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(54) **Title:** PROCESS FOR MAKING MICRO-AERATED CHOCO-MATERIAL

FIG. 1

(57) **Abstract:** There is described a process for producing a micro-aerated choco-material the process comprising the steps of: (I) mixing a choco-material under a high shear of at least 200 s^{-1},the choco-material having a plastic viscosity before aeration as measured according to ICA method 46 (2000) of from 0.1 to 20 Pa.s, and (II) passing the choco-material from step (I) through an injection zone located between two regions held at different pressures, (III) injecting inert gas at a gas pressure of from 2 to 30 bar into the choco-material as it passes through an injection zone using a gas depositing means at a nominal gas flow rate (F_v) which is within the values of F_v that are calculated from equation (2) $P = -A F_v^2 + B F_v + C$ (2) Where P represents the porosity target of the micro-aerated choco-material in % measured under standard conditions, P being from 10 to 19%; and $F_v$represents the nominal volumetric flow rate of the inert gas in normal litres per minute (NL / min.); A,B and C are numerical constants (having the respective units to balance equation (2)); the numerical parts of each of these constants being: A from 0.06 to 0.07; B from 2.00 to 2.05, and C from 3.70 to 3.80; with the proviso that: (A) the flow rate calculated from equation (2) is based on a nominal throughput of the choco-material of 1000 kg / hour in the injection zone, the actual flow rate of inert gas injected in step (III) being adjusted where necessary from the calculated nominal flow rate F_v to match proportionally any differences from 1000 kg / hour in the actual throughout of the choco-material in the injection zone

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[Continued on next page]

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PROCESS AND COMPOSITION

The present invention relates to the field of chocolate confectionery compositions that comprise gas bubbles therein (commonly known as aerated chocolate) and processes for making them.

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

It has been known to prepare chocolate containing gas bubbles (commonly nitrogen or carbon dioxide). However such products typically t bubbles are visible to the consumer (such as in the products sold by the applicant under the Aero® registered trade mark). Such visible bubbles with an average diameter of 100 microns or above are commonly known as macro-aeration. What is less common is to aerate chocolate with bubbles of a size which are sufficiently small so the bubbles are not visible to the naked eye, typically with an average bubble diameter of less than 100 microns (informally known as micro-aeration). There are technical challenges with micro-aerating chocolate. For example the gas must be injected into the chocolate mass in a more precise method using specialized equipment otherwise there is a risk that the bubbles may coalesce to form larger bubbles. Care has to also be taken in terms of depositing. Micro-aerated chocolate mass is very sensitive to any form of mechanical stress, which causes coalescence. A pressurized deposit, directly into the mould is therefore required to ensure optimal aeration quality. Until recently the focus has been to micro-aerate to low levels, primarily for cost reduction reasons.

The applicant has surprisingly discovered that certain micro-aerated chocolate compositions exhibit unexpected properties which are advantageous to the end consumer and also during manufacture. These advantages include improved stability of the matrix of aerated bubbles in the solid product and/or greater ease of removal from a mould and/or packaging. These properties make the product easier to manufacture and/or produce more desired and/or consistent organoleptic properties in the final confectionery product. The invention provides for methods to prepare such micro-aerated chocolate compositions and different uses of such chocolate compositions.

It had previously been thought that micro-aerating chocolate to achieve high porosities would be difficult and expensive, with no added benefit leading to unstable and adversely tasting products. This is the reason that the few prior art micro-aerated products made in practise contain small amounts of gas micro-bubbles to achieve a porosity of at most 8%, often much lower. The applicant has surprisingly found a method for preparing a novel micro-aerated chocolate where the chocolate contains much higher proportion of gas than incorporated heretofor and the micro-bubbles are characterised by optimum parameters (as described herein). Such micro-aerated chocolate exhibits several beneficial properties which have never been appreciated before.

Aeration of chocolate has also been described in the patent literature as follows.

EP2298080 (Kraft) (also referred to herein as Kraft080) discloses a method and apparatus for making aerated food product which details the use of a microporous gas diffuser for the aeration of food products in a low shear mixing method. These products include, allegedly, chocolate, though the single example provided is a chocolate flavoured wafer filling and is not chocolate
Paragraph [0017] of Kraft080 states:

'The viscosity of the process medium before adding the gas through the microporous diffuser is typically in the range of from1 to 200 Pa.s, and preferably within the range of 1 to 60 Pa.s.'

Paragraph [0027] states:

'The gas volume fraction incorporated into the food product depends on the specific application and is typically in the range of 5 to 75% vol., preferably 5 to 40% vol., and most preferably 10 to 30% vol.'

Paragraph [0034] states:

'As mentioned before, the present invention aims at products with small gas cells and preferably products with a microcellular structure. Microcellular generally implies gas cells of an average size of 100 µm or less. Preferably, the average cell size is less than 50 µm and most preferably, the average cell size falls within the range of 5 to 30 µm. In the most preferred embodiments, 90% of the cells have a size between 10 and 50 µm. '

Paragraph [0042] states:

The product of the process according to the present invention typically contains 30% or less by volume of gas. Preferably, the gas volume fraction is less than 25% and most preferable it is in the range of 10 to 25%. The best results are obtained when the aforementioned preferred gas volumes and preferred cell sizes are realised in combination.

Kraft080 discloses a very broad range of viscosities (from 1 to 200 Pa.s) for food media stated to be successfully aerated by this method. It is not credible that all food with such a broad range of viscosities can be aerated by the same method described in Kraft 080 and such statements must be considered highly speculative. For example chocolate masses used to prepare moulded chocolate products have typical plastic viscosities of from 1 to 20 Pa.s and high shear mixing would be required to provide homogenous aeration. The aeration method described in Kraft080 injects gas under low shear with a micro-diffuser. It is doubtful this method could aerate viscous chocolate masses, with viscosities in the high end of the claimed range. It is also doubtful this method could aerate chocolate with bubbles evenly and uniformly distributed within the product. Kraft080 also describes products aerated with very wide gas volume ranges (from 5 to 70%). There is no appreciation of the unique properties of chocolate. The applicant has found aerating chocolate with micro-bubbles at gas volumes above 20% increases the chocolate viscosity leading to difficulty in removing such chocolate from moulds. Therefore the micro-aerated chocolate described in Kraft080, even if was ever made, is far from satisfactory.

Josefin Haedelt et al, Institute of Food Technology, vol. 70 (2), March 2005, p E159-164 (also referred to herein as Haedelt2005) describes vacuum-induced bubble formation in liquid-tempered chocolate. Haedelt2005 acknowledges (page E159, col. 2, lines 7 to 11) that:

'Furthermore the dispersion characteristics obtained under a given set of conditions are not highly reproducible. In general, the effect of operating conditions on key quality parameters, such as density, gas hold-up, and bubble sizes, are far from being well understood.'

The bubble sizes of the aerated chocolate prepared by Haedelt2005 are clearly macro-sized. This can be seen from Table 2 on page E161 which describes samples having a bubble size with mean diameter (mm) prepared at various gas pressures, namely 0.85 mm ± 0.4 standard deviation (SD) (at 1000 Pa); 0.4 mm ± 0.16 mm SD) (at 5000 Pa); and 0.37 mm ± 0.19 mm SD (at 10,000 Pa). Also Table 3 on page E161 describes samples having a bubble size with the following mean diameters (mm) prepared from chocolate with viscosity tempered at the given temperatures, namely: 0.4 mm ± 0.19 mm SD (at 27°C); 0.41 mm ± 0.16 mm SD) (at 30°C); and 0.49 mm ± 0.19 mm SD) (at 33°C).

Josefin Haedelt et al, Journal of Food Science vol. 72(3), 1 April 2007, p E138-142 (also referred to herein as Haedelt 2007). Haedelt2007 investigated the sensory properties produced by using different gases to micro-aerate chocolate, namely carbon dioxide, nitrogen, nitrous oxide, and argon. Haedelt2007, does not consider or disclose the effect of varying any other parameters on the sensory properties of aerated chocolate.

WO2002-13618 (Danone) describes an apparatus for aerating a foodstuff including chocolate.

US4674888 (Komax Systems) describes a gas injector.

EP2543260 (Kraft) (also referred to herein as Kraft060) discloses use of a frozen cone process for micro-aerating a chocolate shell. Such thin shells are very different from thicker moulded chocolate products such as tablets. The use of a cold stamping process avoids challenges associated with flow characteristics of micro-aerated chocolate.
Paragraph [0008] lines 45 to 55 of Kraft060 states:

> *' … wherein the aerated shell layer has a total gas content of at least 5%, the gas content being calculated using the following formula (1):*
>
> *Gas content of aerated shell layer = (M2 - M1) / M1*
>
> *wherein M1 is the mass of the aerated shell layer having volume V1, and M2 is the mass of a non-aerated shell layer having volume V1 and being formed from the same edible liquid as the aerated shell layer and in the same manner as the aerated shell layer.'*

Paragraph [0023] states:

> *The aerated edible liquid to be deposited into the mould cavity in step (ii) suitably has a total gas content of at least 5%, the gas content being calculated using the following formula (2):*
>
> *Gas content of aerated edible liquid = (M2 - M1) / M1*
>
> *wherein M3 is the mass of the aerated edible liquid having volume V2, and M4 is the mass of the same volume of the edible liquid without aeration. This means that the mass of the edible liquid per unit volume (V2) is reduced by at least 5% upon aerating the liquid.*

Paragraph [0024] states:

> *A gas content of at least 5% is advantageous in terms of providing a good texture and reducing the calorie content of the shell. In this regard, the gas content of the aerated edible liquid can be at least 10%, at least 15%, at least 20%, at least 25%, at least 30% or at least 40%, and in some embodiments the gas content is within the range 5-40%, 5-25% or 10-20 mass% so that there is not an excessive loss of gas from the liquid during cold-stamping. A higher initial gas content leads to a greater degree of de-aeration relative to the initial gas content. This is because the gas bubbles have a greater chance of coalescing to form larger bubbles. Large bubbles quickly escape from the liquid due to the large difference between their densities and the density of the liquid.*

Paragraph [0025] states:

> *Another measure of the degree of aeration of the liquid is the volume of gas in the liquid with respect to the total volume of the liquid. In one embodiment, the liquid contains no more than 14 vol%, no more than 18 vol% or no more than 22 vol% of gas. A suitable minimum gas content is 10 vol%. A gas content of 10-22 vol% is advantageous in terms of taste and mouthfeel.*

Paragraph [0026] states:

The aerated liquid can have a density or no more than 1.10 g/cm^3, no more than 1.05 g/cm^3, no more than 1.00 g/cm3, or no more than 0.95 g/cm^3. A density within the range of 0.98-1.10 g/cm^3 is optimal in terms of taste and mouthfeel.

Kraft060 is more concerned in improving methods for making thin chocolate shells than aerating a large chocolate mass such as those used to produce chocolate tablets. The method described in Kraft060 uses cold stamping form a thin shell. Kraft060 does not suggest how to produce a controlled size distribution of small bubbles in a micro-aerated chocolate. This is due in part due to the rapid cooling associated with the cold stamping method, meaning less time for expansion and coalescence of the bubbles. Cooling times for a chocolate tablet are significantly longer due to the use of long cooling tunnels and a much larger mass of chocolate in the mould cavity. The stamping process leads to bubble destruction through the physical force of the stamp impacting the aerated chocolate. The problem of how to ensure uniform distribution of bubbles homogeneously within a solid chocolate product is not addressed by Kraft060 as for a thin shell this not an issue. The method of Kraft060 is not designed for and would be unsuitable to use to aerate thicker moulded product such as tablets. The process of Kraft060 is designed for the production of chocolate shells for the addition of a further component.

US2006-0057265A1 (Knobel) discloses a method for producing confectionary products having an outer shell made of a substance that is placed inside a mould into which a temperature controlled male die is subsequently introduced. The substance is placed under pressure after the male die is introduced.

EP2018811 (Winkler) discloses an apparatus for moulding foodstuffs.

EP0589820 (Aasted-Mikroverk) discloses a method of moulding chocolate articles.

DE 102005018415 (Winkler) discloses a method for making candy products (and candy moulding station) that uses a cold stamp protected from an air by filling the chamber in which stamping occurs with a gas has such as helium that is less dense than air. A mixing zone is formed between the area with the protective gas and air.

WO2009-040530 (Cadbury) discloses an aerated centre filled confectionery composition.

EP0914774 (Aasted-Mikroverk) discloses a method, system and apparatus for producing shells of fat-containing chocolate like masses.

CH680411 (Lindt) describes a method of forming a semi-solid , fatty, aerated masses, especially chocolate and / or chocolate like masses and a device for its implementation.

US5238698 (Jacob Suchard) describes a product and process for producing a lower density milk chocolate composition, substantially free of sucrose and having the taste and mouthfeel of a traditional milk chocolate. Here the milk chocolate composition is aerated with an inert gas under a pressure of about 1.2 about 8 bar at temperature of 27° C. to about 45° C.

EP0230763 (Morinaga) describes aerated chocolate composition with a gaseous continuous phase and the dispersed phase of fine grains of conglomerated solid chocolate. The aerated chocolate has an apparent density of 0.23 to 0.48 g / cm^3. The composition is made by agitating a melted chocolate whilst cooling from 8 to 14 °C lower than the fat contained within the chocolate, to incorporate gas therein. The apparent density of the composition is allowed to reach from 0.7 to 1.1 g / cm^3 and then the composition is exposed to a reduced pressure of 150 Torr or less to expand the composition and convert the gas and solid phases.

EP1346641 (Aasted-Mikroverk) discloses a method of making chocolate shells.

WO2001-080660 (Effem Foods) describes a confectionery product comprising low density chocolate surrounded by a sugar based coating and a process for producing this product. The product is stated to be shelf stable even at elevated ambient temperatures.

GB1305520 (Abalo) describes a continuous process for making foamed candies having a continuous outer shell of non aerated chocolate shell and a foamed chocolate filling in the centre.

WO1999-34685 (Mars) (= US6165531) describes the use of moulds made from a material of low surface energy < 30 mJ / m^2 (such as silicone) for de-moulding of a micro-aerated product. This reference shows (e.g. on page 29) that aerated chocolate is more difficult to de-mould than non-aerated chocolate.

WO2000-078156 (APV) describes use of micro-aerated chocolate for enrobing, Page 5, lines 1 to 5 states:

> *'Existing equipment for aeration within a tempering unit is available, but as no high shear unit is fitted the level of aeration is limited (usually to below 5%) and the ability to produce microscopically-sized bubbles is also limited (this being considered a very desirable attribute in some applications of the invention.)*

The patent application describes mostly detail of the equipment and there is no further suggestion from the above paragraph which levels of aeration may be desirable or what microscopic bubbles would be useful.

WO2004-056191 (Mars) (= US2006-0147584) describes using drop rollers for the production of chocolate lentils, with a low density (i.e. aerated) chocolate core surrounded by a sugar shell. The lentils are analogous to products available commercially from Mars under the registered trademark M&M®. The patent states on page 6 lines 27 to 30 that:

> *' … the chocolate core is dispersed with gas bubbles having an average diameter of less than 25 microns. Typically the average diameter of the gas bubbles is less than about 17 microns. The dispersion is preferably homogeneous throughout the core.'*

These bubble sizes are very small and difficult to produce in a large chocolate mass than a core (e.g. to make chocolate tablets). The patent states on page 4 lines 6 to 8 that:

> *'Most equipment in chocolate manufacturing lines is very specific to the type of confectionery being produced and therefore not readily transferable from one production line to another.'*

Therefore the disclosure of this document relating to aerated chocolate cores would not be considered relevant to prepare chocolate masses more generally. Using cooled rollers and a smaller mass of chocolate means that aeration stability is less of an issue than for a moulded tablet.

WO2013-143938 (Unilever) discloses how colorants can be added to ice cream coatings to counteract the impact of micro-aeration. The patent states on page 4 lines 19 to 22 that:

> *'Preferably 80% of the cumulative area weighted size air bubble distribution is below 60 µm. Preferably, 95% of the cumulative area weighted size air bubble distribution is below 125 µm, preferably below 100 µm. Preferably, 99% of the cumulative area weighted size air bubble distribution is below 150 µm.*

The desire to limit impact on colour teaches away from using a high level of aeration. The document remarks in passing (page 2, line 3) that this aerated chocolate is perceived as more milky, however this remark is not supported by any data. A reader of this reference would understood that in context this comment refers to a perception due to a colour change rather than due to other sensory changes such as a flavour or textural changes.

WO 2014-037910 (Barry Callebaut) describes a micro aerated chocolate used to limit exudation and fat bloom, in which the gas is present as a volume fraction of from 0.1% to 4.5% of gas micro-bubbles having a diameter from 1 to 100 µm.
The patent states on page 5 lines 1 to 10 (informal translation) that:

> *The preferred volume fraction of the gas micro-bubbles is greater than or equal to 0.2%, and more particularly greater than or equal to 0.5% or to 0.8%.*
> *The preferred volume fraction of the gas micro-bubbles is less than or equal to 5.0%, and more particularly less than or equal to 4.5% or still to 4%.*
> *Advantageously the volume fraction of the gas micro-bubbles is less than or equal to 3.5%, or to 3.0% more particularly less than or equal to 2.8% or to 2.0%.*
> *The preferred volume fraction of the gas micro-bubbles is selected in the range from 0.2% to 4.5%, advantageously in the range from 0.3% to 2.5%. Alternatively the volume fraction of the gas micro-bubbles is selected in the range between 0.5% to 2%.*

The patent states on page 4 lines 22 to 25 (informal translation) that:

> *'Advantageously the gas micro-bubbles present have a diameter less than or equal to 100 µm. The diameter of the micro-bubbles may have a diameter from 1 µm to 100 µm, preferably a diameter from 1 µm to 30 µm and in a more preferred embodiment a diameter from 1 µm to 10 µm.'*

The patent states on page 5 lines 26 to 28 (informal translation) referring to foodstuffs of the invention that:

> *… characterised in that dispersed in the composition* [is] *a volume fraction from 0.1 to 5.0% of gas micro-bubbles of diameter ranging from 1 µm to 100 µm.*

Thus the whole teaching of this document is teaches away from using higher amounts of aeration than 5% of gas by volume much lower than the amounts of gas used herein.

EP2016836 (Mondelez) describes a method of producing a confectionery product includes the steps of: a) depositing into a mould an aerated confectionery mass (such as chocolate) such that the equipment keeps the mass under super atmospheric pressure and allows it to flow into the mold, b) depositing at least one particulate material in and/or on the confectionery mass; and c) repeating at least step a) at least once. The patent states that this method avoids applying shearing forces to the mass typical of extrusions method and thus allows the gas bubbles to be maintained in the final product.

WO2006-67123 (= EP1835814, EP1673978 & WO2006-79886) (Mondelez) describes apparatus and method for producing aerated chocolate to avoid the need to reuse aerated chocolate mass in an online process, as the returned portion of the aerated mass has to be de-tempered, de-aerated and re-tempered. The method is a one pass process that matches the aeration rate to the production of the chocolate so no aerated chocolate is wasted and reused. This is achieved using a rotor-stator to aerate the chocolate and controlling and adjusting the rotor speed to the minimum needed to create (non-visible) bubble sizes of just below 50 microns based on the feed rate of the mass through the rotor- stator. The bubbles are stated to have approximately the same size and the amount of gas introduced is said to be constant and independent of feed rate as the rotor speed can be varied to keep the aeration level constant. The small size of bubbles is said to be achieved using a pressurised manifold with multiple nozzles. No further details are given of the size and distribution of the bubbles in the chocolate produced. The invention is more concerned with avoiding issues relating to over production of aerated mass in an online process there is no teaching that this process can be used to form bubbles with the narrow criteria as defined herein or that a particular level of micro-aeration in the final chocolate would be more desirable than any other level.

EP2804487 (= WO2013-108019) (Mondelez) discloses a confectionery composition comprising an edible shell having a filling therein. The filling comprises a fat system and has a solid fat content (SFC) of 35 to 65% at 0°C and 1 to 8% at 30°C. In particular embodiments the fat system is prepared from palm oil mid fraction. The filling is soft at low temperature so that it is palatable. However, it does not melt at ambient temperatures and therefore does not require refrigeration / freezing for storage or transport.

WO2015-101965 (Mondelez) describes a process for the preparation of a confectionery composition and compositions producible by the process. The process comprises providing a first sheet (10) of edible film having a plurality of first recesses (12) therein and a second sheet (22) of edible film, optionally having a plurality of second recesses (24) therein. A liquid filling (18) is supplied to the first recesses (12) and then sealed between the first and second sheets (10, 22) to form capsules (26). Molten chocolate (14) may be applied to the first recesses and/or the second recesses before the liquid filling. The capsules may be placed in a chocolate shell.

WO2015-072942 (Eti Gidan Sanayi) describes an industrial food product with high water activity and filler and free of preservative, colouring agent and emulsifier. The invention is a production method for an industrial convenience food product with ready-to-eat, high water activity and filler, and free of preservative, colouring agent and emulsifier, comprising the process steps of a) preparation and cooking of the bakery products, b) in order to prepare the filler (2), obtaining by product by executing agitation-condensation-pasteurization-homogenization processes within a single unit, reducing the temperature of the by-product and fixing the same at a certain range (50-55°C), processing the by-product with fixed temperature in individual passages (K1,K2,K3,K4), and cooling down the same to a temperature (down to +8°C) far below the freezing point (15°C) without allowing crystallization (constant agitation), and execution of crystallization- aeration processes by retaining air particles within the viscous matrix structure formed by minimizing the temperature variation at this temperature, c) combining the cooked bakery product (1) with the filler (2), d) packing with packages filled with preservative gases.

JP03-883479 (Meji) describes a method for making pneumatic combined oily confectionery comprising a shell of pneumatic oily confectionery and using a moulding method. The method comprises pouring pneumatic combined oily confectionery dough into a mould where a thin layer of oily confectionery is formed, pressing the mould using a pressing pattern to make a doubled shell, and charging edible material as a centre stuffing inside the shell. Alternately, the method comprises the following process: directly pouring pneumatic combined oily confectionery dough into a heated mould to make its interfacial part melt, forming a thin layer on the interfacial part with the inner surface of the mould followed by pressing the dough using a cooled pressing pattern to make a shell, and charging edible material as a centre stuffing inside the shell.

Few chocolate products have been intentionally micro-aerated, the vast majority of aeration is macro-aeration where some or all of the bubbles within the chocolate are visible to the naked eye either because the all the bubbles are made to be macro-sized and/or because the bubbles are produced methods that are imprecise and produce a population of bubbles

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with a wide variation of sizes so that many of bubbles will be unavoidably visible without magnification. There are few aerated chocolate products where the aeration is truly hidden from the end consumer because the bubble sizes are reliably and consistent below the visibility threshold (nominally 100 microns or less).

The applicant has analysed various chocolate products a few of which were found to contain a small amount of entrapped gas bubbles of micro-size. The low levels of such bubbles and their inhomogeneity, indicates such micro-aeration is likely to have been inadvertent and due to naturally incorporated of gas during manufacture.

Dove® - The highest porosity product of this type, which is not believed to have been purposefully micro-aerated, was the chocolate available commercially in the USA from Mondelez under the registered trade mark Dove® which had a 1.85% porosity of micro-bubbles.

Jacob's Club®. The chocolate coated biscuit available commercially in the UK under the registered trade mark Jacob's Club® contained both aerated cream and chocolate and was believed to have been aerated intentionally. Interestingly a significant difference between the level of aeration on the top and sides parts of the product was observed, where the porosity of the chocolate forming the top coating was 8.5 % (average bubble size 281 microns ± 311) whereas at the sides the chocolate porosity was 3.7% (average bubble size 202 microns ± 184). It is worth noting that the average bubble size obtained for the Jacob's Club product is significantly larger than that which would typically be considered micro-aerated (100 microns or less) and the bubbles would be visible to the consumer by naked eye.

Mars ® Easter Eggs – the chocolate used in shell of two different 2014 Easter Eggs produced by Mars (those eggs available commercially in UK under the registered trade mark M&M® and Mars®) were tested for the presence of micro-aeration using X-ray tomography. Alongside these tests, a conventional milk chocolate also available commercially from Mars under the registered trade mark Dove® silky smooth milk chocolate was also tested for micro-aeration. The results were as follows:

Product	Porosity	Mean bubble size (microns)	Standard deviation (SD) (microns)	Median bubble size (microns)
Mars® Egg	6.9 %	73 μm	64 μm	48 μm
M&M® Egg	9%	132 μm	133 μm	84 μm
Dove® milk choc.	1.8%	76 μm	49 μm	60 μm

The Dove® milk chocolate had a porosity of 1.8% and it is believed that this low porosity is much more likely to result from natural micro-aeration as a by-product of a conventional process rather than gas being incorporated intentionally. The Mars® and M&M® eggs were more likely to be aerated deliberately possibly, as these eggs are quite large, as a means to reducing the amount of chocolate for cost saving whilst maintaining product size. They also appear to have been produced using a frozen cone/cold stamping method (perhaps similar to that described in Kraft060 above), where aeration stability is less of a concern due to the rapid cooling associated with this process.

The few aerated products that have been launched and/or described in the prior art, have a wide size distribution of bubbles, larger bubbles and/or result in a product with low porosity (i.e. the gas was added in small amounts).

Thus it can be seen that there has been a technical prejudice against micro-aerating chocolate with uniform bubbles at other than low gas levels (i.e. at 9% porosity or less). There has been a belief that micro-aerating at high gas levels is difficult and expensive to do, and is not advantageous, indeed would adversely impact the organoleptic and aesthetic properties of the chocolate.

The applicant has surprisingly found that a means to aerate choco-material to form a micro-aerated choc-material having a population of small bubbles having a narrow distribution of sizes and uniformly distributed within the material. These choco-materials can readily moulded into micro-aerated choco products such as chocolate tablets, bars and other moulded chocolate confectionery such as moulded chocolate coated wafers (e.g. prepared using a wet filled mould).

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

The object of a preferred embodiment of the present invention is to solve some or all of the problems or disadvantages (such as identified herein) with the prior art, including optionally overcoming the technical prejudice described above preventing the wide adoption of micro-aeration in choco-confectionery.

By micro-aerating a number of different chocolate recipes under different aeration conditions, the applicant has found those optimal composition and/or process parameters of the invention which are selected to achieve corresponding and unexpectedly advantageous properties in the micro-aerated chocolate (as described herein). These parameters define aspects of the present invention.

Without wishing to be bound by any theory, the applicant has observed that micro-aeration increases the viscosity of the aerated chocolate mass post deposit. It is believed that the small bubbles act analogously to small particles an increase the internal surface area for interactions to occur within the fluid chocolate mass. The applicant has selected the parameters used to define the present invention as those such that the degree of aeration is enough to increase the viscosity of the aerated chocolate mass sufficiently to stabilise the gas bubbles and reduce or eliminate coalescence. Thus the micro-sized bubbles that are formed have a more uniform size (narrow size distribution) and are dispersed more homogeneously throughout the chocolate that in previous micro-aerated chocolates. This produces micro-aerated chocolate of high quality (e.g. as determined by the resultant advantageous properties described herein).

The applicant has found a means to calculate a baseline figure of estimated porosity to gas flow (nitrogen) for a chocolate throughput of 1000 kg per hour. This is based on trials carried out on various apparatus at industrial scales.

In a first aspect, the present invention provides a process for producing a micro-aerated choco-material the process comprising the steps of:
(I) mixing a choco-material under a high shear of at least 200 s^{-1} ,the choco-material having a plastic viscosity before aeration as measured according to ICA method 46 (2000) of from 0.1 to 20 Pa.s, and
(II) passing the choco-material from step (I) through an injection zone located between two regions held at different pressures,

(III) injecting inert gas at a gas pressure of from 2 to 30 bar into the choco-material as it passes through an injection zone using a gas depositing means at a nominal gas flow rate (F_v) which is within the range for F_v values calculated from equation (2)

$$P = -A\,{F_v}^2 + B\,F_v + C \qquad (2)$$

where

P represents the porosity target of the micro-aerated choco-material in % measured under standard conditions, P being from 10 to 19%; and

F_v represents the nominal volumetric flow rate of the inert gas in normal litres per minute (NL / min.);

A, B and C are numerical constants (having the respective units to balance equation (2)); the numerical parts of each of these constants being:

A from 0.06 to 0.07;

B from 2.00 to 2.05, and

C from 3.70 to 3.80; with the proviso that:

(A) the nominal flow rate F_v calculated from equation (2) is based on a nominal throughput of the choco-material of 1000 kg / hour in the injection zone, the actual flow rate of inert gas injected in step (III) being recalculated where necessary from the nominal flow rate F_v from equation (2) to match proportionally any differences from 1000 kg / hour in the actual throughput of the choco-material that is passing through the injection zone.

In a second aspect, the present invention provides an aerated choco-material and/or confectionery product obtained by a process according to the first aspect.

Conveniently the injection zone is defined by a conduit with a choco-material entrance and exit are held at different pressures with the gas depositing means being located within the conduit.

Preferably the regions of different pressure around the injection zone are formed by two pumps located outside the injection zone, more preferably the pumps are run at a constant differential pump speed of 25%.

It will be understood that the precise parameters used to determine the porosity from equation (2) may change slightly depending on factors such as mass rheology, pump differential speeds and line pressure, hence the parameters and constants are given as ranges within which the process may be satisfactorily operated. Nevertheless the equation (2) allows a skilled person to achieve a desired target porosity in the final product by selecting given gas flow in step (II) within a fair approximation. Equation (2) also assumes that during gas dispersion in step (II) the choco-material passes by the gas depositing means in the injection zone at a nominal throughput of 1000 kg / hour. Thus where the actual choco-material throughput differs from 1000 kg / hour the actual gas flow required should also be adjusted proportionally up or down from the value for the nominal flow rate (parameter F_v) calculated from equation (2) so the volume of inert gas injected into each kilogram of the choc-material per second remains constant.

Normal litres per minute is the amount of inert gas flow calculated as if the gas was under 'normal' conditions of zero degrees Celsius and one atmosphere (1.01325 bar). A skilled person would well understand how to convert an actual flow rate measured during operation of the process into NL / min using the actual pressure and temperature experienced during the process of the invention and the ideal gas law (PV=nRT). A flow rate sensor may even have pressure and temperature sensors built in to make the conversion automatic and available in real time.

It will also be appreciated that there exists a range of inert gas flow rates for use in step (II) that satisfy equation (2) within which the process can be operated to achieve the desired end results. Thus suitable values of specific gas flow rates F_v that will achieve a desired porosity P in the final product can calculated by finding any solutions for quadratic equation (2), for example by selecting suitable specific values of constants A, B and C within the ranges stated herein (and adjusting for chocolate throughput if required).

Preferably in the mixing step (I) the high shear mixing is performed at a shear rate of at least 300 s^{-1}, more preferably at least 400 s^{-1}.

Usefully in the mixing step (I) the high shear mixing is performed at a shear rate of no more than 1000 s^{-1}, more usefully no more than 800 s^{-1}, most usefully no more than 600 s^{-1}.

Conveniently in the mixing step (I) the high shear mixing is performed at a shear rate of from 200 to 1000 s^{-1}, more conveniently from 300 to 800 s^{-1}, even more conveniently from 400 to 600 s^{-1}, most conveniently from 400 to 500 s^{-1}, for example about 415 s^{-1}.

Optionally the high shear mixing in step (I) may be achieved using a beater mixer to mix the choco-material, with a beater speed of from 200 to 600 revolutions per minute (rpm), more optionally from 300 to 500 rpm, for example 400 rpm.

Advantageously in the gas dispersing step (II), the porosity target ‘y’ may be any porosity value given herein as desired for the choco-materials of the present invention.

The numerical values for constants A, B and/or C in equation (1) (independent of units) may independently be:
usefully A from 0.061 to 0.069; B from 2.01 to 2.04, and C from 3.71 to 3.79;
more usefully A from 0.062 to 0.067; B from 2.01 to 2.03, and C from 3.72 to 3.76;
most usefully A from 0.062 to 0.064; B from 2.01 to 2.02, and C from 3.73 to 3.74;
for example A is 0.0636; B is 2.0197 and C is 3.7353.

In another embodiment of the present invention the gas depositing means is other than a micro-diffuser, more preferably is from one or more nozzles. Usefully the nozzle(s) having a exit diameter of from 2 to 3.5 mm and/or an orifice length of from 6 to 12 mm.

Gas flow rate may be measured as volumetric flow rate denoted by the symbol ‘F_v’ and/or as a mass flow rate denoted by the symbol ‘F_m’. For a fluid (e.g. gas) having density ‘ρ’ (rho), these flow rates may be related by

$$F_v = \frac{F_m}{\rho}$$

where
F_v denotes the volumetric flow rate of inert gas in normal litres of gas per minute (NL / min);
F_m denotes the mass flow rate of the inert gas in kilograms of gas per minute (kg / min); and
ρ (rho) denotes the density of the inert gas in kilograms per normal litre (kg / NL), i.e. measured under normal conditions (0°C and 1 atm.).

Gas mass flow rate F_m can be calculated from gas volumetric flow rate F_v and/or directly measured, independent of pressure and temperature effects, by any suitable means such as thermal mass flow meters, Coriolis mass flow meters and/or mass flow controllers. The desired value of F_m to achieve a desired porosity P can thus optionally be calculated from equations (2), (3) and/or (4).

In yet another embodiment of the present invention the inert gas is dispersed into the choco-material at a gas mass flow rate ('m') which of preferably from 2.4 to 6 kilograms per minute, more preferably from 3.0 to 4.8 kg/min, most preferably from 3.6 to 4.2 kg/min.

In a yet other embodiment of the present invention the inert gas is may be dispersed into the choco-material at a gas pressure of from 2 to 30 bar, usefully from 4 to 15 bar, more usefully from 6 to 12 bar, most usefully from 8 to 11 bar, for example from 9 to 10 bar.

The applicant has surprisingly discovered that gas flow (whether measured by F_v or F_m is a significant factor in determining important properties of micro-aerated choco-material. Adjusting gas flow (when held a constant temperature no higher than the exit temperature from the chocolate temperer) can control the amount of gas dispersed in a micro-aerated choco-material; the stability of the bubbles formed in the micro-aerated choco-material; and/or the degree to which the choco-material can be easily and cleanly removed from a mould (demoulding). The gas flow temperature can be kept constant by control of beater speed (so it is not too fast to heat the choco-material significantly) and/or by use of a cooling jacket. The equation (2) herein can thus be used to calculate the gas flow rate (F_v or F_m) that used by the gas depositor in step (II) of the process of the invention will reliable and consistently produce micro-aerated choco-material with a given target porosity P and/or also other bubble parameters as described herein.

The applicant has also found that in a preferred embodiment of the present invention where the composition is mixed and/or beaten then it is preferably performed under high shear. As used herein the term 'high shear' denotes a shear rate of at least 200 s^{-1}. In one embodiment of the method of the present invention high shear rates of from 200 to 1000 s^{-1} are more preferred, high shear of from 300 to 500 s^{-1} are even more preferred. In another embodiment of the invention the applicant has found that mixing speed has a large impact on mean bubble size and standard deviation. When mixed with a rotator beater at a speed of 100 rpm the mean bubble size is much larger than the median and the standard deviation is high (this means there are a lot of small bubbles and a few very large bubbles in these samples). Beater speeds of from 300 to 500 rpm have been used with a Novac® mixer on an industrial scale to produce more normally distributed bubble sizes, if the beater speed is increased too far, heat generation is likely to become a problem and may de-tempering the chocolate.

A further aspect of the present invention is the method for control of the aerating process of the present invention such that the gas flow rate remains substantially within a range (as calculated from equation (2)) to achieve a desired target porosity in the final micro-aerated chocolate. Such control may be manual or automatic, for example using sensors to automatically adjust gas flow rate of the gas depositor in responses to changes in the process (for example changes in throughput of choco-material) and may be operated by a computer controlled apparatus and/or using a feedback loop.

Without wishing to be bound by any mechanism it is believed that the main factors that influence deposit time are system pressure (back pressure), nozzle diameter and

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temperature after mixing (which impacts viscosity). There is also some evidence that as well as (or instead of) high shear mixing, pressure can be used to reduce marbling in the product (marbling is a due to non-uniform distribution of the bubbles within the chocolate). At high pressure (e.g. ≥ 9 bar), no marbling was evident which is another advantage of using high system pressure for the inert gas up to the point of deposit.

Preferably the gas bubbles are produced in the compositions of the invention using an aerating machine selected from one or more of the following machines and/or components thereof:
(i) one or more rotor stator mixers (for example those having mixing heads with intermeshing pins, available commercially under the trade mark Mondomix® from Haas (ii) a gas injector where preferably the composition is pumped by at least two pumps to pass an injection site being located between said pumps, and the inert gas is dispersed into the composition by injection at the injection site at high gas pressure, more usefully the gas pressure being less than or equal to 9 bar. System pressure is 9 bar post gas injection. The advantage of injecting between 2 pumps is that the pressure at this part of the process is lower and shielded from the rest of the system. Suitable gas injectors may comprise the Novac injector as defined herein and/or described in WO2005/063036); and/or
(iii) a jet depositor for depositing the composition onto a substrate under positive pressure (for example as described in WO2010/102716).

More preferably the aerating machine comprises a Novac injector and/or a jet depositor; even more preferably a Novac injector, most preferably where the gas is injected into the composition in between two pumps, usefully at a pressure of from 2 to 30 bar, more usefully from 4 to 15 bar, even more usefully from 6 to 12 bar, most usefully from 8 to 11 bar, for example 9 bar or 10 bar.

Each of these machines are described more fully below.

A rotor stator mixing head (that available from Haas under the trade mark Mondomix®) is shown in Figure 4 and 5 herein.

A modular mixing head with three different sets of rotor stators and referred to by the trade name Nestwhipper is shown in Figure 6 herein.

Any suitable gas injector, especially those where the gas is injected into the composition at an injection site between two pumps, optionally capable of being operated at pressures from 2 to 30 bar. The most preferred injectors are those denoted herein by_the term ‘Novac®’ which refers to the injectors described in the applicant’s patent application WO2005/063036 the contents of which are hereby incorporated by reference. A Novac® gas injector comprises a two pumps with gas injected between them (as shown schematically in Figure 7). For preparing the micro-aerated choco-material of the present invention gas injectors such as the Novac® offers several advantages:

Firstly the gas injection is effectively isolated from any pressure fluctuations occurring in the rest of the system. This gives a more stable gas flow into the product.

Secondly injectors such as the Novac® can optionally operate at higher pressures compared to conventional rotor stator systems (9 bar is a typical operating pressure for the Novac® compared to 6 bar typical operating pressure for a Mondomix®). When the injector is attached to a jet depositor, this is additionally useful as higher flow rates can be delivered with consequent faster line speeds.

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Thirdly the whole system is fully pressurized up to the point of deposit. This results in significant advantages described herein such as optimising final aeration quality and reducing the opportunity for bubble coalescence.

As used herein the term ‘jet depositor’ refers to an apparatus for depositing a fluid food product (e.g. a liquid, semi-liquid or semi -solid food) under positive pressure (i.e. pressure above ambient pressure). A preferred jet depositor comprises a reciprocating valve spindle to deposit the food and/or is as described in the applicant’s patent application WO2010/102716 the contents of which are hereby incorporated by reference.

Usefully in the process of the invention the composition is pumped by at least two pumps to pass an injection site being located between said pumps, where in step (a) the inert gas is dispersed into the composition by injection at the injection site at high gas pressure, more usefully the gas pressure being greater than or equal to 9 bar.

Preferably in the process of the invention the gas bubbles are formed in the composition (preferably during step (a) using an aerating machine selected from one or more of the following machines and/or components thereof:
(i) one or more rotor stator mixing heads (for example those available under the trade designation Mondomix®),
(ii) a gas injector where preferably the composition is pumped by at least two pumps to pass an injection site being located between said pumps, and the inert gas is dispersed into the composition by injection at the injection site at high gas pressure, more usefully the gas pressure being greater than or equal to 9 bar (for example the Novac® injector as defined herein and/or described in WO2005/063036); and/or
(iii) a jet depositor for depositing the composition onto a substrate under positive pressure (for example as described in WO2010/102716).

In one preferred embodiment of the present invention it was found that the two process parameters that impacted porosity and aeration quality to be most extent were gas flow and temperature. The control of other parameters in the aeration process was found to have little or no effect. Without wishing to be bound by any theory the applicant believes that when producing micro-aerated chocolate the crystallisation of the fat is the main factor which holds the aerated structure. Micro-aerated chocolate is also stable over time.

Preferred values of these parameters are described below.

Conveniently in step (a) the gas is dispersed into a molten choco-material at a mass flow rate of from 0.6 to 12 kg / min; more conveniently from 1.2 to 9 kg / min; most conveniently from 2.4 to 6 kg / min.

Usefully when the choco-material is chocolate and/or compound in step (a) the gas is dispersed into the composition when the composition is at a temperature of from 28 to 33°C, more usefully from 30 to 32°C, most preferably 31°C.

It will be appreciated that to achieve a desired gas flow and temperature, other parameters of the specific equipment used will need to be adjusted (such as mixer speed, system pressure and/or jacket temperature). How to do so for a particular system (to achieve any given gas flow and temperature target) will be within the routine skill of a skilled person in the art. This is of course independent from the non-obvious appreciation of which gas flow and temperatures might be advantageous to select compared to other values. It is surprising that by controlling gas flow rate and temperature (in a process as described herein) certain porosity and bubble size properties in the resultant aerated compositions can be achieved reliably and controlled within narrow limits to produce stable micro-aerated bubbles in the final chocolate product which are also easier to demould. It is then further surprising that the micro-aerated compositions of the invention that have certain porosities (10% to 19%) and small homogenous bubble sizes exhibit unexpectedly useful properties compared to otherwise similar micro-aerated compositions with different porosity or bubble sizes.

In another aspect of the present invention there is provided an aerated choco-material and/or confectionery product obtained and/or obtainable by a process of the invention as described herein. Such an aerated choco-material and/or confectionery product may optionally have dispersed therein bubbles of an inert gas, the dispersed bubbles being characterised by the following parameters

(a) mean bubble size less than or equal to 100 microns,
(b) standard derivation of bubble size less than or equal to 60 microns;
(c) a total bubble surface area (also referred to herein as TSA) of from 0.5 to 1.2 m^2 per 100g of the aerated choc-material;

where parameters (a) and (b) are determined from X-ray tomography and/or confocal laser scanning microscopy (CLSM) and parameter (c); and where the gas bubbles are homogenously distributed within the choco-material, having a homogeneity index of at least 0.8; and

TSA may be determined by any suitable empirical method, well known to those skilled in the art and/or may be determined by calculation. In one preferred embodiment of the invention the TSA is determined from equation (1):

$$TSA = \frac{3.P.m_{ac}}{d_{ac}.r} \qquad (1)$$

where TSA is total bubble surface area, P is porosity of the aerated choco-material, m_{ac} is mass of aerated composition (g), d_{ac} is density of aerated composition (g/cm^3) and r is the radius of a bubble of mean size (cm).

Preferably the aerated choco-material of the invention is a chocolate mass.

Conveniently the plastic viscosity of the pre-aerated choco-material of or used in the invention is measured herein according to ICA method 46 (2000) under standard conditions unless otherwise stated and more preferably is from 0.1 to 10 Pa.s.

The micro-aerated choco-material of the invention described herein (and/or made according to any process of the invention as described herein) has a total bubble surface area (TSA) of from 0.5 to 1.2; preferably from 0.55 to 1.10, more preferably from 0.6 to 1.0; most preferably from 0.65 to 0.90, for example from 0.7 to 0.8 m^2 per 100 g of the aerated choco-material. The term surface area or total surface area (TSA) referred to herein can be calculated from equation (1) herein and/or measured by any suitable apparatus or method known to those skilled in art. In one embodiment of the invention the TSA is a specific surface area (SSA) and may be measured as described in the article 'Determination of Surface Area. Adsorption Measurements by Continuous Flow Method' F. M. Nelsen, F. T. Eggertsen, Anal. Chem., 1958, 30 (8), pp 1387–1390 for example using nitrogen gas and SSA calculated from the BET isotherm.

Usefully the choco-material is chocolate or compound, more usefully chocolate, most usefully dark and/or milk chocolate, for example milk chocolate such as a moulded milk chocolate tablet (optionally with inclusions and/or fillings therein).

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In one embodiment of the invention the homogeneity index that measures how uniformly the bubbles are distributed within the composition may be determined by taking an image (from X-ray tomography and/or CLSM) and measuring the number of bubbles that intersect along at least 3 parallel horizontal lines of equal length (preferably at least 1 cm) located on the image to be equally spaced from each other and the image edges. The ratio of the minimum number of bubbles on one of these lines to the maximum number of bubbles on one of these lines can be defined as a number bubble homogenous distribution index (NBHDI) which may be at least 0.8, preferably greater than or equal to 0.85, more preferably greater than or equal to 0.9, most preferably ≥ 0.95, for example about 1.

In another alternative or cumulative embodiment of the invention the homogeneity index that measures how uniformly the bubbles are distributed may be determined by taking an image (from X-ray tomography and/or CLSM) and measuring along each of at least 3 parallel horizontal lines of equal length (preferably at least 1 cm) located on the image to be equally spaced from each other and the image edges, the length of each line that lies inside the void of a gas bubble. The ratio of the minimum void length on one of these lines to the maximum void length on one of these lines can be defined as a void length bubble homogenous distribution index (VLBHDI) which may be at least 0.8, preferably greater than or equal to 0.85, more preferably greater than or equal to 0.9, most preferably ≥ 0.95, for example about 1.

In another aspect of the micro-aerated choco-material of invention the inert gas bubbles are also characterised by the parameters
X(90,3) of 100 microns; and Q(0) of 20.

Bubble size may be measured from images obtained using suitable instruments and methods known to those skilled in the art. Preferred methods comprise X-ray tomography and/or confocal laser scanning microscopy (CLSM), more preferably X-ray tomography. Both these methods are described more fully later herein.

In various embodiments of the present invention, which values for parameters that are preferred will vary within the claimed values depending on the recipe of the choco-material that is used. However to exhibit the advantages described herein the choco-material will have at least the parameter values given herein.

The term choco-material (and related terms) are defined later in this application, preferred choco-materials of the invention being chocolate and related compositions such as compound also defined later herein.

As used herein the term inert gas denotes a gas that is substantially unreactive with the components of a choco-material and are also food grade approved i.e. suitable to form part of a foodstuff which will be consumed by human beings. Thus inert gases will not contain components which might substantially oxidise the choco-material (or components thereof), for example gases which contain significant amounts of oxygen (such as air) are not inert gases as used herein. Preferably the inert gas is selected from nitrogen, nitrous oxide and/or carbon dioxide; more preferably from nitrogen and/or carbon dioxide; most preferably is nitrogen.

The bubble size as defined by the parameters of the present invention is also referred to herein as micro-aerated.

The amount of gas in the choco-material may optionally also be determined by the porosity of the choco-material when solid. Thus the amount of inert gas dispersed in the micro-aerated choco-material may be sufficient to produce a porosity (as defined herein) in the ranges and/or of the values described herein. The amount of gas used to achieve the defined porosities can be for example using the flow rates and/or temperatures as described herein.

Optionally in one embodiment the micro-aerated choco-material of the invention may have a porosity (as defined herein) of greater than or equal to 10% usefully greater than or equal to 11%, more usefully ≥ 12%, even more usefully ≥ 13%, most usefully ≥ 14%.

Optionally in another embodiment the micro-aerated choco-material of the invention may have a porosity (as defined herein) less than or equal to 19%, conveniently ≤ 18%, more conveniently ≤ 17%, even more conveniently ≤ 16%, most conveniently ≤ 15%.

Optionally in a still other embodiment the micro-aerated choco-material of the invention may have a porosity (as defined herein) of from 11% to 19%, advantageously from 12% to 18%, more advantageously from 13% to 17%, even more advantageously from 14% to 16%, most advantageously from 14.5% to 15.5%.

A further aspect of the invention provides a micro-aerated choco-material, fat based composition and/or confectionery product obtained and/or obtainable from a process of the present invention.

A yet other aspect of the invention broadly provides a foodstuff and/or confectionery product comprising a micro-aerated choco-material, composition of the present invention and/or component(s) thereof as described herein.

Many other variations embodiments of the invention will be apparent to those skilled in the art and such variations are contemplated within the broad scope of the present invention. Thus it will be appreciated that certain features of the invention, which are for clarity described in the context of separate embodiments may also be provided in combination in a single embodiment. Conversely various features of the invention, which are for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination.

Further aspects of the invention and preferred features thereof are given in the claims herein, which form an integral part of the disclosure of the present invention whether or not such claims correspond directly to parts of the description herein.

Certain terms as used herein are defined and explained below unless from the context their meaning clearly indicates otherwise.

Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of “including, but not limited to”.

Within the context of the present invention, terms such as “fat based” and/or ‘’fat based edible product’ denotes a composition, preferably a choco-confectionery that comprises a matrix of edible hydrophobic material (e.g. fat) as the continuous phase and a dispersed phase comprising solid particles dispersed within the edible hydrophobic continuous phase.

Within the context of the present invention the term ''fat'' as used herein denotes hydrophobic material which is also edible. Thus fats are edible material (preferably of food grade) that are substantially immiscible with water and which may comprise one or more solid fat(s), liquid oil(s) and/or any suitable mixture(s) thereof. The term ''solid fat'' denotes edible fats that are solid under standard conditions and the term ''oil'' or ''liquid oil'' (unless the context indicates otherwise) both denote edible oils that are liquid under standard conditions.

Preferred fats are selected from one or more of the following: coconut oil, palm kernel oil, palm oil, cocoa butter (CB), cocoa butter equivalents (CBE), cocoa butter substitutes (CBS), cocoa butter replacers (CBR), butter oil, lard, tallow, oil / fat fractions such as lauric or stearic fractions, hydrogenated oils, and blends thereof as well as fats which are typically liquid at room temperature such as any vegetable or animal oil. However fats that are most preferred for use herein for use in preparing the micro-aerated choco-materials of the present invention are CB, CBE, CBS, CBR and/or any mixtures and/or combinations thereof.

The liquid oil may comprise mineral oils and/or organic oils (oils produced by plants or animals), in particular food grade oils. Examples of oils include: sunflower oil, rapeseed oil, olive oil, soybean oil, fish oil, linseed oil, safflower oil, corn oil, algae oil, cottonseed oil, grape seed oil, nut oils such as hazelnut oil, walnut oil, rice bran oil, sesame oil, peanut oil, palm oil, palm kernel oil, coconut oil, and emerging seed oil crops such as 25 high oleic sunflower oil, high oleic rapeseed, high oleic palm, high oleic soybean oils & high stearin sunflower or combinations thereof.

The fat content in the product of the present invention may be provided by fats of any origin. The fat content is intended to indicate the total fat content in the composition, comprising either the content coming from solid fats and/or the content of liquid oils and thus the oil content will also contribute to the total amount of fat content as described herein for a fat based confectionery composition.

The term 'fat based composition and/or mass' respectively identifies a fat-based composition and/or mass (including its recipe and ingredients) which is used for the preparation of the products of the invention.

The term 'fat based confectionery composition and/or mass' identifies a confectionery composition and/or mass (including its recipe and ingredients) which is used for the preparation of fat based confectionery products such as micro-aerated choco-material of the invention.

The present invention relates specifically to a confectionery product, composition and/or mass that that comprise choco-material (preferably chocolate and/or compound, more preferably chocolate) as defined herein as well as optionally other confectionery products and/or components thereof.

The term 'chocolate' as used herein denotes any product (and/or component thereof if it would be a product) that meets a legal definition of chocolate in any jurisdiction and also include product (and/or component thereof) in which all or part of the cocoa butter (CB) is replaced by cocoa butter equivalents (CBE) and/or cocoa butter replacers (CBR).

The term 'chocolate compound' or 'compound' as used herein (unless the context clearly indicates otherwise) denote chocolate-like analogues characterized by presence of cocoa solids (which include cocoa liquor/mass, cocoa butter and cocoa powder) in any amount,

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notwithstanding that in some jurisdictions compound may be legally defined by the presence of a minimum amount of cocoa solids.

The term ‘choco-material’ as used herein denote chocolate, compound and other related materials that comprise cocoa butter (CB), cocoa butter equivalents (CBE), cocoa butter replacers (CBR) and/or cocoa butter substitutes (CBS). Thus choco-material includes products that are based on chocolate and/or chocolate analogues, and thus for example may be based on dark, milk or white chocolate and/or compound.

Unless the context clearly indicates otherwise it will also be appreciated that in the present invention any one choco-material may be used to replace any other choco-material and neither the term chocolate nor compound should be considered as limiting the scope of the invention to a specific type of choco-material. Preferred choco-material comprises chocolate and/or compound, more preferred choco-material comprises chocolate, most preferred choco-material comprises chocolate as legally defined in a major jurisdiction (such as Brazil, EU and/or US).

The term ‘choco-coating’ as used herein (also refers to a ‘choco-shell’) denotes coatings made from any choco-material. The terms ‘chocolate coating’ and ‘compound coating’ may be defined similarly by analogy. Similarly the terms ‘choco-composition, (or mass)’, ‘chocolate composition (or mass)’ and ‘compound composition (or mass)’ denote compositions (or masses) that respectively comprise choco-material, chocolate and compound as component(s) thereof in whole or part. Depending on their component parts the definitions of such compositions and/or masses may of course overlap.

The term ‘choco-confectionery’ as used herein denotes any foodstuff which comprises choco-material and optionally also other ingredients and thus may refer to foodstuffs such confections, wafers, cakes and/or biscuits whether the choco-material comprises a choco-coating and/or the bulk of the product. Choco-confectionery may comprise choco-material in any suitable form for example as inclusions, layers, nuggets, pieces and/or drops. The confectionery product may further contain any other suitable inclusions such as crispy inclusions for example cereals (e.g. expanded and/or toasted rice) and/or dried fruit pieces.

The choco-material of the invention may be used to mould a tablet and/or bar, to coat confectionery items and/or to prepare more complex confectionery products. Optionally, prior to its use in the preparation of a choco-confectionery product, inclusions according to the desired recipe may be added to the choco-material. As it will be apparent to a person skilled in the art, in some instances the product of the invention will have the same recipe and ingredients as the corresponding composition and/or mass while in other instances, particularly where inclusions are added or for more complex products, the final recipe of the product may differ from that of the composition and/or mass used to prepare it.

In one strongly preferred embodiment of the invention the choco-confectionery product comprises a substantially solid moulded choco-tablet, choco-bar and/or baked product surrounded by substantial amounts of choco-material. These products are prepared for example by substantially filling a mould with choc-material and optionally adding inclusions and/or baked product therein to displace choc-material from the mould (so-called wet shelling processes), if necessary further topping up the mould with choco-material. For such strongly preferred products of the invention the choco-material forms a substantial or whole part of the product and/or a thick outside layer surrounding the interior baked product (such as a wafer and/or biscuit laminate). Such solid products where a mould is substantially filled with chocolate are to be contrasted with products that comprise moulded thin chocolate shells which present different challenges. To prepare a thin coated chocolate shell a mould is coated with a thin layer of chocolate, the mould being inverted to remove excess chocolate and/or stamped with a cold plunger to define the shell shape and largely empty the mould. The mould is thus coated with a thin layer of chocolate to which further ingredients and fillings may be added to form the interior body of the product. The challenges to maintain a uniform and consistent level of micro-aeration throughout the body of a thick or solid chocolate product such as a tablet or bar are different from micro-aerating a thin chocolate shell. Thin shells are also made by enrobing or frozen cone methods (some of which have been described in the prior art acknowledged previously) which would be unsuitable for micro-aeration.

Unless the context herein clearly indicates otherwise it will also be well understood by a skilled person that the term choco-confectionery as used herein can readily be replaced by and is equivalent to the term chocolate confectionery as used throughout this application and in practice these two terms when used informally herein are interchangeable. However where there is a difference in the meaning of these terms in the context given herein, then chocolate confectionery and/or compound confectionery are preferred embodiments of the choco-confectionery of the present invention, a preferred embodiment being chocolate confectionery.

Preferred choco-confectionery may comprise one or more choco-product(s) and/or choco-ingredients therefor, for example selected from the group consisting of: chocolate product(s). compound product(s), chocolate coating(s) and/or compound coating(s). The products may comprise uncoated products such as choco-bar(s) and/or choco-tablet(s) with or without inclusions and/or products coated with choco-material such as coated biscuits, cakes, wafers and/or other confectionery items. More preferably and/or alternatively any of the aforementioned may comprise one or more cocoa butter replacer(s) (CBR), cocoa-butter equivalent(s) (CBE), cocoa-butter substitute(s) (CBS) and/or any suitable mixture(s) thereof.

In choco-confectionery the cocoa butter (CB) may be replaced by fats from other sources. Such products may generally comprise one or more fat(s) selected from the group consisting of: lauric fat(s) (e.g. cocoa butter substitute (CBS) obtained from the kernel of the fruit of palm trees); non-lauric vegetable fat(s) (e.g. those based on palm or other specialty fats); cocoa butter replacer(s) (CBR); cocoa butter equivalent(s) (CBE) and/or any suitable mixture(s) thereof. Some CBE, CBR and especially CBS may contain primarily saturated fats and very low levels of unsaturated omega three and omega six fatty acids (with health benefits). Thus in one embodiment in choco-confectionery of the invention such types of fat are less preferred than CB.

It will be appreciated that one aspect of the present invention may provide for a choco-confectionery composition, preferably which has a lower total fat content (at least 5 parts or 5% by weight) than previously obtainable from prior art choco-material.

One embodiment of the invention provides a multi-layer product optionally comprising a plurality of layers of baked foodstuff (preferably selected from one or more wafer and/or biscuit layers, and/or one or more fillings layers there between with at least one coating layer located around these layers foodstuff, the coating comprising a choco-material of or prepared according to the invention.

A further embodiment of the invention provides a choco-confectionery product, further coated with chocolate (or equivalents thereof, such as compound) for example a praline, chocolate shell product and/or chocolate coated wafer or biscuit any of which may or may not be layered. The chocolate coating can be applied or created by any suitable means, such as enrobing or moulding. The coating may comprise a choco-material of or prepared according to the invention.

Another embodiment of the invention provides a choco-confectionery product of and/or used in the present invention, that comprises a filling surrounded by an outer layer for example a praline, chocolate shell product.

In another preferred embodiment of the invention the foodstuff comprises a multi-layer coated choco- product comprising a plurality of layers of wafer, choco-material, biscuit and/or baked foodstuff, with filling sandwiched between them, with at least one layer or coating being a choco-material (e.g. chocolate) of the invention. Most preferably the multi-layer product comprises a choco-confectionery product (e.g. as described herein) selected from sandwich biscuit(s), cookie(s), wafer(s), muffin(s), extruded snack(s) and/or praline(s). An example of such a product is a multilayer laminate of baked wafer and/or biscuit layers sandwiched with filling(s) and coated with chocolate.

Baked foodstuffs used in the invention may be sweet or savoury. Preferred baked foodstuffs may comprise baked grain foodstuffs which term includes foodstuffs that comprise cereals and/or pulses. Baked cereal foodstuffs are more preferred, most preferably baked wheat foodstuffs such as wafer(s) and/or biscuit(s). Wafers may be flat or shaped (for example into a cone or basket for ice-cream) and biscuits may have many different shapes, though preferred wafer(s) and/or biscuit(s) are flat so they can be usefully be laminated together with a confectionery filling of the invention (and optionally a fruit based filling). More preferred wafers are non-savoury wafers, for example having a sweet or plain flavour.

A non-limiting list of those possible baked foodstuffs that may comprise choco-compositions that comprise choco-material of and/or used in the present invention are selected from: high fat biscuits, cakes, breads, pastries and/or pies; such as from the group consisting of: ANZAC biscuit, biscotti, flapjack, kurabiye, lebkuchen, leckerli, macroon, bourbon biscuit, butter cookie, digestive biscuit, custard cream, extruded snacks, florentine, garibaldi gingerbread, koulourakia, kourabiedes, Linzer torte, muffin, oreo, Nice biscuit, peanut butter cookie, polvorón, pizzelle, pretzel, croissant, shortbread, cookie, fruit pie (e.g. apple pie, cherry pie), lemon drizzle cake, banana bread, carrot cake, pecan pie, apple strudel, baklava, berliner, bichon au citron and/or similar products.

Preferably the micro-aerated choco-material of or prepared according to the invention may be suitable for use as (in whole or in part as a component) of one or more coatings and/or fillings.

The coating and/or filling may comprise a plurality of phases for example one or more solid and/or fluid phases such as fat and/or water liquid phases and/or gaseous phases such as emulsions, dispersions, creams and/or foams.

Therefore broadly a further aspect of the invention comprises a foodstuff comprising choco-material and/or choco-composition as described herein.

A yet further aspect of the invention broadly comprises use of a choco-material of or prepared according to the invention as a choco-confectionery product and/or as a filling and/or coating for a foodstuff of the invention as described herein.

In one embodiment of the present invention, the process may be performed in any type of equipment which is able to perform a mixing action at modulated speed. Non limiting examples of this type of equipment are: vertical and horizontal mixers, turbo mixers, planetary and double planetary mixers, continuous mixers, inline mixers, extruders, screw mixers, high shear and ultra-high shear mixers, cone and double cone mixers, static and dynamic mixers, rotary and static drum mixers, rotopin mixer, ribbon blenders, paddle blenders, tumble blenders, solids/liquid injection manifold, dual-shaft and triple shaft mixers, high viscosity mixers, V blenders, vacuum mixers, jet mixers, dispersion mixers, mobile mixers and banbury mixers.

Unless defined otherwise, all technical and scientific terms used herein have and should be given the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.

Unless the context clearly indicates otherwise, as used herein plural forms of the terms herein are to be construed as including the singular form and vice versa.

The terms ‘effective’, ‘acceptable’ ‘active’ and/or ‘suitable’ (for example with reference to one or more of any process, use, method, application, preparation, product, material, formulation, composition, recipe, component, ingredient, compound, monomer, oligomer, polymer precursor, and/or polymer described herein of and/or used in the present invention as appropriate) will be understood to refer to those features of the invention which if used in the correct manner provide the required properties to that which they are added and/or incorporated to be of utility as described herein. Such utility may be direct for example where a moiety has the required properties for the aforementioned uses and/or indirect for example where a moiety has use as a synthetic intermediate and/or diagnostic and/or other tool in preparing other moeity of direct utility. As used herein these terms also denote that sub-entity of a whole (such as a component and/or ingredient) is compatible with producing effective, acceptable, active and/or suitable end products and/or compositions.

Preferred utility of the present invention comprises use as a food stuff, preferably as a confectionery product and/or intermediate in the manufacture thereof.

Unless the context clearly indicates otherwise, as used herein plural forms of the terms herein are to be construed as including the singular form and vice versa.

The term “comprising” as used herein will be understood to mean that the list following is non exhaustive and may or may not include any other additional suitable items, for example one or more further feature(s), component(s), ingredient(s) and/or substituent(s) as appropriate.

In the discussion of the invention herein, unless stated to the contrary, the disclosure of alternative values for the upper and lower limit of the permitted range of a parameter coupled with an indicated that one of said values is more preferred than the other, is to be construed as an implied statement that each intermediate value of said parameter, lying between the more preferred and less preferred of said alternatives is itself preferred to said less preferred value and also to each less preferred value and said intermediate value.

For all upper and/or lower boundaries of any parameters given herein, the boundary value is included in the value for each parameter. It will also be understood that all combinations of preferred and/or intermediate minimum and maximum boundary values of the parameters described herein in various embodiments of the invention may also be used to define alternative ranges for each parameter for various other embodiments and/or preferences of the invention whether or not the combination of such values has been specifically disclosed herein.

Unless noted otherwise, all percentages herein refer to weight percent, where applicable.

It will be understood that the total sum of any quantities expressed herein as percentages cannot (allowing for rounding errors) exceed 100%. For example the sum of all components of which the composition of the invention (or part(s) thereof) comprises may, when expressed as a weight (or other) percentage of the composition (or the same part(s) thereof), total 100% allowing for rounding errors. However where a list of components is non exhaustive the sum of the percentage for each of such components may be less than 100% to allow a certain percentage for additional amount(s) of any additional component(s) that may not be explicitly described herein.

The term ''substantially'' as used herein may refer to a quantity or entity to imply a large amount or proportion thereof. Where it is relevant in the context in which it is used ''substantially'' can be understood to mean quantitatively (in relation to whatever quantity or entity to which it refers in the context of the description) there comprises an proportion of at least 80%, preferably at least 85%, more preferably at least 90%, most preferably at least 95%, especially at least 98%, for example about 100% of the relevant whole. By analogy the term ''substantially-free'' may similarly denote that quantity or entity to which it refers comprises no more than 20%, preferably no more than 15%, more preferably no more than 10%, most preferably no more than 5%, especially no more than 2%, for example about 0% of the relevant whole. Preferably where appropriate (for example in amounts of ingredient) such percentages are by weight.

Compositions of and/or used in the present invention may also exhibit improved properties with respect to known compositions that are used in a similar manner. Such improved properties may be preferably as defined herein. Preferred compositions of and/or used in the present invention, may exhibit comparable properties (compared to known compositions and/or components thereof in two or more of those properties.

Any weight percentages in parameters above are calculated with respect to initial weight of the component.

Improved properties as used herein means the value of the component and/or the composition of and/or used in the present invention is > +8% of the value of the known reference component and/or composition described herein, more preferably > +10%, even more preferably > +12%, most preferably > +15%.

Comparable properties as used herein means the value of the component and/or composition of and/or used in the present invention is within +/-6% of the value of the known reference component and/or composition described herein, more preferably +/- 5%, most preferably +/- 4%.

The percentage differences for improved and comparable properties herein refer to fractional differences between the component and/or composition of and/or used in the invention and the known reference component and/or composition described herein where the property is measured in the same units in the same way (i.e. if the value to be compared is also measured as a percentage it does not denote an absolute difference).

TEST METHODS

Unless otherwise indicated or the context clearly indicates otherwise all the tests herein are carried out under standard conditions as also defined herein.

BUBBLE SIZE

The bubble size values given herein are measured by X-ray tomography and/or confocal laser scanning microscopy (CLSM) as described below.

Bubble size may be determined by measuring the volume distribution of the sample by plotting volume (%) versus size (microns) for example from images generated using the techniques described herein. Bubble size is then quoted as the linear dimension which corresponds to the diameter of an approximate spherical bubble having the same volume as the mean volume calculated from the measured volume distribution and is referred to herein as mean bubble size in microns. A normal bubble size distribution (BSD) with single maximum peak (mono modal) is assumed in most cases for the bubbles generated in the present invention. However other BSDs (e.g. multimodal such as bimodal) are not excluded from this invention. The BSD is measured by the standard derivation from the mean bubble size also measured in microns.

As an alternative measure of bubble size, d90 may also be used (also expressed in linear dimensions) which denotes the size of bubble below which 90% (by number) of the bubbles in a given aerated sample lie.

NUMBER WEIGHTED MEAN DIAMETER OF BUBBLE SIZE ($X_{P, 0}$)

The parameter denoted by a symbol in the format $X_{P, 0}$ is measured in units of length (e.g. microns) and denotes that bubble diameter for which P % of the total number of bubbles counted in the sample have a diameter smaller or equal to the length given for this parameter. Thus for example if $X_{50,0}$ = 1 micron, this means 50% of the total number of bubbles in the sample have a diameter of 1 micron or less. Parameter $X_{50,0}$ is commonly used to indicate number weighted diameter but analogously, parameters $X_{90,0}$ and $X_{10,0}$ (the diameters below wich respectively 90 % and 10 % of all bubbles lie) may also be used.

SPAN (Q0)

SPAN (Q0) may be calculated for the number based bubble size distribution by determining the ratio of $(X_{90,0} - X_{10,0}) / X_{50,0}$. This is a measure to evaluate the width of the number weighted bubble size distribution. A lower SPAN (Q0) value indicates a narrower bubble size distribution and with this a more homogenous and more stable foam structure.

VOLUME WEIGHTED MEAN DIAMETER OF BUBBLE SIZE ($X_{50,3}$)

The parameter denoted by the symbol in the format $X_{P, 3}$ is measured in units of length (e.g. microns) and denotes that bubble diameter for which P % of the total volume taken by the bubbles in the sample have a diameter smaller or equal to the length given for this parameter. Thus for example if $X_{50,3}$ = 1 micron, this means 50% of the total volume of bubbles in the sample is provided by those particles having a diameter 1 micron or less. Parameter $X_{50,3}$ is commonly used to indicate volume weighted diameter but analogously, parameters $X_{90,3}$ and $X_{10,3}$ (the diameters at which respectively 90 % and 10 % of the volume occupied by all bubbles lie) may also be used.

SPAN (Q3)

SPAN (Q3) was calculated for the volume weighted bubble size distribution by determining the ratio of $(X_{90,3} - X_{10,3}) / X_{50,3}$. This is a measure to evaluate the width of the volume weighted bubble size distribution. A lower SPAN (Q3) value indicates a narrower bubble size distribution and with this a more homogenous and more stable foam structure.

DETERMINING BUBBLE SIZE USING X-RAY TOMOGRAPHY OR CLSM

<u>X-ray tomography</u>

A rotating sample is bombarded with polychromatic X-rays, and X-ray intensity resulting from interaction with the sample is spatially recorded by a pixelated planar detector which forms a two dimensional image of the projected absorption of the sample. A three dimensional reconstruction of the sample is then performed from the collection of 2D projections using back projection algorithms. This is described in ‘Principle of X-ray tomography’, K.S Lim, M. Barigou, X-ray micro-computed tomography of cellular food products, Food Research International 37 (2004) 1001–1012. X-ray tomography is non-invasive and is a powerful technique for mapping air voids embedded in a solid matrix (such as the bubbles in micro-aerated chocolate). X-ray tomography has a high resolution of up to 1 µm and no sample preparation is required, it provides an easy, quantitative means of evaluating bubble sizes from the images generated. Unless otherwise indicated herein samples evaluated herein by X-ray tomography used the instrument MicroCT 35 available commercially from Scanco medical AG. The samples (e.g. chocolate pieces) to be X-rayed were gently cut in the z-axis using razor blades and small cylinder like samples were trimmed and placed in sample holders.

Confocal laser scanning microscopy (CLSM)

For CLSM a pinhole in an optically conjugate plane in front of the detector is added to a fluorescence microscope in order to eliminate the out-of-focus signal (a large unfocused background part not coming from the specimen). As only light produced by fluorescence very close to the focal plane can be detected, the image's optical resolution, particularly in the sample depth direction, is much better than that of wide-field microscopes. Moreover, the sample is illuminated point by point. However, as much of the light from sample fluorescence is blocked at the pinhole, this increased resolution is at the cost of decreased signal intensity – so long exposures are often required. CLSM provides images of good resolution in a comparative and qualitative method. The principle of CLSM is described in the following article. G.L. Hand, E.R. Weeks, ‘Physics of the colloidal glass, 2012 Rep. Prog. Phys. 75 (especially section 2.2). CLSM equipment is less expensive than an X-ray tomograph and is user friendly. Unfortunately, confocal microscopy implies a long destructive preparation (analyzed sample surface must be completely straight and dyes are used). Confocal microscopy does not provide quantitative information (the scanning process needs to be repeated with different samples which assume that the preparation of the samples is very similar). Dyes are used in order to highlight the presence of bubbles hence a better determination of the bubble characteristics.

Unless otherwise indicated herein samples evaluated herein by CLSM used the confocal microscope available commercially from Leica instrument under the trade designation LAS, Type DM6000. The samples (e.g. chocolate pieces) to undergo CLSM were gently cut in the z-axis using razor blades and small cylinder like samples were trimmed and placed in sample holders. Then samples were then dyed for the confocal microscope using first Nile red then adding Fast green (as shown in the table below). In the morphology images generated by CLSM shown herein, the Nile red signal is displayed in a red look-up-table and the Fast green one in a green look-up-table. The remaining dark areas having a circular shape are therefore assumed to be gas bubbles. The sugar is represented by smaller black areas with irregular borders.

Compound	Dye	Wavelength (nm)	Emission bandwidth (nm)	Color
Fat	Nile red	490	500-600	Red
Protein	Fast green	638	650-750	Green
Sugar	--	--	--	Black
Bubble	--	--	--	Black

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There is no data processing associated with the confocal microscope, so bubble diameter can be measured using the scale which is integrated into the image software.

POROSITY

Porosity values (P) stated as a percentage were derived from computed tomography evaluation. Porosity describes the ratio of void fraction to the total volume of a sample. Hence porosity represents the ratio of the volume of gas V_G within a sample to the total sample volume V_s, hence V_G/V_S. Porosity may also be estimated as otherwise described herein or calculated from Over-Run (OR) measurements (also stated as a percentage) in standardized plastic cups using the following equations.

$$\%OR = \frac{m_{non\ aerated} - m_{aerated}}{m_{aerated}} \times 100$$

$$\%P = \frac{OR}{OR + 100} \times 100$$

COMPUTED TOMOGRAPHY ANALYSIS

Foamed confectionary samples were stored below 5 °C until analysis. The samples may be analyzed using a CT 35 (Scanco Medical, Brüttisellen, Switzerland) operated in a climate chamber set to 15 °C. The bubble detection resolution of the device is 6 micron. Cumulative bubble size distributions Q(x) (characterized by: $X_{50,3}$ $X_{90,3}$ $X_{10,3}$ and $X_{50,0}$ $X_{90,0}$ $X_{10,0}$), V_G and V_S, may be measured by computer X-ray tomography and extracted by image analysis. From the bubble sizes $X_{50,3}$ $X_{90,3}$ $X_{10,3}$ and $X_{50,0}$ $X_{90,0}$ $X_{10,0}$ the size distribution widths SPAN(Q3), SPAN(Q0) can also be derived.

STANDARD CONDITIONS

As used herein, unless the context indicates otherwise, standard conditions (e.g. for defining a solid fat or liquid oil) means, atmospheric pressure, a relative humidity of 50% ±5%, ambient temperature (22ºC ±2º) and an air flow of less than or equal to 0.1m/s. Unless otherwise indicated all the tests herein are carried out under standard conditions as defined herein.

TEXTURE AND VISCOSITY

Texture of foodstuffs is perceived as a composite of many different characteristics comprising various combinations of physical properties (such as mechanical and/or geometrical properties) and/or chemical properties (such as fat and/or moisture content). As used herein in relation to the compositions of the invention for a given fat and moisture content the composition texture can be related to the viscosity of the composition as a fluid when subjected to shear stress. Provided that the measuring technique is carefully controlled and the same shear rates are used apparent viscosity can be used herein as a guide to indicate texture. The term "viscosity" as used herein refers to the apparent viscosity of a fluid as measured by conventional methods known to those skilled in the art but in particular the method described herein is preferred. Some fluids display non-Newtonian rheology and cannot be totally characterized by a single rheological measurement point. Despite this apparent viscosity is a simple measure of viscosity useful for the evaluation of such fluids.

The viscosity of the compositions according to the invention and/or prepared by a method of the invention, as well as comparative examples, (for example choc-materials such as chocolate) can be characterized by two measurements, one at about $5s^{-1}$ for low flow situations to approximate to the yield value and a second one at $20s^{-1}$ for higher flow rates. (See Beckett 4th edition, chapter 10.3). As used herein for the purpose of measuring the viscosity of the fillings of the present invention the yield value of viscosity is used to determine texture measured at a low flow rate of $5s^{-1}$.

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The preferred method for measuring the yield value for viscosity uses an instrument denoted by the trade designation RVA 4500 (available commercially from Rapid Viscosity Analyzer, Newport Scientific, Australia) measured under standard conditions (unless otherwise indicated) and at a rate of $5s^{-1}$. In this test method 10 grams of the sample composition are added to the canister supplied with the RVA instrument and then measurement is performed using the following profile: a constant temperature of 35°C, mixing vigorously at 950 rpm for 10 seconds then at 160 rpm for the duration of the test which is 30 minutes. The test is done in duplicates or triplicates to ensure repeatability. The final viscosity is used for comparison as well as the quality of the RVA viscosity curve.

WEIGHT PERCENT
All percentages are given in percent by weight, if not otherwise indicated.

<u>Figures</u>
The invention is illustrated by the following non-limiting Figures 1 to 19 where:
Figure 1 is a photograph of a cross section of comparative chocolate of the invention (Comp A) which was aerated with nitrogen to achieve a porosity of 5%. As can been many larger bubbles are formed with overall a wider size distribution of bubbles due to coalescence of the initially smaller bubbles when a low amount of gas is initially dispersed into the chocolate mass.
Figure 2 is a photograph showing the difference in stability between chocolate aerated to from left to right Comp B (porosity of 10%), Example 1 (porosity of 12.5%) and Example 2 (porosity 15%).
Figure 3 is a photograph showing the instability of chocolate aerated at a higher level (from left to right Comp C (porosity 20%) and Comp D (porosity 25%)
Figure 4 shows the mixer head of a rotor stator mixer available commercially from Hass under the trade mark Monodmix®
Figure 5 shows the mixer blades from the mixer head of a rotor stator mixer available commercially from Hass under the trade mark Monodmix®
Figure 6 shows the modular mixer head of a rotor stator mixer used by Nestle under the trade mark Nestwhipper®
Figure 7 is a schematic drawing of the gas injector referred to herein as Novac (as described in WO2005-063036) combined with a jet depositor system (as described in WO2010/102716).
Figure 8 shows a prior art micro-aerated chocolate sample - Comp E (micro-aerated to 12% porosity) which has been tested in the aeration test described herein, the sample surface having risen due to instability of the incorporated gas.
Figure 9 shows a micro-aerated chocolate sample of the invention - Example 3 - (micro-aerated to 15% porosity, simply by increasing the gas flow slightly compared to Comp E shown in Figure 8), where there is no dome formed at the sample surface when tested in the aeration test described herein, indicating the aeration becomes stable at a level of 15% porosity.

Figure 10 shows a micro-aerated chocolate tablet micro-aerated to 10% porosity using and formed in an angular mould, i.e. where the vertices form sharp corners. In the tablet shown in Figure 10 bubbles are clearly visible on the surface of the angular mould, and also appear consistently at the same position on each pip. The appearance of the tablet is aesthetically undesirable.
Figure 11 shows a micro-aerated chocolate tablet made from a micro-aerated chocolate mass aerated to 10% porosity using the same chocolate and process conditions as for the tablet shown in Figure 10, but formed in a mould having rounded vertices, i.e. the only difference in the tablets shown in Figures 10 or 11 being the mould design. As can been

seen the visual appearance of this tablet compared to that of Figure 10 is more homogenous and aesthetically is much improved.
For chocolates with relatively low viscosity, the challenge at higher aeration levels can be to actually hold the gas within the solidifying matrix, meaning that coalescence occurs. This leads to clearly visible bubbles both inside and on the bar surface (please see Figure 15 and Figure 16 herein).
Figure 12 to 16 herein show tablets produced using the same chocolate mass, all temper and mini Novac parameters being kept constant, apart from the gas flow which was adjusted to give the desired porosity level. It is particularly interesting to note the fact that at lower aeration levels, not only is the aeration visible but also the de-moulding properties are impacted. The reason behind this impact on de-moulding is not understood but impacts most masses that have been tested.
Figure 12 shows a micro-aerated dark chocolate with 5% porosity (Nestlé, Brazil). Please note the visible bubbles and also marks resulting from poor de-moulding.
Figure 13 shows a micro-aerated dark chocolate with 10% porosity: good de-moulding and invisible bubbles. The mass did rise during the cup test, showing some signs of instability.
Figure 14 shows a micro-aerated dark chocolate with 15% porosity: good homogeneous aeration and de-moulding properties. The ‘cup’ test showed the aeration to be very stable.
Figure 15 shows a micro-aerated dark chocolate with 20% porosity: bubbles have started to coalesce and are clearly visible inside the bar.
Figure 16 shows a micro-aerated dark chocolate with 23% porosity: bubbles have started to coalesce and are clearly visible inside and at the surface of the bar. It was not possible to increase the porosity any further than 23% by just adjusting the gas flow alone.
Figures 17, 18 and 19 are images of a micro-aerated sample of the chocolate mass used (when unaerated) to prepare the confectionery product sold by the applicant in Brazil as chocolate tablets under the trade mark Garoto® (see Example 5 and Table 2 herein), where Figure 17 was generated with X-ray tomography, Figure 18 with confocal microscopy (CLSM) and Figure 19 is a 3D visualization of the micro-aerated Garoto® chocolate.

It should be noted that embodiments and features described in the context of one of the aspects or embodiments of the present invention also apply to the other aspects of the invention. Although embodiments have been disclosed in the description with reference to specific examples, it will be recognized that the invention is not limited to those embodiments. Various modifications may become apparent to those of ordinary skill in the art and may be acquired from practice of the invention and such variations are contemplated within the broad scope of the present invention. It will be understood that the materials used and the chemical details may be slightly different or modified from the descriptions without departing from the methods and compositions disclosed and taught by the present invention.

Further aspects of the invention and preferred features thereof are given in the claims herein.

Examples

The present invention will now be described in detail with reference to the following non limiting examples which are by way of illustration only.

The applicant prepared various samples of micro-aerated chocolate tablets. All samples were aerated (unless indicated otherwise) using the equipment described in the applicant’s patent applications WO2005-063036 and/or WO2010/102716. When the same recipes were compared at different levels of micro-aeration (as measured by the porosity of the final product when solid) the following general observations in Table 1 were made consistently.

Table 1

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Porosity (%)	Aeration Quality
5%	Aeration unstable at this level, due to coalescence of the micro gas bubbles
9%	Still some instability observed in the aerated matrix
15%	Optimal aeration level, good stable foam
20%	Good stable foam but significant viscosity increase, considerable vibration required to ensure that when moulded, the chocolate composition filled all the extremities of the mould
25%	Unstable aeration, coalescence, ‘spitting’ from the nozzle and poor flow in the mould

Comp A

Comparative example A (Comp A) is a chocolate aerated with nitrogen to achieve a porosity of 5%.

As can be seen from Figure 1 (photograph of a cross section) Comp A contains many large bubbles (some of which are very visible to the naked eye) and overall exhibits a wide distribution of bubble sizes. Without wishing to be bound by any theory the applicant believes that this may be due to coalescence of the small bubbles initially formed when a low amount of the nitrogen gas was dispersed into the chocolate mass.

Examples 1 and 2 and Comp B

Chocolate was prepared to the same recipe and micro-aerated with nitrogen to achieve a porosity of 10% (Comp B), 12.5% (Example 1) and 15% (Example 2).

An aeration stability test is shown in Figure 2 which is a photograph showing these examples (respectively from left to right Comp B, Example 1 and Example 2) after undergoing the aeration stability test as described herein.

As can be seen from Figure 2 Comp B forms a dome whereas Examples 1 and 2 do not, which indicates the improved stability of Ex 1 and 2, which compared to Comp B. This shows that aerated compositions of the invention that have a porosity and bubble sizes and distribution as defined herein have desirable properties. Such parameters have been found to define an optimum region that is selected from the general scope of parameters within aerated compositions can be prepared.

Comp C and D

Similarly to above chocolate compositions were prepared and aerated with nitrogen to achieve much higher porosities of respectively 20% (Comp C) and 25% (Comp D).

Figure 3 is a photograph showing the instability of these samples (left to right Comp C and D) after they have undergone the aeration stability test as described herein. Visible aeration can be seen on the surface of the chocolate especially for Comp D.

Comp C and D were also found to exhibit too large a viscosity to be easily handled especially in an industrial process under the normal temperatures at which moulding and demoulding occurs. For example these samples were found to be too viscous to readily flow into moulds to provide good surface definition. The resultant moulded products nmade from Comp C or Comp D were also very difficult to be removed from a mould (demould) without damage to the product. So surprisingly the applicant has found that there is an upper limit to micro-aerating chocolate. Adding gas to chocolate as small bubbles (micro-aeration) to achieve porosity levels of 20% or above has been shown to be impractical.

Results

Without being bound by any theory, in one most preferred embodiment of the invention the optimal porosity range is believed to be from 12.5% - 15% for the micro-aerated chocolate masses tested. Surprisingly these porosities were found to gives a workable viscosity and a stable and homogeneous micro-aeration (invisible bubbles to the naked eye) as seen in the profile of bubble size distribution. For micro-aerated chocolate with porosities above 15%, viscosity starts to become a challenge, before significant coalescence occurs at porosity above 20%. Micro-aerated chocolate prepared with much lower porosity (e.g. see Comp A oft 5% porosity) also forms inhomogeneous bubbles which is both visually unappealing and effects the organoleptic properties of the chocolate.

Example 3
The following product recipe for a chocolate mass (sold by the applicant in Mexico as a chocolate tablet under the registered trademark Carlos V) was aerated with Nitrogen

The chocolate is a relatively low fat recipe (24.7% fat content by weight) and therefore has a relatively high viscosity (yield value = 8.64Pa, plastic viscosity = 6.52Pa.s).

Examples 4 to 6 and Comp E
The bubble size and BSD present in various samples of conventional chocolate masses, which were then micro-aerated at different levels) were evaluated using two methods of bubble measurement, X-ray tomography and CLSM.

Comp E and Example 4
Micro-aerated samples of the chocolate mass used (when unaerated) to coat the confectionery product sold under the trade mark KitKat®, referred to in Table 2 as KitKat®. It can be seen that a low levels of aeration (Comp E), the bubbles coalesce and are thus have a larger mean size (> 200 microns) and broader BSD. The larger bubbles are noticeable to the naked eye. At higher levels of aeration surprisingly both the mean bubble size and standard deivation decreases (narrower BSD, i.e more uniform, smaller bubble size).

Example 5
Micro-aerated sample of the chocolate mass used (when unaerated) to prepare the confectionery product sold by the applicant in Brazil as chocolate tablets under the trade mark Garoto®, referred to in Table 2 as Garato®. Pictures of micro-aerated Garoto obtained with X-ray tomography are shown in Figure 17 and confocal microscopy (CLSM) in Figure 18. A 3D visualization of micro-aerated Garoto chocolate is shown in Figure 19 where the different colours represent the different depths and highlight the presence of bubbles as described herein.

Example 6
Micro-aerated sample of the chocolate mass used (when unaerated) to prepare the confectionery product sold by the applicant in Brazil as chocolate tablets under the trade mark Nestle Classic®, referred to in Table 2 as Nestle Classic®.
The results are given in Table 2.

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Table 2

Example	Sample	Method	Mean bubble size (µm)	Standard deviation (µm)
Comp E	KitKat® 8.8% aeration	CLSM	212	52.3
		X-ray	290	54
Ex 4	KitKat® 11.5% aeration	CLSM	55.9	51.2
		X-ray	39	23
Ex 5	Garoto® 10% aeration	CLSM	54.6	21.3
		X-ray	42	16
Ex 7	Nestle Classic®15% aeration	CLSM	45.8	12.4
		X-ray	45	17

CLAIMS

1. A process for producing a micro-aerated choco-material the process comprising the steps of:
(I) mixing a choco-material under a high shear of at least 200 s^{-1} ,the choco-material having a plastic viscosity before aeration as measured according to ICA method 46 (2000) of from 0.1 to 20 Pa.s, and
(II) passing the choco-material from step (I) through an injection zone located between two regions held at different pressures,
(III) injecting inert gas at a gas pressure of from 2 to 30 bar into the choco-material as it passes through an injection zone using a gas depositing means at a nominal gas flow rate (F_v) which is within the values of F_v that are calculated from equation (2)

$$P = -A\,{F_v}^2 + B\,F_v + C \qquad (2)$$

where
P represents the porosity target of the micro-aerated choco-material in % measured under standard conditions, P being from 10 to 19%; and
F_v represents the nominal volumetric flow rate of the inert gas in normal litres per minute (NL / min.);
A, B and C are numerical constants (having the respective units to balance equation (2)); the numerical parts of each of these constants being:
A from 0.06 to 0.07;
B from 2.00 to 2.05, and
C from 3.70 to 3.80; with the proviso that:
(A) the flow rate calculated from equation (2) is based on a nominal throughput of the choco-material of 1000 kg / hour in the injection zone, the actual flow rate of inert gas injected in step (III) being adjusted where necessary from the calculated nominal flow rate F_v to match proportionally any differences from 1000 kg / hour in the actual throughout of the choco-material in the injection zone.

2. A process as claimed in claim 1, in which the injection zone is defined by a conduit with a choco-material entrance and exit are held at different pressures with the gas depositing means being located within the conduit.

3. A process as claimed in any one of the preceding claims, in which the pressure difference around the injection zone is formed by two pumps located outside the injection zone.

4. A process as claimed in claim 3, in which the two pumps are run at a differential pump speed of from 20% to 30%, preferably in which the two pumps are run at a constant differential pump speed of 25%.

5. A process as claimed in any one of the preceding claims, in which in the mixing step (I) the high shear mixing is performed at a shear rate of from 200 to 1000 s^{-1}, preferably in which the high shear mixing is performed at a shear rate of from 300 to 800 s^{-1}, and preferably in which the high shear mixing is performed at a shear rate of from 400 to 600 s^{-1}.

6. A process as claimed in any one of the preceding claims, in which in the mixing step (I) the high shear mixing is achieved using a beater mixer to mix the choco-material, with a beater speed of from 200 to 600 revolutions per minute (rpm).

7. A process as claimed in any one of the preceding claims, in which in equation (2) the numeral value for constant A is from 0.061 to 0.069, preferably in which in equation (2) the numeral value for constant A is 0.0636.

8. A process as claimed in any one of the preceding claims, in which in equation (2) the numeral value for constant B is from 2.01 to 2.04, preferably in which in equation (2) the numeral value for constant B is 2.0197.

9. A process as claimed in any one of the preceding claims, in which in equation (2) the numeral value for constant C is from 3.71 to 3.79, preferably in which in equation (2) the numeral value for constant C is 3.7353.

10. A process as claimed in claim 9, in which in equation (2) the numeral value for constant A is 0.0636 and B is 2.0197.

11. A process as claimed in any one of the preceding claims in which the gas depositing means is one or more nozzles, preferably in which the nozzle(s) have an exit diameter of from 2 to 3.5 mm and/or an orifice length of from 6 to 12 mm.

12. A process as claimed in any one of the preceding claims, in which in equation (2) the porosity target P used to calculate the gas flow is from 11% to 19, preferably in which P is from 13% to 17%, and preferably in which P is from 14.5% to 15.5%.

13. A process as claimed in any one of the preceding claims, in which in step (II) the inert gas is injected at a pressure of from 4 to 15 bar, preferably in which the inert gas is injected at a pressure of from 8 to 11 bar.

14. A process as claimed in any one of the preceding claims, in which the choco-material is chocolate.

15. A process as claimed in any one of the preceding claims, in which the nominal flow rate F_v of the inert gas is controlled in real time by an automatic means (optionally a computer) to remain within the values calculated from equation (2) to achieve the desired target porosity P in the micro-aerated choco-material obtained from the process.

16. An aerated choco-material and/or confectionery product obtained by a process as claimed in any one of the preceding claims.

Comp A

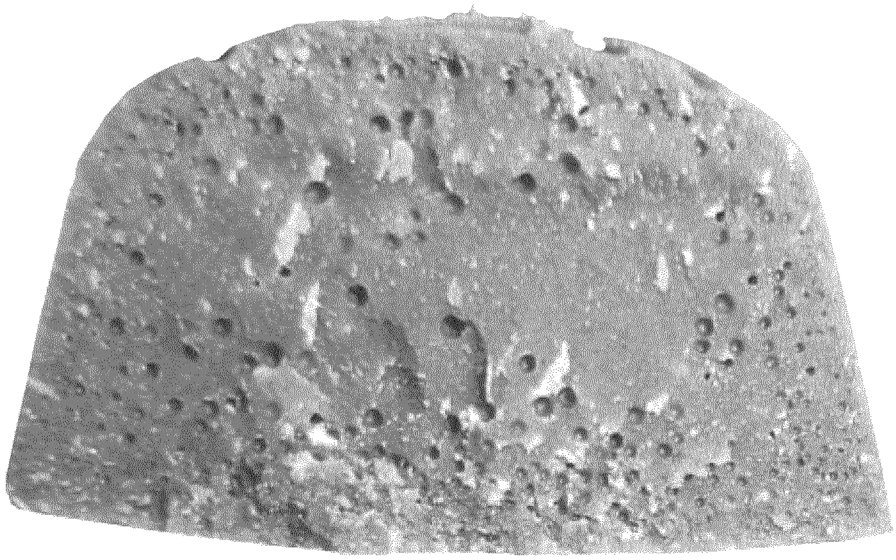

FIG. 1

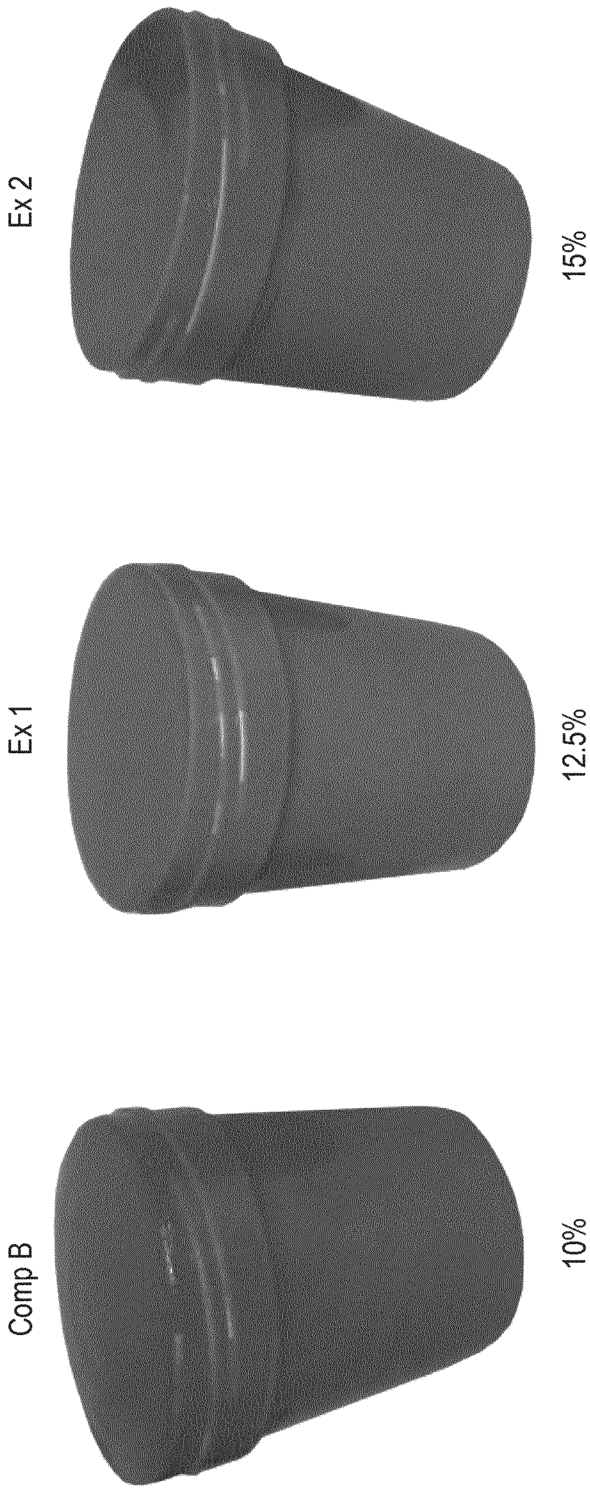

FIG. 2

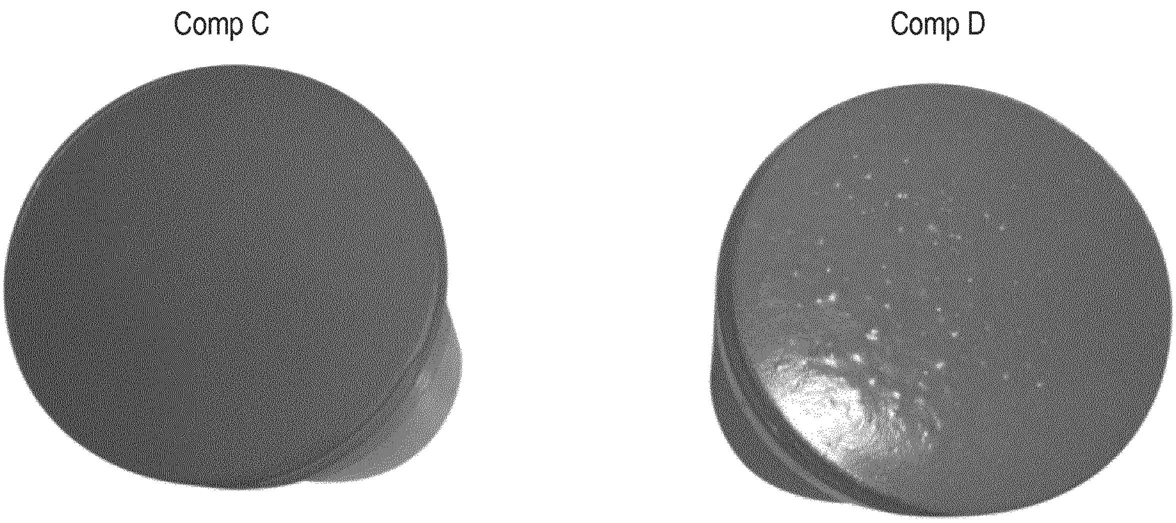

FIG. 3

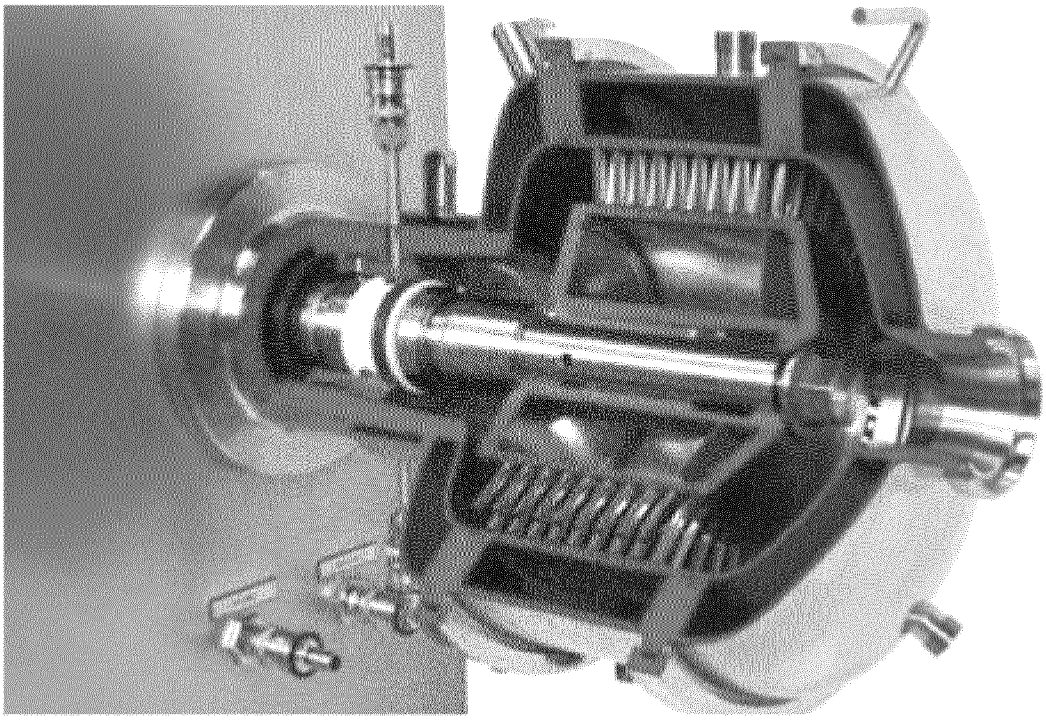

FIG. 4

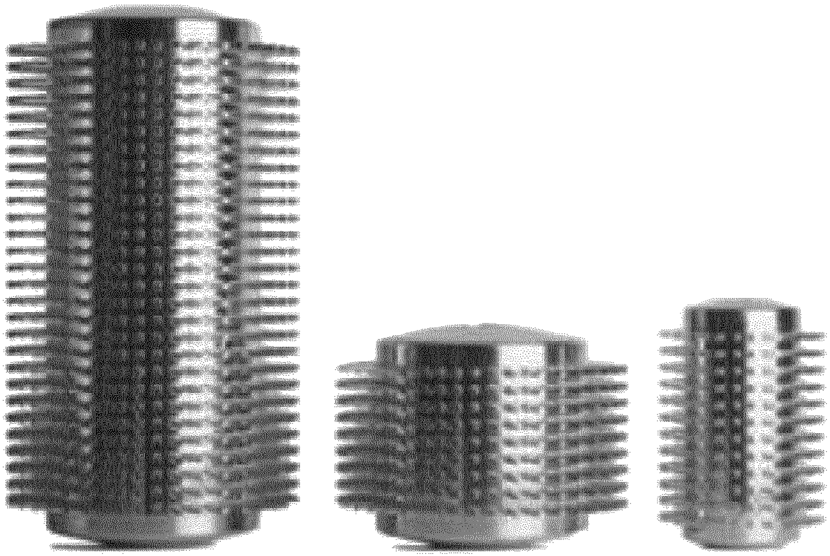

FIG. 5

FIG. 6

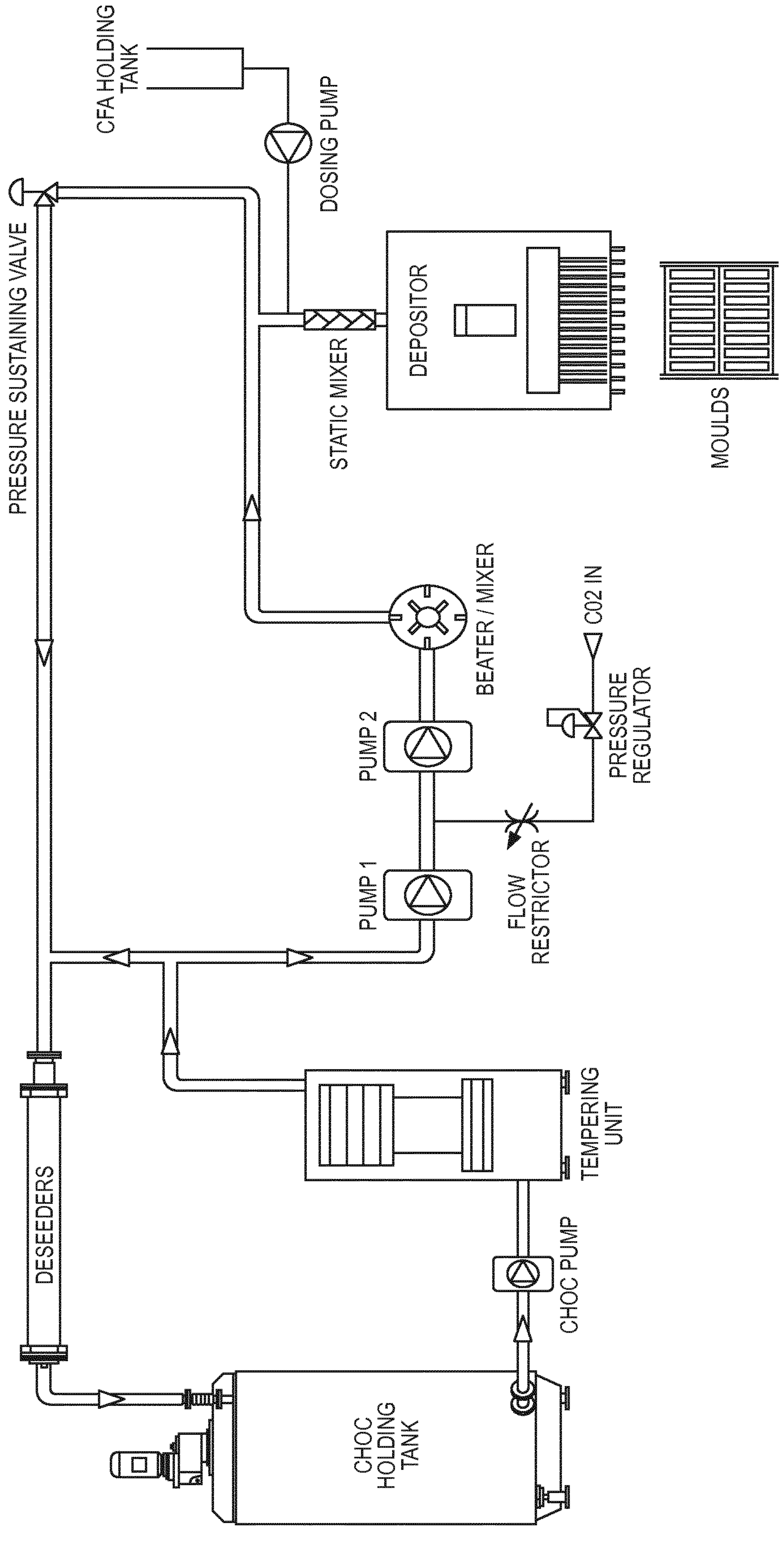
CFA HOLDING TANK
DOSING PUMP
PRESSURE SUSTAINING VALVE
STATIC MIXER
DEPOSITOR
MOULDS
BEATER / MIXER
C02 IN
PRESSURE REGULATOR
PUMP 2
PUMP 1
FLOW RESTRICTOR
TEMPERING UNIT
DESEEDERS
CHOC PUMP
CHOC HOLDING TANK

FIG. 7

FIG. 8

FIG. 9

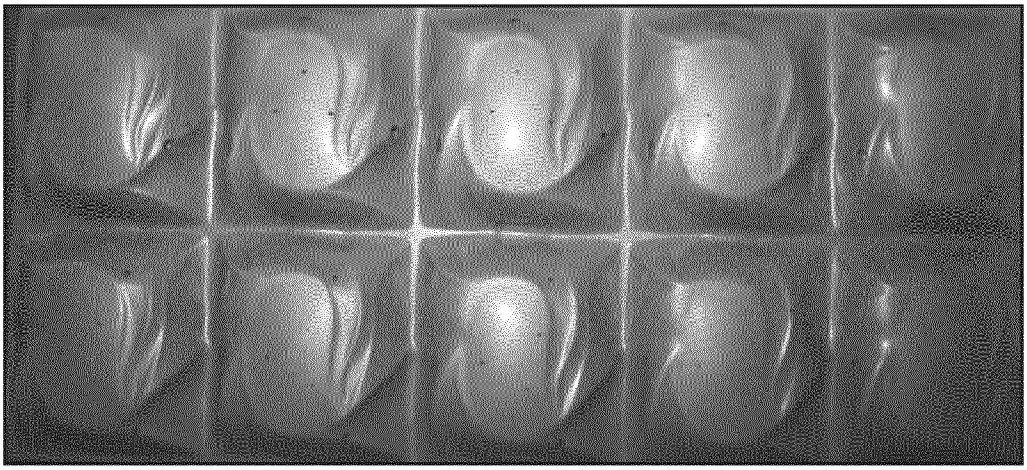

FIG. 10

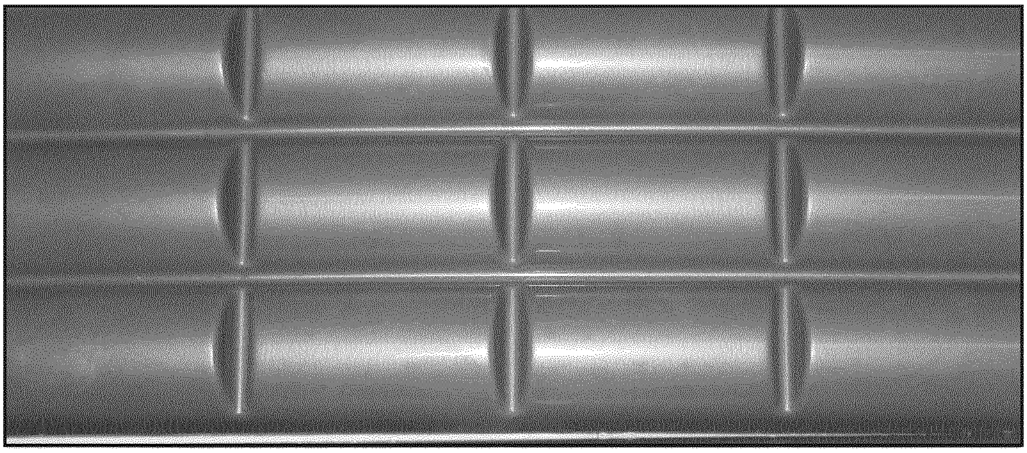

FIG. 11

FIG. 12

FIG. 13

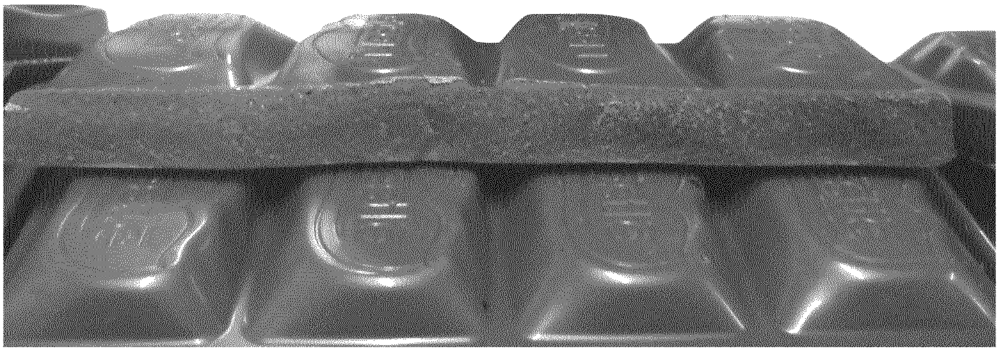

FIG. 14

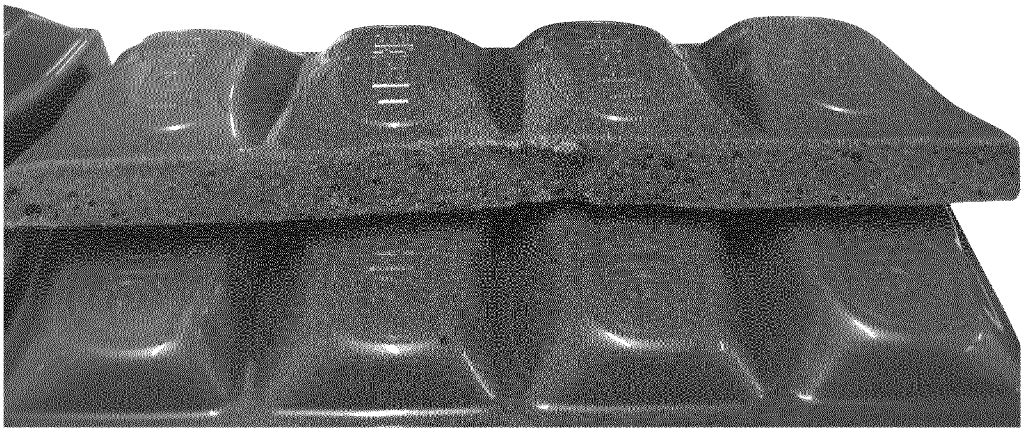

FIG. 15

FIG. 16

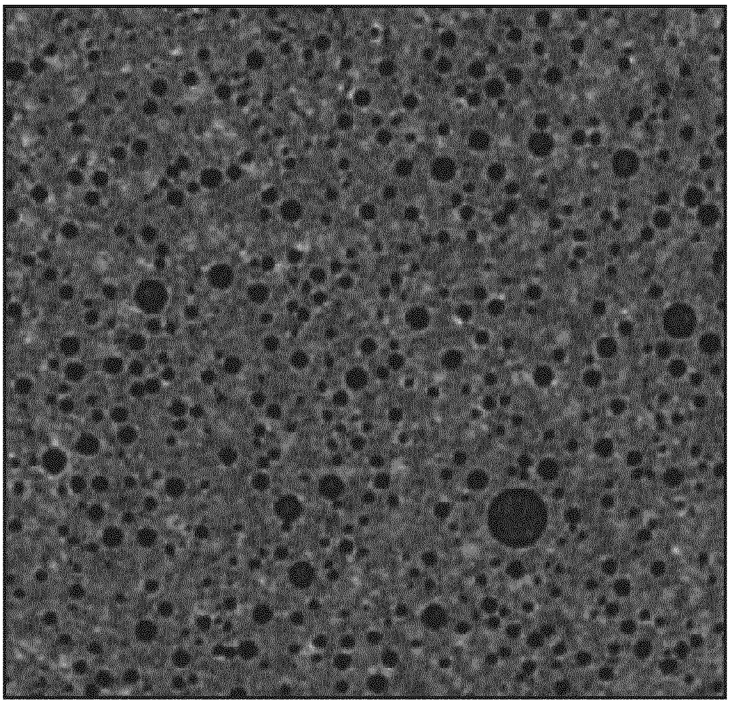

FIG. 17

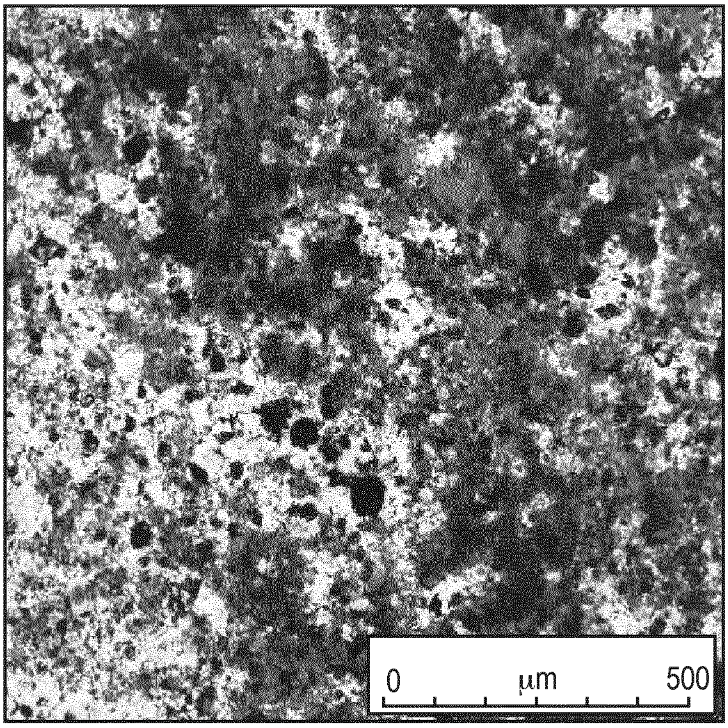

FIG. 18

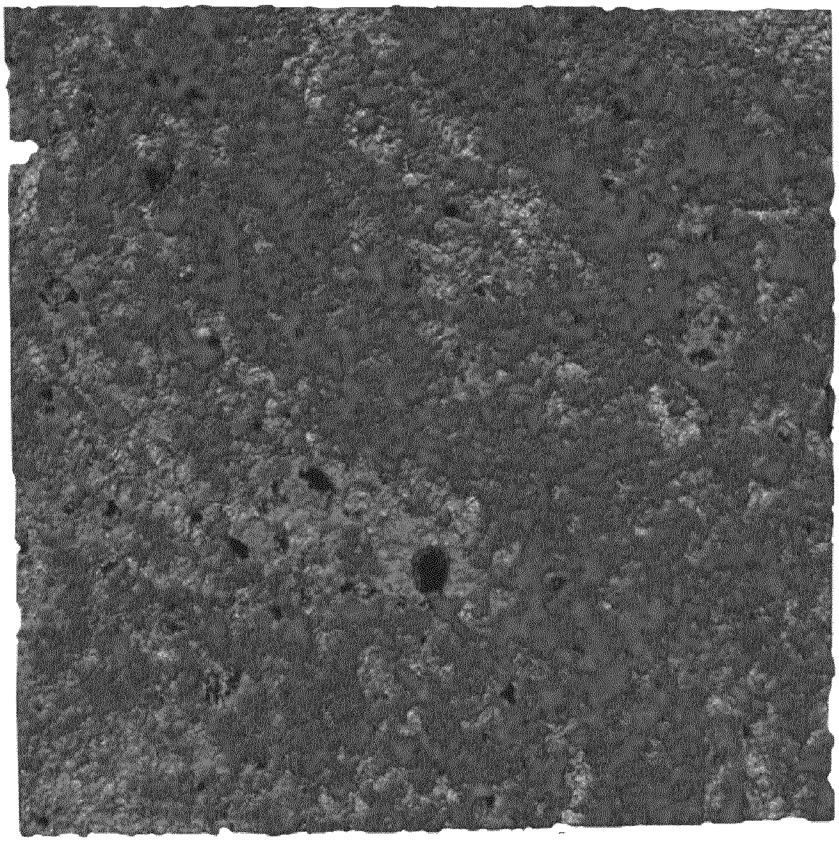

FIG. 19