include coffee oils or gases captured from the coffee grinder.

10 As noted above, it is known in the prior art that acrylamide falls very gradually during storage of roasted coffee. The inventors have found that this reduction is greatly accelerated by higher storage temperatures. At high temperatures a significant reduction can be effected within a few hours. However, this also leads to a problem. We found, by tasting, that hot-stored roast whole beans suffered a large impact on flavour, due to aroma loss.

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However, the inventors have found that this impact on flavour and aroma can be mitigated by performing the heat treatment as described herein under conditions whereby the aroma compounds are not lost. For example, where the beans are heated in a sealed vessel with minimal headspace, the equilibrium of aroma is shifted back towards the beans, both during
20 the warm/hot storage, and afterwards, when the temperature is lowered again. Flushing with nitrogen removes oxygen, which is another source of aroma deterioration at higher temperatures. Some pressure is generated in a sealed vessel, either during nitrogen flushing, raising the temperature, or from gas loss from the coffee, so the treatment vessel needs to be able to accommodate slightly higher pressure (i.e. be a pressure vessel) or to
25 be flexible, as this allows the headspace to increase in volume.

Accordingly, in one embodiment, the treatment-chamber is a sealed pressure chamber. The chamber is loaded with beans or ground coffee under an oxygen-free environment.

Preferably the treatment-chamber is loaded substantially to capacity with the roasted coffee.

30 Preferably the treatment-chamber is flushed with an inert gas before loading. During the heat treatment the pressure in the vessel increases, but the pressure chamber is able to withstand this.

In one embodiment, the treatment-chamber comprises a gas circulation system for
35 circulating oxygen-free process gas or gases. That is, the treatment chamber for the beans may comprise at least one inlet and at least one outlet, with a heated oxygen-free gas

stream being used to heat/cool the beans, where the gas stream is continually recirculated through a heating/cooling device located outside the chamber. During the heat treatment the pressure in the vessel would not increase as this would be controlled by the gas circulation system.

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Preferably the method reduces the acrylamide levels by at least 30%, more preferably at least 40%, and more preferably at least 75%. Reductions of 80% and even 95% can be achieved as shown in the examples. The method may have some consequence for the taste of the product, however, with higher levels of acrylamide reduction leading to higher impacts on the taste.

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Preferably the treated coffee is cooled, or allowed to cool, to less than 30°C before opening the treatment-chamber. This helps to avoid loss of aroma and volatiles. Preferably the chamber is kept sealed at a temperature of less than 20°C, preferably less than 10 °C and more preferably less than 5 °C, for a period of at least 1 minute, preferably at least 10 minutes and more preferably for at least 1 hour, after the treatment. Surprisingly, this step of holding the coffee at a low temperature seems to cause the coffee to reabsorb additional flavour compounds, changing the flavour of the product.

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If the roasted coffee was provided as whole beans in step (ii), then after step (iii) they will be milled or ground.

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Preferably the acrylamide-depleted roasted coffee powder has a particle size having a D50 of from 5 to 100µm, preferably 10 to 50µm, and preferably having a D90 of less than 120µm, preferably less than 80µm. This particle size can be determined by providing roasted coffee in step (ii) having this particle size distribution or, alternatively, by milling the roasted coffee after step (iii). This milling may be a further size reduction if the roasted coffee was already milled before step (ii), or may be a first milling of whole coffee beans.

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30 Step (iv)

The method then comprises a step (iv) of drying the aqueous coffee extract to form a soluble coffee powder. Suitable drying techniques are well known in the art and the most well-known are spray-drying and freeze-drying. Preferably the step (iv) of drying the aqueous coffee extract is a spray-drying or freeze-drying step. Any steps normally used in the production of such products may be used herein, including the addition of gases for foaming and reducing

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product density, and the supplementation with roast and ground coffee particles or other beverage ingredients such as creamer or sugar.

5 It is preferred that these techniques are so-called gas-injection spray-drying or gas-injection freeze-drying techniques, whereby an inert gas such as carbon dioxide or nitrogen is added before drying to adjust the powder density. This can improve solubility and product performance.

10 As discussed above, the roast and ground coffee which is acrylamide-depleted can either be mixed into the aqueous coffee extract before the drying step (iv), or it can be mixed with the final soluble coffee powder. In either instance, there is provided an instant coffee powder containing both soluble coffee and roast and ground coffee.

15 The roast and ground coffee is added to the soluble coffee to provide an instant coffee powder comprising soluble coffee and from 1wt% to 20wt% roast and ground coffee, by weight of the instant coffee powder.

20 The aqueous coffee extract preferably has a solids content of from 35 to 65wt% before drying, more preferably 45 to 55wt%. It should be noted that this includes the solids of the roast and ground coffee additive, in those embodiments where it is added before drying.

Aqueous coffee extract

25 There are two optional further approaches described herein, whereby the acrylamide levels can be further lowered. According to the first approach, the roasted coffee which is used to produce the soluble coffee portion of the final instant coffee product is itself subjected to the same heat treatment discussed above (all aspects discussed above apply equally to this method).

30 That is, preferably the aqueous coffee extract in step (i) is obtained in a method comprising:
(I) providing roasted coffee:
(II) holding the roasted coffee in a substantially oxygen-free treatment-chamber at a temperature of from 70 to 120°C for at least 30 minutes to form acrylamide-depleted roasted coffee;

35 wherein either:

a) the roasted coffee provided in step (I) is a roasted coffee powder, whereby

step (II) provides an acrylamide-depleted roasted coffee powder; or
b) the method further comprises a step of grinding the acrylamide-depleted roasted coffee obtained in step (II) to form an acrylamide-depleted roasted coffee powder;

5 and, wherein the method further comprises:

(III) extracting the acrylamide-depleted roasted coffee powder with water to form the aqueous coffee extract.

10 Preferably the roasted coffee provided in step (I) has been roasted to a CMU colour greater than 100, preferably greater than 120 and more preferably greater than 130.

Preferably step (III) is performed at a temperature of at least 140°C, preferably at least 175°C.

15 According to an alternative method, preferably the aqueous coffee extract in step (i) is obtained in a method comprising:

(I) providing a roast and ground coffee powder;

(II) extracting the roast and ground coffee powder with water to form a precursor aqueous coffee extract; and

20 (III) contacting the precursor aqueous coffee extract with spent coffee grounds at a temperature of 70 to 120°C for at least 30 minutes to form the aqueous coffee extract.

Preferably step (II) is performed at a temperature of at least 140°C, preferably at least 175°C.

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The method of this alternative involves contacting an acrylamide-containing aqueous coffee extract with spent coffee grounds at a temperature of 70 to 120°C for at least 30 minutes to form an acrylamide-depleted coffee extract. That is, the aqueous coffee extract to be treated is held with spent coffee grounds at temperatures kept within the range of 70 to 120°C for at
30 least 30 minutes. The holding may involve the use of a storage tank, filtering through a bed of spent coffee beans optionally with a recirculation process, or a slurry treatment system. When filtering through the bed, a recirculation system can ensure that the extract stays at a suitable temperature for a suitable time while in contact with the beans.

35 The extract is contacted for a time and then the contact is stopped. That is, the spent coffee grounds are separated from the coffee extract, so that the coffee extract can be used as

normal (such as to make a soluble coffee powder). The spent coffee grounds may be readily removed from the extract by a screening or decanting step. Many different techniques and devices are known for use in separating coffee extracts from roasted coffee beans. In this way the spent coffee grounds can be reused to treat further extract, until they are enriched with acrylamide and may be discarded from the process.

Preferably, after the step of contacting an acrylamide-containing aqueous coffee extract with spent coffee grounds, there is a further step of recovering the spent coffee grounds from the aqueous coffee extract to provide a treated acrylamide-depleted aqueous coffee extract. This step will preferably remove at least 90wt%, more preferably at least 95wt% and most preferably at least 99wt% or substantially all of the spent coffee grounds.

Spent coffee grounds are a known product in the art of soluble coffee extraction. In general, so long as roast and ground coffee still contains any extractable material which could be obtained by a further extraction step without requiring such high temperatures as to cause undesirable levels of off-flavour production, it will be subjected to further processing and is not considered to be spent. Thus spent coffee grounds are the roast and ground coffee material remaining after aqueous extraction at the point where they would ordinarily be discarded or combusted for energy generation.

In the context of the present invention, spent coffee grounds have at least been subjected to an aqueous extraction at a temperature of 175°C or higher, preferably 200°C or higher and more preferably 205°C to 240°C. Preferably the spent coffee is devoid of further useful extractable coffee solids.

The acrylamide-containing aqueous coffee extract is contacted with the spent coffee grounds at a temperature of at least 70°C since below this temperature the rate of acrylamide reduction is too low for commercial use. A temperature below 120°C is used to prevent the release or production of additional acrylamide in the extract. The processing time is at least 30 minutes to achieve sufficient acrylamide reduction at these temperatures. Preferably the acrylamide-containing aqueous coffee extract is contacted with the spent coffee grounds at a temperature of from 100 to 120°C. Most preferably the temperature is from 110 to 120°C.

Preferably the processing time is from 30 minutes to 50 hours, preferably 1 hour to 24 hours and more preferably 2 hours to 10 hours. These time periods strike the optimum balance for

reduction without compromising the flavour and compatibility with industrial instant coffee production. After this time period is complete, the spent coffee grounds are removed from the aqueous coffee extract.

- 5 The amount of spent grounds required for the process depends on the amount of coffee extract to be treated. Typically an amount of at least 1kg of spent coffee grounds can be used to treat 100kg of coffee extract, by weight of the soluble coffee solids in the coffee extract (i.e. on a dry basis), more preferably at least 10kg of spent coffee grounds and preferably from 20 to 100kg of spent coffee grounds per 100kg of coffee extract.

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Such a holding step, involving contacting coffee extract with coffee material at a temperature lower than a previous extraction step is not performed in conventional industrial processing. This is because the drive in conventional processing is to increase the yield with increasing temperature steps and then to produce a dried powder product quickly to avoid taking up
15 factory space and to avoid holding times which could lead to a loss of product quality.

- The method produces an acrylamide-depleted coffee extract. Preferably this comprises less than 400 ppb acrylamide, more preferably less than 200 ppb acrylamide more preferably less than 100 ppb acrylamide, and most preferably essentially no acrylamide. Preferably the
20 method reduces the acrylamide levels by at least 30%, more preferably by at least 40%, preferably more than 75%. Levels of reduction can be more than 80%, such as 95% when using higher temperatures and longer treatment times as shown in the examples. The method may have some consequence for the taste of the product, however, with higher levels of acrylamide reduction leading to higher impacts on the taste.

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Preferably the acrylamide-containing aqueous coffee extract is passed through the spent coffee grounds in a continuous process. This is industrially efficient and allows for continuous production of dried coffee products.

- 30 Preferably the spent coffee grounds are provided as a bed of spent coffee grounds. Use of percolation of water through coffee beds is well known in the art, so it is straightforward to adapt existing equipment to the treatment method described herein.

- Preferably the bed of spent coffee is held in a sealed chamber, which can be optionally
35 maintained under a super-atmospheric pressure. This is preferably at least 1 bar above

standard atmospheric pressure, such as from 1 to 500Bar, preferably from 2 to 25 Bar This helps to avoid the loss of volatile flavour and aroma compounds during the treatment.

- 5 Preferably the aqueous coffee extract obtained in step (III) has a solids content of 35 to 65wt%, more preferably 45 to 55wt%.

The instant coffee powder

- 10 According to a further aspect there is provided an instant coffee powder comprising soluble coffee and from 1wt% to 20wt% roast and ground coffee, by weight of the instant coffee powder, wherein the roast and ground coffee has a roasting CMU colour greater than 100, preferably greater than 120 and more preferably greater than 130, and wherein the instant coffee powder has an acrylamide content of less than 900mg/g, preferably less than 700mg/g and most preferably less than 400mg/g.

- 15 Preferably the roast and ground coffee is distributed homogenously within the soluble coffee. That is, preferably the roast and ground coffee was provided within the aqueous coffee extract before it was dried, rather than being added by dry admixture afterwards.

- 20 Preferably the instant coffee powder is obtainable by the method according to the method described herein. This product would be discernibly different from conventional coffee products on the basis of the low acrylamide content, but the comparably lighter roast colour of the added roast and ground coffee component.

- 25 The instant coffee powder described herein may be further provided with additional ingredients, such as creamer and/or sweetener ingredients. Preferably these are simply dry mixed with the instant coffee powder after it has been produced according to the present invention. An exemplary three-in-one product would comprise, in a single-serving sachet, the coffee powder, creamer and a sweetener, such as sugar. This allows the consumer to make
30 a complete beverage, just by adding hot water to the contents of the sachet.

- The invention will now be described further in relation to the following non-limiting Figures, in which Figures 1 to 6 show a flow-chart of the key process steps of the invention. As discussed herein, the precise point at which the coffee is milled may be varied. In each
35 figure, wet-mixing and dry-mixing are generally alternatives, although in principle both types of mixing could be performed.

Measurement Techniques

Size

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Particle size measurements are now conventional in the art for determining particle size distributions of ground coffee. The particle size distributions and associated D50 and D90 values are determined by laser diffraction.

10 The diffraction of a laser light beam is dependent on the size of particles passing through it. A suitable detector & computer system convert the beam diffraction pattern into a particle size distribution. For the measurements a Sympatec Helos laser diffraction particle size measurement system can be used with a Rodos dry dispersion unit for powders and computer interface plus hardware to run the data logging & calculation software.

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The procedure and settings used were as recommended by the manufacturer for the type and size range of product being measured. The sample size poured into the dispersing system was around 10 – 20g. A lens with a focal length of 1000 mm, suitable for particle sizes between 9 – 1759 microns was used.

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Logging, calculation & presentation of the data are carried out by the software provided by the manufacturer. This is set to calculate & present values for “Q3” - a normalised particle volume distribution - and its first derivative, q3 - a particle volume distribution density. For the purposes of this calculation, the software is set to assume the particles of roast & ground
25 coffee are spherical. This is considered a reasonable assumption from close inspection (by microscopy) of the ground coffee powder. The values for VMD and fines can be obtained directly from the outputted information.

Colour

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Colour can be measured with the Probat Colorette 4. The Colorette 4 serves for colour and intensity measurement of ground roasted coffee in visible areas of the light. It works according to the principle of reflection measurement. The Colorette illuminates the sample with a clock-pulsed LED and measures the light reflected by the sample. The output values
35 are indicated as colour values in CIE L*ab and Colorette Units (CMU). The device is calibrated before use in accordance with the standard device instructions.

It is important that the sample is truly representative and a minimal sample amount of 100g is available.

- 5 Colour measurements are taken as standard based on a grind size having X50 of 450 μ m $\pm$ 30 μ m. Whole beans are ground to this size before performing the colour measurement. Where a colour measurement is required for roast and ground coffee not of this grind size, the value can be accurately assessed based on calibration curves. That is, a colour measurement on a more coarsely or finely ground coffee can be calibrated to determine the colour for the same coffee ground to 450 μ m and, hence, a comparable CMU value can be determined.

Examples

- 15 The invention will now be described further in relation to the following non-limiting Examples.

Roast and ground coffee was held in an air-tight chamber under an inert atmosphere. Their levels of acrylamide were measured before and after treatment. The reduction observed is summarised in the table below.

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Treatment Temperature ($^{\circ}$ C)	Holding time (hrs)	Normalised Acrylamide Level
120	1	0.18
120	3	0.05
70	3	0.58
70	50	0.39
37	400	0.85
37	750	0.85
37	1100	0.68
37	1450	0.52
23	400	0.92
23	750	0.92
23	1100	0.89
23	1450	0.76

Although preferred embodiments of the invention have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the scope of the invention or of the appended claims.

Claims:

1. A method for the manufacture of an instant coffee powder, the method comprising:
(i) providing an aqueous coffee extract;
5 (ii) providing roasted coffee;
(iii) holding the roasted coffee in a substantially oxygen-free treatment-chamber at a temperature of from 70 to 120°C for at least 30 minutes to form acrylamide-depleted roasted coffee; and
(iv) drying the aqueous coffee extract to form a soluble coffee powder;
10 wherein, either:
a) the roasted coffee provided in step (ii) is a roasted coffee powder, whereby step (iii) provides an acrylamide-depleted roasted coffee powder; or
b) the method further comprises a step of grinding the acrylamide-depleted roasted coffee obtained in step (iii) to form an acrylamide-depleted roasted
15 coffee powder;
and, wherein, the method further comprises:
(v) adding the acrylamide-depleted roasted coffee powder to the aqueous coffee extract before the drying step (iv), or adding the acrylamide-depleted roasted coffee powder to the soluble coffee powder obtained in step (iv), to thereby form an instant coffee powder
20 comprising soluble coffee and from 1wt% to 20wt% roast and ground coffee, by weight of the instant coffee powder.
2. The method according to claim 1, wherein the treatment-chamber in step (iii) is a sealed pressure chamber and/or comprises a gas circulation system for circulating oxygen-
25 free process gases.
3. The method according to claim 1 or claim 2, wherein the treatment-chamber in step (iii) is pre-flushed with nitrogen before being loaded with the roasted coffee beans to be treated.
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4. The method according to any preceding claim, wherein in step (iii) the roasted coffee beans are held in the treatment-chamber at a temperature of from 100 to 120°C.
5. The method according to any preceding claim, wherein in step (iii) the roasted coffee
35 beans are held at the temperature of from 70 to 120°C for from 1 to 50 hours, preferably 2 to 10 hours.

6. The method according to any preceding claim, wherein after step (iii) and before step (v) the acrylamide-depleted roasted coffee is cooled, or allowed to cool, to less than 30°C before opening the treatment-chamber.
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7. The method according to any preceding claim, wherein the instant coffee powder comprises from 12 to 18wt% roast and ground coffee.
8. The method according to any preceding claim, wherein the step (iv) of drying the aqueous coffee extract is a spray-drying or freeze-drying step.
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9. The method according to any preceding claim, wherein the acrylamide-depleted roasted coffee powder has a particle size having a D50 of from 5 to 100µm, preferably 10 to 50µm, and preferably having a D90 of less than 120µm, preferably less than 80µm.
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10. The method according to any preceding claim, wherein the roasted coffee provided in step (ii) has been roasted to a CMU colour greater than 100, preferably greater than 120 and more preferably greater than 130.
11. The method according to any preceding claim, wherein the roasted coffee provided in step (ii) is provided at a temperature of less than 50°C, preferably at room temperature.
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12. The method according to any preceding claim, wherein the aqueous coffee extract in step (i) is obtained in a method comprising:
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- (I) providing roasted coffee:
- (II) holding the roasted coffee in a substantially oxygen-free treatment-chamber at a temperature of from 70 to 120°C for at least 30 minutes to form acrylamide-depleted roasted coffee;
- wherein either:
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- a) the roasted coffee provided in step (I) is a roasted coffee powder, whereby step (II) provides an acrylamide-depleted roasted coffee powder; or
- b) the method further comprises a step of grinding the acrylamide-depleted roasted coffee obtained in step (II) to form an acrylamide-depleted roasted coffee powder;
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- and, wherein the method further comprises:

(III) extracting the acrylamide-depleted roasted coffee powder with water to form the aqueous coffee extract.

13. The method according to claim 12, wherein the roasted coffee provided in step (I) has been roasted to a CMU colour greater than 100, preferably greater than 120 and more preferably greater than 130.

14. The method according to any preceding claim, wherein the aqueous coffee extract in step (i) is obtained in a method comprising:

10 (I) providing a roast and ground coffee powder;

(II) extracting the roast and ground coffee powder with water to form a precursor aqueous coffee extract; and

(III) contacting the precursor aqueous coffee extract with spent coffee grounds at a temperature of 70 to 120°C for at least 30 minutes to form the aqueous coffee extract.

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15. The method according to claim 14, wherein step (II) is performed at a temperature of at least 140°C, preferably at least 175°C.

16. The method according to claim 14 or claim 15, wherein the precursor aqueous coffee extract is contacted with the spent coffee grounds at a temperature of from 100 to 120°C.

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17. The method according to any of claims 14 to 16, wherein the precursor aqueous coffee extract is contacted with the spent coffee grounds for from 1 to 50 hours, preferably 2 to 10 hours.

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18. The method according to any of claims 14 to 17, wherein the spent coffee grounds are provided as a waste product following aqueous extraction of roast and ground coffee at a temperature of at least 175°C.

19. The method according to any of claims 14 to 18, wherein the roast and ground coffee powder provided in step (I) has been roasted to a CMU colour greater than 100, preferably greater than 120 and more preferably greater than 130.

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20. An instant coffee powder comprising soluble coffee and from 1wt% to 20wt% roast and ground coffee, by weight of the instant coffee powder, wherein the roast and ground coffee has a roasting CMU colour greater than 100, preferably greater than 120 and more

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preferably greater than 130, and wherein the instant coffee powder has an acrylamide content of less than 900mg/g;

preferably wherein the roast and ground coffee is distributed homogenously within the soluble coffee.

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21. The instant coffee powder according to claim 20, wherein the instant coffee powder is obtainable by the method according to any of claims 1 to 19.