(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 October 2018 (11.10.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/185502 A1

(51) International Patent Classification:
A23G 1/32 (2006.01) *A23L 33/20* (2016.01)
A23G 1/36 (2006.01) *A23G 1/50* (2006.01)
A23G 1/40 (2006.01)

(21) International Application Number:
PCT/GB2018/050939

(22) International Filing Date:
09 April 2018 (09.04.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1705624.3 07 April 2017 (07.04.2017) GB
1707330.5 08 May 2017 (08.05.2017) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: LOW-SUGAR CHOCOLATE

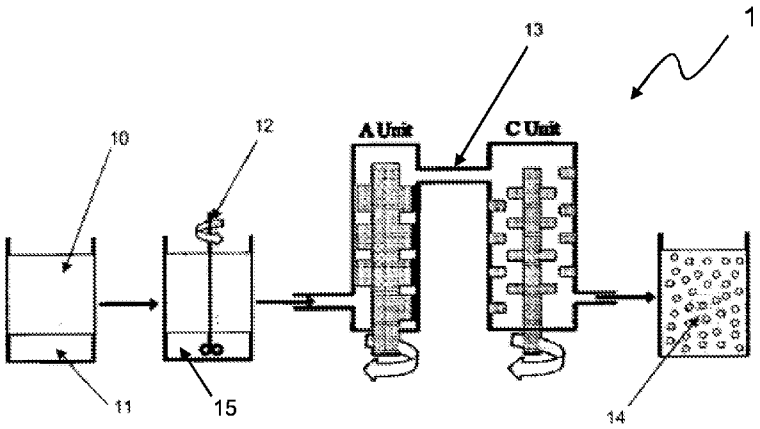


FIGURE 1

(57) Abstract: A low sugar chocolate composition comprising a water-in-oil emulsion comprising cocoa butter, an emulsifier and a fat-crystal stabilised and non-gelled aqueous phase dispersed substantially through the cocoa butter continuous phase, and one or more additional ingredients of chocolate including a natural sugar in less than 45% by weight of the total composition.

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TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

LOW-SUGAR CHOCOLATE

This invention relates generally to chocolate and particularly to low sugar chocolate compositions, chocolate-based filling compositions and methods of manufacturing the same.

There is an increasing interest amongst health-conscious consumers to reduce the calorific content of their food. Manufacturers face the problem of providing low-calorie alternatives of traditional products, such as chocolate, that meet consumer expectations. Additionally, consumers are usually not willing to pay a premium for low-calorie alternatives, so any process or ingredient modifications must be cost effective.

A conventional chocolate composition may contain approximately 30 to 40% fat and 50 to 60% sugar, the remainder comprising other nutrients such as protein and fibre. Clearly, the calorific burden of the chocolate is borne by both the sugar and the fat content. A reduced calorie solution directed towards the reduction of fat has been disclosed in our earlier patent application, published as WO2010/146350. In that application a comestible product comprising a water-in-oil emulsion formed from cocoa butter and a fat-crystal stabilised aqueous phase, with one or more ingredients of chocolate, was disclosed. The calorific content of the chocolate was markedly reduced (*e.g.* by 12 %) by replacing a proportion of the fat which would have otherwise been used with encapsulated water, trapped within fat crystals in the cocoa butter. In order to stabilise the aqueous phase it was found necessary to use hydrocolloids. Indeed, in the absence of such hydrocolloids the performance of the chocolate was determined to be unsatisfactory.

Previous attempts to reduce the sugar content in chocolate products have included the use of bulking agents and/or artificial sweeteners. For example, WO2016/097069A1 describes the replacement of sugar in chocolate products with polydextrose, resistant maltodextrin and high intensity sweetener. However, the use of these synthetic substances leads to a chocolate product with organoleptic properties that poorly match that of conventional chocolate, these including snap, gloss, creamy texture, rich taste and melt-in-mouth quality. Moreover, consumers are increasingly focused on natural ingredients, and often want to avoid the use of artificial sweeteners in their food.

Accordingly, there is a desire to have a low sugar chocolate composition and a method of manufacturing the same, with substantially the same organoleptic properties of conventional chocolate.

A first aspect of the invention provides a low sugar chocolate composition comprising a water-in-oil emulsion comprising cocoa butter, an emulsifier, and a fat-crystal stabilised and non-gelled aqueous phase dispersed substantially through the cocoa butter continuous phase, and one or more additional ingredients of chocolate including a natural sugar in less than 45% by weight of the total composition.

A second aspect of the invention provides a method of manufacturing a low sugar chocolate composition, the method comprising steps of:

a) Mixing the cocoa butter and an emulsifier;
b) Heating the mixture;
c) Adding the water and mixing to form the water-in-oil emulsion;
d) Adding the one or more additional ingredients of chocolate;
e) Adding a natural sugar in less than 45% by weight of the total composition;
f) Preferably cooling the mixture.

The inventor has found that it is possible to incorporate water into cocoa butter, optionally mixed with other ingredients, but excluding sugar at this stage, by trapping the water using fat crystal shells, which osmotically separate the water and the sugar. The replacement of sugar for water molecules in the water-in-oil composition allows for the manufacture of a low sugar chocolate composition. Advantageously, the chocolate does not suffer with the 'bloom' appearance caused by migration of water to the surface.

It has been surprisingly found that the amount of sugar added to the composition can be reduced as compared to previous work. It is believed that the presence of the fat crystal stabilised aqueous phase is able to displace sugar without a concomitant impact on taste or organoleptic properties. Moreover, the reduction in sugar content ensures that the extra-shell environment is intrinsically less hydrophilic because of the decrease in sugar content. The lower sugar concentration ensures that there is a lower water osmotic gradient across the shell boundary, making shell fractures less likely.

Moreover, this is further advantageous insofar as it enables the shells to be formed absent any gelling agent, such as hydrocolloids, which reduces cost, complexity and may improve the texture and mouth-feel of the low sugar chocolate product of the invention.

Controlling the temperature during formation of the shells is important for the formation of robust shells.

By natural sugar we mean monosaccharides, disaccharides or oligosaccharides, as opposed to artificial sweeteners. The natural sugar may be selected from one or more of, for example, glucose, fructose, sucrose, lactose, maltose, trehalose, cellobiose or maltodextrins. Typically the sugar is sucrose. One type of sugar may be present in the low sugar chocolate composition, or a mixture of two or more may be used in combination. The sugar may be corn syrup. The sugar may be ground sugar, milled sugar or icing (confectioner's) sugar.

The total concentration of natural sugar in the low sugar chocolate composition is less than 45% by weight of the low sugar chocolate composition. Typically, the total concentration of natural sugar is less than 40% by weight, and even more typically is less than 35% by weight of the total low sugar chocolate composition. In some embodiments, the concentration of the natural sugar may be less than 30% by weight, say 25% by weight or 20% by weight. In some embodiments, the total concentration of natural sugar is as low as 12.5% by weight of the total low sugar chocolate composition. There may be no particular lower limitation on the concentration of natural sugar in the low sugar chocolate composition, this being dependent on the one or more additional components added to the composition, and the consumer preference for taste and texture of the final chocolate product. That said, in embodiments we prefer a sugar content (w/w) of from 10 to 40%, for example from 10 to 35%, say 10 to 30%, and in some embodiments 10 to 25 or 20%.

The water-in-oil emulsion is defined as a mixture of two or more immiscible liquids. A hydrophilic phase (water) is dispersed in a hydrophobic continuous phase (cocoa butter), which may optionally contain one or more other ingredients of chocolate. By cocoa butter we mean Theobroma oil or Theobroma cocoa, which is a pale-yellow, edible vegetable fat extracted from cocoa.

The most common form of cocoa butter has melting point of around 34-38°C, rendering chocolate a solid at room temperature that readily melts once inside the mouth. Cocoa butters displays polymorphism having different crystals with different melting points. Cocoa butter and its various types of crystals are generally known in the art.

During the emulsification process it is believed that water droplets become encapsulated in a fat layer which crystallises on cooling to form a stable shell around the water droplet. Cocoa butter forms a number of crystal forms with type V being the preferred form in chocolate products (T_m 33.8°C, and often reported in the range 32 to 34°C). If the fat crystals are held at a temperature just below the melting temperature of the type V crystals, but above the melting temperature of other crystal forms, a tempering process takes place where the crystals of types I to IV will be melted leaving only the type V crystals. The type V crystals then seed the growth of further type V crystals until a complete crystal shell comprising type V crystals is formed.

As stated above, controlling of the temperature during the formation of the shells is important to allow the formation of robust shells. Indeed, maintaining the temperature just below the melting point of the type V crystals causes the crystals to grow, which eliminates grain boundaries and causes or allows the shells to sinter. The rate of this sintering process in the crystal shells will be determined by temperature with the rate increasing with decreasing temperature.

In an embodiment the temperature may be held at a temperature which is between 1°C (or 2°C) and 10°C less than the melting point of the type V crystals, and preferably in the range of 1°C (or 2°C) and 9, 8, 7, 6 or 5°C less than the melting point of the type V crystals. In an embodiment the temperature may be cycled in a 1 to 8°C range, for example in a 1 to 5°C range, for example a 2°C range in a temperature range between 1°C (or 2°C) and 10°C less (or 9, 8, 7, 6 or 5°C less) than the melting point of the type V crystals to form the sintered fat crystal shells. In a preferred embodiment, the temperature is held at a temperature of about 28 to 31°C and then cycled upwardly and downwardly by 1, 2 or3°C. We believe that a temperature cycling regime helps to form smooth shells of type V crystals. The composition may then be subsequently cooled. Whilst the time at which the composition is held at the controlled temperature (and/or cycled) is not crucial, we prefer a time period of less than 30 minutes, preferably less than 20, 15, 10, 9, 8, 7, 6 or 5 minutes.

Well sintered shells are smooth and do not have a grainy appearance. The more completely sintered the shells the more robust they are. Indeed, it is our belief that the grain boundaries may provide points of weakness within the shells and, as such, avoiding such grain boundaries is beneficial. Indeed, we believe that the removal (or at least substantial removal) of grain boundaries within the shells leads to a lower level of shell compromise (*e.g.* shell breakage) and thereby less bloom in the finished product from escaped water which, in the case of no shell compromise, would otherwise remain captive within the shells.

The cocoa butter used in the present invention may be refined cocoa butter or unrefined cocoa butter. Advantageously, the natural waxes of the unrefined cocoa butter may be useful in the formation of the water-in-oil emulsion, providing a cost effective process without the need for addition of artificial or processed oils. The natural waxes of cocoa do not melt and are able to form shell structures around water droplets in the oil-in-water emulsion.

Additionally or alternatively, a source of natural cocoa butter wax may be added and/or an additional fat or wax source, for example, vegetable oils, or any high melting triglyceride, may be added to the cocoa butter. Alternatively, an inorganic material may be added to form water-in-oil emulsion such as calcium carbonate. We believe, although we neither wish nor intend to be bound by any particular theory, that the presence of fat, wax or inorganic material helps to further stabilise the shells which form around the encapsulated water.

The concentration of cocoa butter in the water-in-oil emulsion may be between 30 to 80% by weight. Typically the concentration of cocoa butter is 40 to 50% by weight of the water-in-oil emulsion. The remainder of the water-in-oil emulsion is predominantly comprised of water, with an emulsifier also optionally present. Consequently, the concentration of water in the water-in-oil emulsion may be between 20 to 60% by weight of the water-in-oil emulsion. Typically, the concentration of water is between 40 to 60% by weight. The ratio of water to cocoa butter that is used is variable and dependent only on the desired properties of the final chocolate product.

The concentration of emulsifier in the water-in-oil emulsion may be between 0.1 to 10% by weight of the water-in-oil emulsion, typically between 0.5 to 6% by weight, and even more typically between 1 to 5% by weight of the water-in-oil emulsion.

The emulsifier may be any suitable emulsifier. Preferably, the emulsifier is polyglycerol polyricinoleate (PGPR) (E476). Advantageously PGPR has been found to reduce the viscosity of chocolate, making it easier to work during processing. However, other emulsifiers may be used, such as lecithin.

The concentration of cocoa butter in the low sugar chocolate composition may be between 20 to 60% by weight of the total low sugar chocolate composition. Typically, the concentration of cocoa butter in the low sugar chocolate composition is between 20 to 40%, and even more typically between 25 to 35%, say 30% by weight of the total low sugar chocolate composition. The concentration of cocoa butter in the low sugar chocolate composition is dependent upon the type of chocolate product being produced.

One or more additional ingredients of chocolate may be included, for example cocoa solids and/or milk powder depending on whether a dark, milk or white chocolate composition is desired. Typically dark chocolate products comprise a mixture of cocoa liquor, cocoa powder, and cocoa butter. Typically milk chocolate products comprise a mixture of cocoa liquor, cocoa powder, cocoa butter, and also include milk fat and milk solids, for example, milk powder. Typically white chocolate products do not include cocoa liquor or cocoa powder, but do include milk fats and milk solids.

The additional ingredients of chocolate may optionally include one or more of artificial sweeteners, flavourings, fruits, nuts, biscuit pieces, candy particles, and/or colourings. Any suitable artificial sweetener may be used including erythritol, stevia, xylitol, sucralin, rebaudioside A (*e.g.* as sold under the brand name Truvia (RTM)), saccharine and aspartame. Any suitable flavouring may be included in the low sugar chocolate composition including, for example, vanilla essence, mint flavouring, or orange flavouring.

Pickering stabilisers for example solid particles of cocoa powder may be present. The Pickering stabilisers may be present in the cocoa butter. These may be located at the interface between the oil and water to provide greater stability to the emulsion, which may result in an increased weight of water being introduced into the emulsion. Advantageously, Pickering particles at the interface help to maintain the emulsion in the event that the fat crystals are subsequently melted.

The steps in the method of manufacturing a low sugar chocolate composition are not necessarily limited to the alphabetical order in which they are listed. For example, the addition of one or more additional ingredients of chocolate in step d) may take place concurrently with step a). In this case, the one or more additional ingredients of chocolate are added to the cocoa butter, which is then mixed with an emulsifier. For example, the cocoa solids and/or milk powder may be mixed with the cocoa butter prior to step a). Alternatively, the cocoa solids and/or milk powder may be added after the mixture has been heated in step c), or concurrently with the addition of a natural sugar in step e), or after the mixture has been cooled in step f).

However, the addition of osmotically active compounds such as the natural sugar, in less than 45% by weight of the total composition, is added after the water-in-oil emulsion has been formed after completion of step c). All osmotically active compounds are excluded from the formation of the water-in-oil emulsion but may be added after that stage of the process is complete.

The mixture of cocoa butter and emulsifier is heated in step b) to a temperature of between 55 to 65°C, most typically to approximately 60°C. This temperature is suitable for melting crystal Forms I-VI present in cocoa butter. Typically the temperature is maintained at 60°C when the water is added in step c).

The method may employ a margarine line, which may comprise a scrape surface heat exchanger and pin stirrer.

The mixture in step f) is cooled to a controlled temperature. Typically the controlled temperature is between 5°C and room temperature (up to 25°C). Most typically, the mixture of step f) is cooled to 5°C. The mixture in step f) may be tempered in a heating and cooling cycle to melt and recrystallise the cocoa butter to obtain the desired Form V crystals. In an embodiment, the mixture of step f) is cooled to 20°C to induce crystallisation, re-heated to between say above 27°C to 31°C to melt all crystal forms in the cocoa butter other than the desired Form V crystals, and then re-cooled to result in sintered Form V crystals at the interface of the fat crystal shell. When the mixture is re-heated to between, say, above 27°C and 31°C, it may be held at this temperature (the 'hold temperature') for a period of time, for example less than 30 minutes, say less than 20, 15, 10, 9, 8, 7, 6 or 5 minutes. Additionally and preferably, the temperature may be cycled from the hold temperature by,

say, +1°C, +2°C or +3°C and then back to the hold temperature to develop or help develop sintered fat crystal shells. Further sintering of the fat crystal shells is possible by heating the mixture to the hold temperature to melt the undesired crystal forms, and re-cooling to 20°C to induce Form V crystallisation. This sequence may be performed once, or more than once, in a continual cycle. The heating and cooling sequences may be achieved with an SSHE (scraped surface heat exchanger)/pin stirrer.

Accordingly, step f may comprise holding or maintaining the chocolate composition at a temperature of above 27°C to 31°C. Additionally or alternatively, step f may comprise cooling to 5 to 25°C, reheating and holding or maintaining the chocolate composition at a temperature of above 27°C to 31°C and then re-cooling. Step f may also comprise holding or maintaining the chocolate composition at a temperature of above 27°C to 31°C and cycling the temperature upwardly and downwardly to a temperature just below the melting point of the type V crystals by, say, +1°C, +2°C to +3°C, one, two or more times.

The cooling temperature is selected to obtain the desired Form V fat crystals in the final low sugar chocolate composition.

Advantageously, no hydrocolloid is required in the low sugar chocolate composition of the present invention.

The products are comestible products and as such are fit to be eaten as food, drunk or otherwise taken into the body. The low sugar chocolate may be used in confectionary such as a chocolate bar, such as a solid chocolate bar or a chocolate bar comprising an outer chocolate encasement with an inner filling. The low sugar chocolate may also be used as a coating or a component in a cake, dessert or pudding. The low sugar chocolate composition may be a chocolate based filling. The chocolate based filling may be used, for example, in chocolate encased confectionary, cake fillings, patisserie items, desserts, or any other comestible product.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such

features are incompatible. For the avoidance of doubt, the terms “may”, “and/or”, “e.g.”, “for example” and any similar term as used herein should be interpreted as non-limiting such that any feature so-described need not be present. Indeed, any combination of optional features is expressly envisaged without departing from the scope of the invention, whether or not these are expressly claimed. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is schematic drawing of the process for producing the water-in-oil emulsion;
Figure 2 is an SEM (Scanning Electron Microscope) image of a product according to the invention
Figures 3 is an SEM image of an incompletely sintered shells;
Figure 4 is an SEM images of a partially sintered shells;
Figure 5 is an enlarged view of Figure 4; and
Figure 6 is an SEM image of a shell formed in accordance with the invention.

Referring first to Figure 1 there is shown a schematic diagram of a preferred embodiment of a process 1 used to produce the water-in-oil emulsion. The process 1 comprises a cocoa butter and emulsifier mixture 10, water 11, the cocoa butter/emulsifier/water mixture 15, and an overhead stirrer 12, a margarine line 13, a water-in-oil emulsion 14.

In this embodiment of the process 1, the cocoa butter and emulsifier mixture 10 is heated to 60°C in a water bath (not shown), the water 11 is then added, and the resulting cocoa butter/emulsifier/water mixture 15 is stirred using the overhead stirrer 12 for a period of approximately 5 minutes until the mixture is homogeneous. The cocoa butter/emulsifier/water mixture 15 is then pumped through the margarine line 13.

Cocoa butter displays polymorphism with six crystal forms (Forms I-VI), which all melt at different temperatures. Heating the cocoa butter and emulsifier mixture 10 to a temperature of 60°C is suitable for melting all six crystal forms.

The margarine line 13 comprises a scrape surface heat exchanger (A Unit) and pin stirrer (C Unit). The margarine line 13 is a continuous process in which the temperature of the two jackets can be manipulated so that tempering can occur during the emulsification stage through the control of shear and temperature. Maintaining the temperature at 20°C in the scrape surface heat exchanger (A Unit) allows the cocoa butter to cool to room temperature (approximately 25°C).

Either before or after cooling the water-in-oil emulsion 14 to a temperature of 25°C, the one or more optional additional ingredients of chocolate may be added. Additionally, the natural sugar in less than 45% weight of the total composition may be added at this stage.

The emulsification process to produce the water-in-oil emulsion allows hydrophilic water droplets to become encapsulated in the fat layer, which crystallise on cooling to form stable hydrophobic shells around water droplets. The preferred Form V crystals are formed during the tempering process described. When the mixture is cooled to 25°C, the fat crystals are held at a temperature just below the melting temperature of the Form V crystals, which allows the undesired Form I to IV crystals to melt. The Form V crystals then seed the growth of further Form V crystals until a complete crystal shell comprising Form V crystals is formed. This gives chocolate its desirable characteristics including its creamy texture and melt-in-mouth quality.

To form robust fat crystal shells the crystal shells are sintered by preferably cycling the temperature of the chocolate in a, say, 1 to 2°C range in a temperature range between 28°C and 31°C with dark chocolate preferably towards the top of this temperature range, milk chocolate preferably in the middle and white chocolate preferably towards the bottom of this temperature range.

The resulting low sugar chocolate product may be poured into a suitable mould ready for storage, distribution and sale to the consumer.

This process is advantageous for the production of low sugar chocolate products for the following reasons. The encapsulation of water in these sintered fat shells allows for less sugar to be used in the chocolate composition to that used in conventional chocolate, without compromising on taste and texture, by osmotically separating the water from the sugar in the cocoa butter continuous phase.

The inventor has surprisingly found that, in contrast to previous disclosures, the use of less sugar in the chocolate composition provides a stable water-in-oil emulsion, which may be formed without the need for a gelling agent. Previously, it was thought that low calorie chocolate compositions required the use of a hydrocolloid, such as kappa carrageenan, to stabilise the fat crystal stabilised aqueous phase. It has been surprisingly found that gelling agents are not required to produce a low sugar chocolate composition with the desired physical and organoleptic properties of conventional chocolate.

Without wishing to be bound by theory, it is believed that the use of less sugar in the cocoa butter continuous phase leads to a lower osmotic gradient across the shell boundary between the fat crystal stabilised, non-gelled, aqueous phase, than that of previous disclosures using water-in-oil emulsions. Advantageously, the low osmotic gradients imparts greater stability to the fat crystal shells encapsulating the water, which reduces water leakage into the cocoa butter continuous phase, resulting in a smooth and creamy low sugar chocolate product.

More advantageously, if the natural waxes of the unrefined cocoa butter are included in the water-in-oil composition, then this results in very stable sintered fat crystal shells, which shield the water from osmotically active in the composition, such as sugar. This provides a chocolate that is smooth in texture, but with no discernible different in the sweetness in comparison to conventional chocolate. Additionally, unrefined cocoa butter is a natural product, which requires less processing that refined cocoa butter, and therefore is an attractive alternative to processed fat sources.

To further exemplify the invention, reference is also made to the following figures and non-limiting examples:

Example 1

Firstly, a cocoa butter emulsion was made comprising 20% distilled water and 80% lipid phase (made up of 96% cocoa butter and 4% polyglycerol polyricinoleate (PGPR)). The cocoa butter used was a commercial grade. The PGPR was supplied by Kerry Bio-Science.

The cocoa butter and PGPR were heated together using a water bath to a temperature of 60°C, to melt all six forms of cocoa butter crystals. The aqueous phase was added to the

cocoa butter and PGPR mixture and stirred for 5 minutes using an over-head stirrer fitted with an anchor head until the mixture looked homogeneous. This pre-emulsion was then pumped through a bench-top margarine line comprising a scrape surface heat exchanger followed by a pin stirrer. Both the scrape surface heat exchanger and pin stirrer units are fitted with water baths so temperature of each unit can be altered to result in a chocolate product that is tempered and robust shells of type V crystals are formed.

Further ingredients required for the chocolate were then added to the emulsion and mixed by stirring to give a homogeneous mixture with the following composition:

Cocoa butter emulsion	40%
Sugar	25%
Milk Powder	28%
Cocoa Powder	7%

Resulting in a 30% sugar reduction over a typical milk chocolate.

The ingredients selected for this example were readily available commercial products. The sugar was Silver Spoon icing sugar which was ground to a very fine powder using a pestle and mortar. The milk powder was Marvel Original Dried Skimmed Milk Powder (ingredients dried skimmed milk 99.5% and vitamins A & D) from Premier Foods Ltd. The cocoa powder used was Cadbury Bournville Cocoa (ingredients cocoa powder) from Cadbury Ltd. Bournville, Birmingham, UK.

After mixing the bulk of the chocolate mixture was transferred to a sealable storage container for storage in a refrigerator. After a period of 2 months the chocolate showed no sign of bloom formation, indicating that no migration of the water content had taken place. A sample of the chocolate was taken for melting point determination using Differential Scanning Calorimetry (DSC). The sample was found to be tempered with a Form V fat crystal network structure for the cocoa butter corresponding to a melting point of 32°C for an acceptable mouth feel.

Example 2

A low sugar chocolate was made by first making a water in cocoa butter emulsion with a water content of 20%.

A pre-emulsion was produced with 79% fat phase, 20% aqueous phase and 1% PolyGlycerol PolyRicinoleate (PGPR). This fat phase was heated to 60°C using a water bath and a cocoa butter emulsion was prepared by adding the aqueous phase to the fat phase mixture and stirred for 5 minutes to produce a pre-emulsion using an over-head stirrer fitted with an anchor head until the mixture looked homogeneous.

The pre-emulsion was then emulsified in a high shear mixer (Silverson L4RT, 5000 rpm, 5 mins) to produce a fine water-in-oil emulsion with water droplets with a size of approximately 4µm.

The emulsion mixture was then mixed with the cocoa solids and ground sugar (in a ratio of 35% emulsion, 25% cocoa powder and 40% sugar) at above 27°C to produce a full chocolate and cooled to room temperature or 5°C. The heating/cooling process was repeated. The sample was checked using a DSC and was found to be tempered with a Form V fat crystal network structure for the cocoa butter corresponding to a melting point of 32°C for an acceptable mouth feel. The resulting chocolate was found to have a glossy surface appearance and snapped as expected for a dark chocolate.

The product had the typical fat content of a dark chocolate but with a sugar reduction of 20% over a typical dark chocolate.

Example 3

Example 2 was repeated but the emulsification process was carried out in a scrape surface heat exchanger (SSHE) and a pin stirrer at temperatures of 20°C and 27°C respectively. This resulted in a water droplet size of approximately 2µm. The resulting emulsion was then mixed with the cocoa powder and ground icing sugar at above 27°C (in a ratio of 35% emulsion, 25% cocoa powder and 40% sugar) to produce a full chocolate before cooling to room temperature. The heating/cooling process was repeated and the temperature cycled at the hold temperature in accordance with the invention. The resulting dark chocolate was glossy and snapped.

The product had the typical fat content of a dark chocolate but with a sugar reduction of 20%.

Referring now to Figure 2 there is shown an SEM (Scanning Electron Microscope) image of the resultant shell formation from the following process. Cooling in the SSHE to 20°C induces crystallisation and then re-heating to between above 27°C and 31°C in the pin stirrer results in only form V crystals to survive (i.e. tempered chocolate) with re-cooling then resulting in sintered form V crystals at the interface (i.e. shell formation). If necessary, further sintering of the fat crystal shells can be achieved by cycling the temperature of the chocolate in a 1, 2 or 3°C range in a temperature range between 28°C and 31°C followed by subsequent cooling to 20°C. This is best achieved by a SSHE/pin stirrer/SSHE/pin stirrer sequence.

Figure 3 shows a shell with a grainy surface which is indicative of incomplete sintering. Figures 4 and 5 show images of partially sintered shells where the grainy surfaces are clearly evident next to smooth parts. Figure 6 shows a completely sintered shell which is smooth and absent grain boundaries or a grainy surface. The shell of Figure 6 was made by holding the chocolate mixture at a temperature of less than the melting point of type-V crystals but above that of Type I to IV crystals for a period of time ("the hold temperature" - in this case about 29°C), cycling the temperature upwardly by 1 to 2°C then cooling to the hold temperature, and repeating the process. The mixture was subsequently cooled.

Example 4

A low sugar chocolate was made by first making a water in cocoa butter emulsion with a water content of 40%.

A pre-emulsion was produced with 59% fat phase, 40% aqueous phase and 1% PolyGlycerol PolyRicinoleate (PGPR). This fat phase was heated to 60°C using a water bath and a cocoa butter emulsion was prepared by adding the aqueous phase to the fat phase mixture and stirred for 5 minutes to produce a pre-emulsion using an over-head stirrer fitted with an anchor head until the mixture looked homogeneous.

The pre-emulsion was then emulsified in a high shear mixer (Silverson L4RT, 5000 rpm, 5 mins) to produce a fine water-in-oil emulsion with water droplets with a size of approximately 3μm.

The emulsion mixture was then mixed with the cocoa solids and ground sugar (in a ratio of 42% emulsion, 25% cocoa powder and 33% sugar) at above 27°C to produce a full chocolate and cooled to room temperature or 5°C. The heating and cooling process was repeated. The sample was checked using a DSC and was found to be tempered with a Form V fat crystal network structure for the cocoa butter corresponding to a melting point of 32°C for an acceptable mouth feel. The resulting chocolate was found to have a glossy surface appearance and snapped as expected for a dark chocolate.

The product had the typical fat content of a dark chocolate but with a sugar reduction of 33%.

Example 5

Example 3 was repeated with a ratio of water to cocoa butter of 50% to 50%. The droplet size obtained was in the range 3μm to 4μm. The resulting emulsion was mixed with cocoa powder and milled sugar (in a ratio of 50% emulsion, 25% cocoa powder and 25% sugar) to produce a full chocolate. The mixture was held at a certain temperature and cycled in accordance with the invention and then cooled to room temperature or 5°C. Again, the desired Form V fat crystal network structure with a melting temperature of 32°C was produced. The resulting dark chocolate was glossy and snapped.

Example 6

Example 3 was repeated with a ratio of water to cocoa butter of 60% to 40%. The droplet size obtained was in the range 5μm to 7μm. The resulting emulsion was mixed with cocoa powder and milled sugar (in a ratio of 62.5% emulsion, 25% cocoa powder and 12.5% sugar) to produce a full chocolate. The mixture was heated and cycled in accordance with the invention and then cooled to room temperature or 5°C. Again, the desired Form V fat crystal network structure with a melting temperature of 32°C was produced and the chocolate was glossy and snapped.

The resulting dark chocolate was glossy and snapped but had a 75% reduction in the sugar content of a typical dark chocolate.

It will also be appreciated by those skilled in the art that any number of combinations of the aforementioned features and/or those shown in the appended drawings provide clear

advantages over the prior art and are therefore within the scope of the invention described herein.

CLAIMS

1. A low sugar chocolate composition comprising a water-in-oil emulsion comprising cocoa butter, an emulsifier, and a fat-crystal stabilised and non-gelled aqueous phase dispersed substantially through the cocoa butter continuous phase, and one or more additional ingredients of chocolate including a natural sugar in less than 45% by weight of the total composition

2. A low sugar chocolate composition of Claim 1, comprising a natural sugar in less than 35% by weight of the total composition.

3. A low sugar chocolate composition of Claim 2, comprising a natural sugar in less than 25% by weight of the total composition, say 12.5% by weight of the total composition.

4. A low sugar chocolate composition of Claim 3, in which the natural sugar is a monosaccharide.

5. A low sugar chocolate composition of Claim 3, in which the natural sugar is a disaccharide.

6. A low sugar chocolate composition of Claim 3, in which the natural sugar is selected from one or more of glucose, fructose, sucrose, lactose, maltose, trehalose, cellobiose or maltodextrins.

7. A low sugar chocolate composition of Claims 4, 5, or 6, comprising cocoa butter which is unrefined and contains natural waxes.

8. A low sugar chocolate composition of Claims 4, 5, or 6, comprising refined cocoa butter.

9. A low sugar chocolate composition of Claims 7 or 8, comprising vegetable fat as an additional fat or wax source.

10. A low sugar chocolate composition of Claims 8 or 9, comprising calcium carbonate in the water-in-oil emulsion.

11. A low sugar chocolate composition of Claim 10, in which the concentration of the emulsifier is between 1 to 5% by weight of the water-in-oil emulsion.

12. A low sugar chocolate composition of Claim 11, in which the emulsifier is polyglycerol polyricinoleate (PGPR) (E476).

13. A low sugar chocolate composition of Claim 11, in which the emulsifier is lecithin.

14. A low sugar chocolate composition of Claims 12 or 13, in which the concentration of the cocoa butter is 40 to 80% by weight of the water-in-oil emulsion.

15. A low sugar chocolate composition of Claim 14, in which the concentration of the water is 20 to 60% by weight of the water-in-oil emulsion.

16. A low sugar chocolate composition of Claim 15, in which the concentration of the cocoa butter in the low sugar chocolate composition is 20 to 40% by weight of the low sugar chocolate composition.

17. A low sugar chocolate composition of any preceding Claim, in which the one or more additional ingredients of chocolate are one or more of cocoa solids, milk powder, cocoa liquor, and/or cocoa powder.

18. A low sugar chocolate composition of any preceding Claim, in which the one or more additional ingredients of chocolate are one or more of artificial sweeteners, flavourings, fruits, nuts, biscuit pieces, candy particles, and/or colourings.

19. A method of manufacturing a low sugar chocolate composition, the method comprising steps of:
    a) Mixing the cocoa butter and an emulsifier to form a mixture;
    b) Heating the mixture;
    c) Adding the water and mixing to form the water-in-oil emulsion;
    d) Adding one or more additional ingredients of chocolate;
    e) Adding a natural sugar in less than 45% by weight of the total composition to form a chocolate composition.

20. A method of manufacturing a low sugar chocolate composition of Claim 19, in which the natural sugar is added in step e) in less than 35% by weight of the total composition.

21. A method of manufacturing a low sugar chocolate composition of Claim 20, in which the natural sugar is added in step e) in less than 25% by weight of the total composition, say 12.5% by weight of the total composition.

22. A method of manufacturing a low sugar chocolate composition of Claim 21, in which the natural sugar is selected from one or more of glucose, fructose, sucrose, lactose, maltose, trehalose, cellobiose or maltodextrins.

23. A method of manufacturing a low sugar chocolate composition of Claim 22, comprising cocoa butter which is unrefined and contains natural waxes.

24. A method of manufacturing a low sugar chocolate composition of Claim 23, in which the concentration of the emulsifier is between 1 to 5% by weight of the water-in-oil emulsion.

25. A method of manufacturing a low sugar chocolate composition of Claim 24, in which the emulsifier is polyglycerol polyricinoleate (PGPR) (E476).

26. A method of manufacturing a low sugar chocolate composition of Claim 25, in which the one or more additional ingredients of chocolate are selected from one or more of cocoa solids, milk powder, cocoa liquor, cocoa powder, artificial sweeteners, flavourings, fruits, nuts, biscuit pieces, candy particles, and/or colourings.

27. A method of manufacturing a low sugar chocolate composition of Claim 26, in which step d) takes place concurrently with step a).

28. A method of manufacturing a low sugar chocolate composition of Claims 25 or 26, in which mixture of cocoa butter and emulsifier is heated in step b) to a temperature of between 55 to 65°C.

29. A method of manufacturing a low sugar chocolate composition of Claim 28, in which a margarine line comprising a scrape surface heat exchanger and pin stirrer are employed.

30. A method in accordance with any one of Claims 19 to 29, further comprising a step f) of holding or maintaining the chocolate composition at a temperature of above 27°C to 31°C.

31. A method according to Claim 30, wherein step f is completed by cooling to 5 to 25°C, reheating and holding or maintaining the chocolate composition at a temperature of above 27°C to 31°C and then cooling.

32. A method according to Claim 30 or 31, further comprising holding or maintaining the chocolate composition at a temperature of above 27°C to 31°C and cycling the temperature upwardly and downwardly by +1°C, +2°C or +3°C one, two or or more times.

33. A method of manufacturing a low sugar chocolate composition of any preceding Claim, in which Form V fat crystals are formed in the final low sugar chocolate composition.

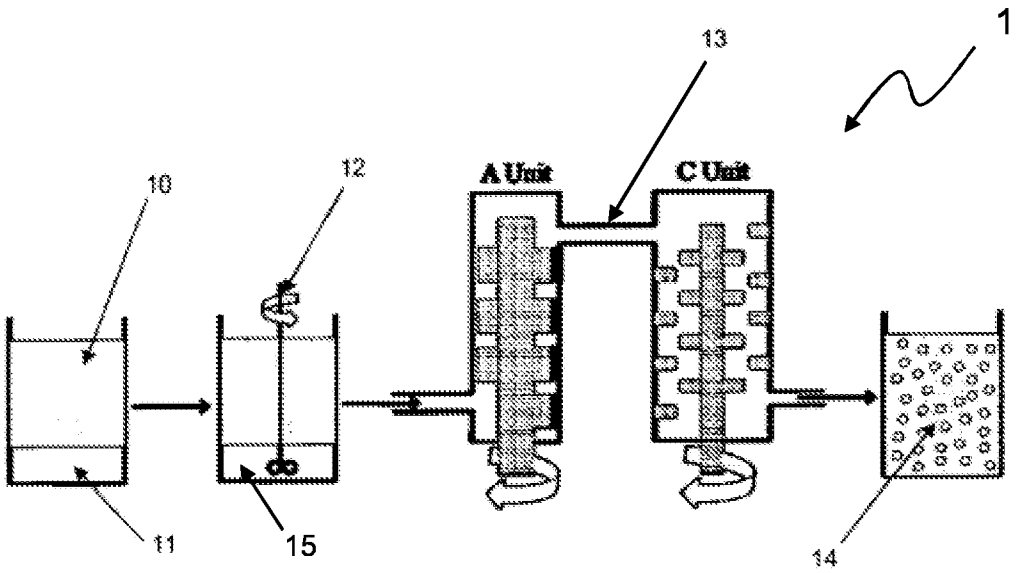


FIGURE 1

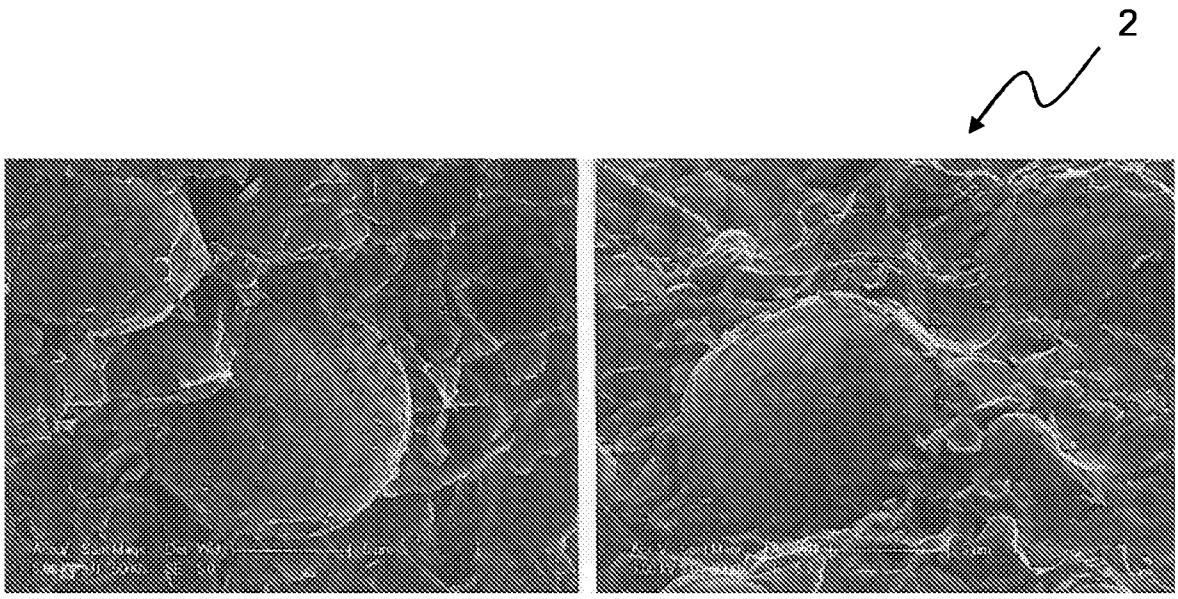


FIGURE 2

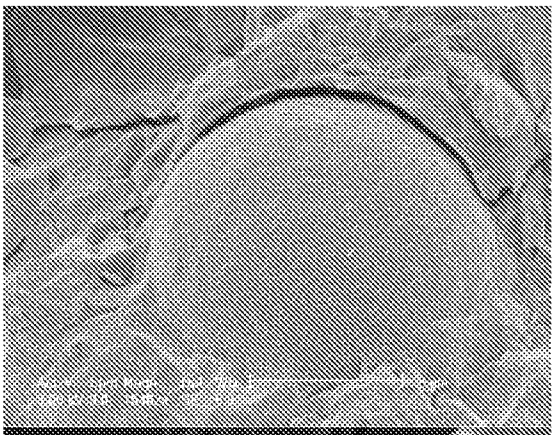


Figure 3

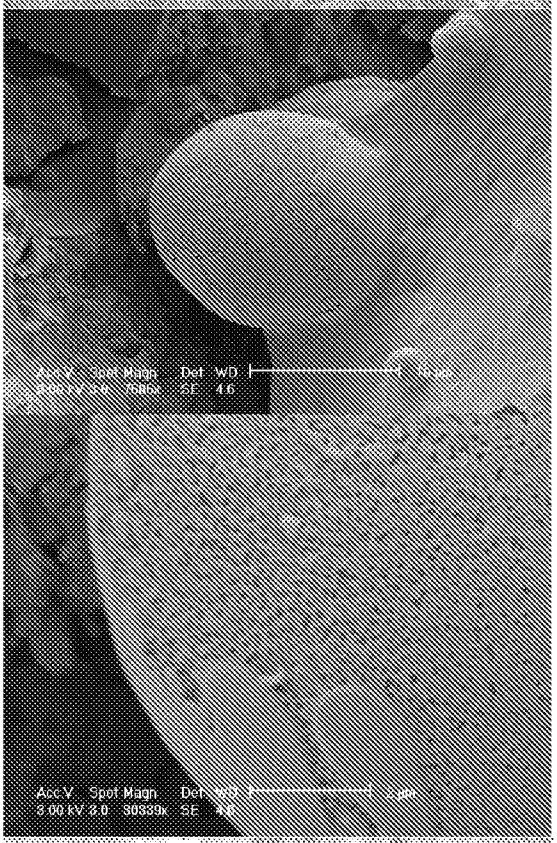


Figure 4

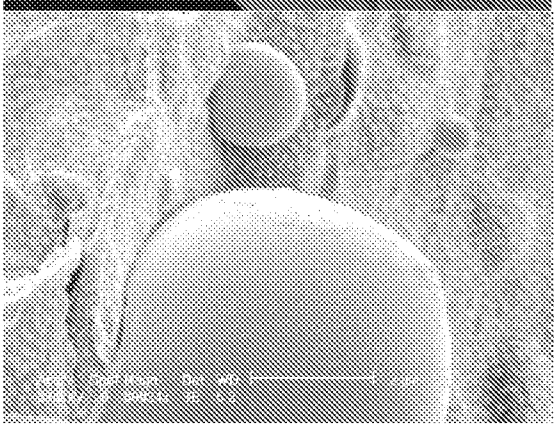


Figure 5

Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2018/050939

A. CLASSIFICATION OF SUBJECT MATTER
INV. A23G1/32 A23G1/36 A23G1/40 A23L33/20 A23G1/50
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A23G A23L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	claims 1,15; examples 1-3	19-33

X	US 2008/187629 A1 (BECKETT STEPHEN THOMAS [GB] ET AL) 7 August 2008 (2008-08-07)	1-28, 30-33
Y	paragraph [0035] - paragraph [0036]; claim 1; examples 1,2	29
	paragraph [0026]	
	paragraph [0025]	

A	Stephen T. Beckett: "Industrial Chocolate Manufacture and Use: Fourth Edition", 2009, Blackwell Publishing, XP002781586, ISBN: 978-1-405-13949-6	1-33
	page 268 - page 271; tables 6.1,6.2,20.1	
	page 89	

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
4 June 2018	12/06/2018

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2018/050939

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2016/037791 A1 (DE BARI VINCENZO [IT] ET AL) 11 February 2016 (2016-02-11) Examples; claims 1,11,12,7 -----	1-33 29

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