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(54) Title: FOOD OR FEED INCLUDING MORINGA OIL

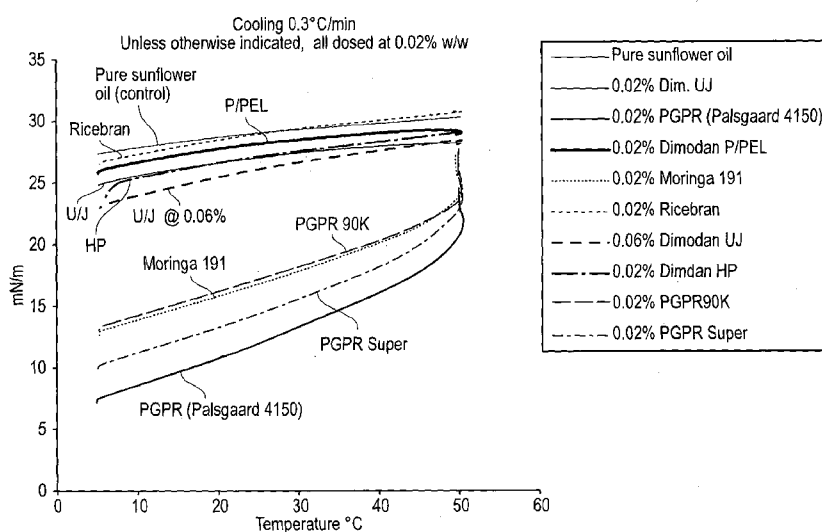


FIG. 1

(57) Abstract: The present invention provides a food or feed comprising (i) a foodstuff (ii) a mono or di ester of glycerol and Moringa oil.



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FOOD OR FEED INCLUDING MORINGA OIL

FIELD OF INVENTION

- 5 The present invention relates to a food or feed. In particular, the present invention relates to a food or feed comprising an emulsifier derivable from a food source and which is advantageous over prior emulsifiers.

BACKGROUND

10

An emulsion is a colloid consisting of a stable mixture of two immiscible phases, typically liquid phases in which small droplets of one phase are dispersed uniformly throughout the other. A typical emulsion is an oil and water emulsion, such as a water-in-oil emulsion. Emulsions may, for example, be industrial emulsions such as water-
15 containing crude oils emulsified by addition of surface active substances, or edible emulsions such as mayonnaise, salad cream or margarine.

Emulsions are typically stabilised by the addition of an emulsifier and many effective emulsifiers are known. Many frequently used emulsifiers are mono or di esters of fatty
20 acids and glycerol. However, providing a source of suitable fatty acids can be problematic. Fatty acids are typically provided from triglycerides and these are sourced from triglycerides oils of natural sources. Many well known sources of oils are plants, animals and fish. However, there is an increasing demand for certain of these oils and many oils which are becoming unacceptable to consumers for ethical or health reasons.
25 There is therefore a desire to provide monoglycerides prepared from source oils which are easily grown, not in high demand, are ethically acceptable and which have a fatty acid profile which provides for an effective emulsifier.

In view of the above, it would be desirable to produce a food or feed containing an
30 emulsifier which has effective emulsifying properties and which is sourced in a manner acceptable to consumers.

SUMMARY ASPECTS OF THE PRESENT INVENTION

- 35 In one aspect, the present invention provides a food or feed comprising (i) a foodstuff; and (ii) a mono or di ester of glycerol and Moringa oil.

In one aspect, the present invention provides an emulsifier composition comprising (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil.

- 5 In one aspect, the present invention provides a food or feed comprising (i) a foodstuff; (ii) an emulsifier composition comprising (a) polyglycerol polyricinoleic acid, and (b) a mono or di ester of glycerol and Moringa oil.

- 10 In one aspect, the present invention provides a process for preparing a food or feed comprising as defined herein, comprising the steps of contacting (i) a foodstuff and (ii) a mono or di ester of glycerol and Moringa oil.

In one aspect, the present invention provides use of a mono or di ester of glycerol and Moringa oil to prepare a food or feed.

15

It has been surprisingly found that oil from plants from the genus *Moringa* may be used in the preparation of mono or di esters of glycerol, commonly known to one skilled in the art as mono- and diglycerides, which may be effective emulsifiers for use in food or feed. The *Moringa* plant is particularly advantageous as a source of oil to prepare the mono- and diglycerides because the plant has been known as a source of edible materials for many years. Therefore the oil obtained from the plant may be regarded as safe for consumption. The use of mono and diglycerides prepared from *Moringa* oil has not previously been taught for such applications.

20

- 25 *Moringa* is the sole genus in the flowering plant family Moringaceae. The 13 species it contains are from tropical and subtropical climates and range in size from tiny herbs to very large trees. *Moringa* may therefore be grown in many climates in which cash crops may not currently be cultivated. *Moringa* cultivation is promoted as a means to combat poverty and malnutrition and the plant grows quickly in many types of environments. The seeds contain 30-50% oil and may produce 100-200 gal/acre/year. *Moringa* species are drought-resistant and can grow in a wide variety of poor soils, even barren ground, with soil pH between 4.5 and 9.0.

30

DETAILED DESCRIPTION

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As discussed above, in one aspect, the present invention provides a food or feed comprising (i) a foodstuff; and (ii) a mono or di ester of glycerol and Moringa oil.

Moringa

5

It will be appreciated by one skilled in the art that the term 'Moringa' refers to the sole genus in the flowering plant family Moringaceae.

As discussed in Pandey A., Pradheep, K., Gupta, R., Roshini Nayar, E., Bhandari, D.C.,
 10 (2010) Drumstick tree, *Moringa oleifera* Lam, a multipurpose potential species in India, Genetic Resources and Crop Evolution, Springer, the genus *Moringa* Adans. (family Moringaceae) has more than 13 species (Verdcourt 1985), of which two species viz. *M. oleifera* Lam. (syn. *M. pterygosperma* Gaertn.) and *M. concanensis* Nimmo occur in India. *M. oleifera* (the drumstick tree, horse radish tree, West Indian Ben) is a fast-growing,
 15 medium sized and drought-resistant tree distributed in the sub-Himalayan tracts of northern India (Singh et al. 2000; Hsu et al. 2006). The species of *Moringa* are further discussed in Bennet, R.N., Mellon, F.A., Foidl, N., Pratt, J.H., DuPont, M.S., Perkins, L., and Kroon, P.A. (2003) "Profiling gluconsinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees, *Moringa oleifera* L. (horseradish tree) and *Moringa stenopetalia* L." Journal of Agricultural and Food Chemistry 51(12) 3546-
 20 3553. *M. oleifera* (locally called shobhanjana, murungai, soanjna, shajna, sainjna) is considered to be the best known and widely distributed tree species among the genus (Morton 1991; Fuglie 1999). This is the only species in this genus which has been accorded some research and development at the world level.

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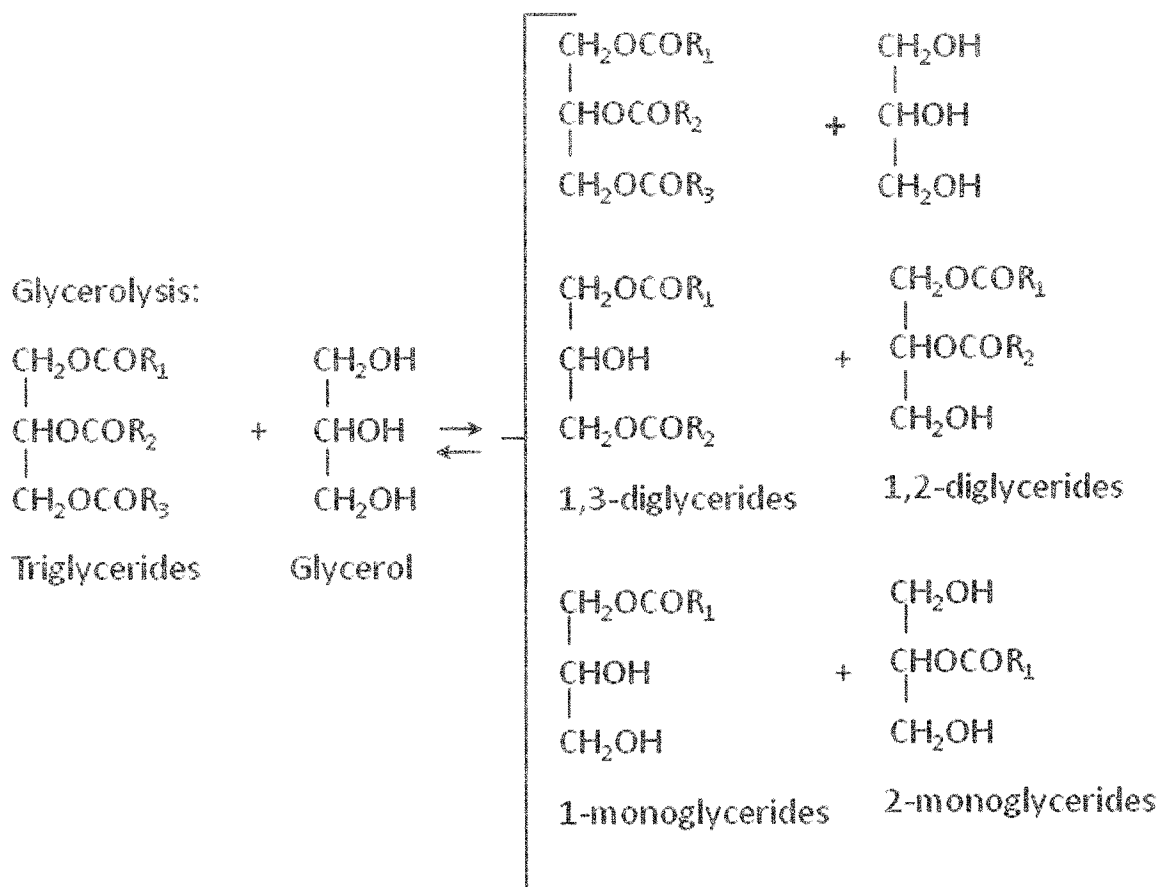
For completeness, the current known species of the plant family Moringaceae are *Moringa arborea* Verdc. (Kenya), *Moringa borziana* Mattei, *Moringa concanensis* Nimmo, *Moringa drouhardii* Jum. – Bottle Tree (southwestern Madagascar), *Moringa hildebrandtii* Engl. – Hildebrandt's Moringa (southwestern Madagascar), *Moringa longituba* Engl.,
 30 *Moringa oleifera* Lam. (syn. *M. pterygosperma*) – Horseradish Tree (northwestern India), *Moringa ovalifolia* Dinter & Berger, *Moringa peregrina* (Forssk.) Fiori, *Moringa pygmaea* Verdc., *Moringa ruspoliana* Engl., *Moringa rivaie* (Kenya, Ethiopia and Somalia) and *Moringa stenopetala* (Baker f.) Cufod.

35 In a preferred aspect the Moringa is a plant of the species *Moringa oleifera*.

Mono or Di Ester Of Glycerol And Moringa Oil

The process for making mono or di esters of fatty acids and glycerol, in other words mono and diglycerides and the process for making distilled monoglycerides are well known to the person skilled in the art. For example information can be found in "Emulsifiers in Food Technology", Blackwell Publishing, edited by R. J. Whitehurst, page 40-58.

Mono- and diglycerides are generally produced by interesterification (glycerolysis) of triglycerides with glycerol, see fig. below:



Triglycerides react with glycerol at high temperature (200-250°C) under alkaline conditions, yielding a mixture of monoglycerides, diglycerides and triglycerides as well as unreacted glycerol. The content of monoglycerides varies typically from 10-60% depending on the glycerol/fat ratio. Alternatively mono- and diglycerides may also be prepared via direct esterification of glycerol with a fatty acid mixture.

If glycerol is removed from the mixture above by e.g. distillation, the resulting mixture of monoglycerides, diglycerides and triglycerides is often sold as a "mono-diglyceride" and used as such. Distilled monoglyceride may be separated from the mono-diglyceride by
5 molecular or short path distillation.

Usage

The mono or di ester of glycerol and Moringa oil may be provided in the food or feed in
10 the desired amount to achieve the desired function of the mono or di ester of glycerol and Moringa oil.

In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 0.01% w/w based on the total weight of the food or
15 feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 0.02% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 0.05% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is
20 present in the food or feed in an amount of at least about 0.1% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 0.2% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 0.5% w/w based
25 on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 1.0% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 1.2% w/w based on the total weight of the food or feed. In one embodiment, mono or di
30 ester of glycerol and Moringa oil is present in the food or feed in an amount of at least about 1.5% w/w based on the total weight of the food or feed.

In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.01 to about 2.0% w/w based on the total weight of the
35 food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.02 to about 2.0% w/w based on the total

weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.05 to about 2.0% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.1 to about 2.0% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.2 to about 2.0% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.5 to about 2.0% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.5 to about 1.5% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 0.8 to about 1.5% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 1.0 to about 1.5% w/w based on the total weight of the food or feed. In one embodiment, mono or di ester of glycerol and Moringa oil is present in the food or feed in an amount of from about 1.0 to about 1.2% w/w based on the total weight of the food or feed.

Food or Feed

In addition to providing a food or feed containing a mono or di ester of glycerol and Moringa oil, the present invention provides a process for preparing the food or feed. Thus there is provided a process for preparing a food or feed comprising as defined herein, comprising the steps of contacting (i) a foodstuff and (ii) a mono or di ester of glycerol and Moringa oil. In a further aspect, the present invention provides use of a mono or di ester of glycerol and Moringa oil to prepare a food or feed.

According to the present invention, "food" refers to an edible material suitable for human consumption. According to the present invention, "feed" refers to an edible material suitable for non-human animal consumption.

In one aspect the food or feed is a food. In one aspect the food or feed is a feed

The foodstuff may be solid or liquid. In some cases, the foodstuff may transform during cooking from a solid to a liquid. Furthermore, foodstuffs comprising a combination of liquid and solid components are also encompassed by the present invention.

- 5 Examples of foodstuffs in which the present invention may be employed include, but are not limited to spreads, bakery margarine, cake margarine, ice cream, liquid bread improvers, whipped frozen desserts, ice cream, beverages including cola drinks, sausages, burgers, reconstituted meat, reconstituted fish, non-emulsified salad dressings, extruded foodstuffs including tortilla chips, breakfast cereals and corn snacks; biscuits,
10 baked goods including breads and pastries, anhydrous dispersions and semi-solid food products..

In one embodiment, the foodstuff is selected from the group consisting of spreads, bakery margarine, cake margarine, ice cream, liquid bread improvers. In one preferred
15 aspect the foodstuff is selected from whipped frozen desserts. A particularly preferred whipped frozen dessert is an ice cream. It is understood that the present emulsifier provides whipped frozen desserts and ice cream in particular which may have improved eating quality and has improved aging properties, that is aging has a less detrimental impact on the ice cream, for example ice crystal growth is minimised during aging.

20

In one embodiment, the food or feed is selected from a combination of one or more foodstuffs.

The mono or di ester of glycerol and Moringa oil has emulsifying properties. However, it
25 is not essential that the food or feed be an emulsion. For example, there are certain application areas where emulsifiers are desired but the food stuff itself is not an emulsion. Examples of these are beverages including cola drinks, sausages, burgers, reconstituted meat, reconstituted fish, non-emulsified salad dressings, extruded foodstuffs including tortilla chips, breakfast cereals and corn snacks; biscuits, baked goods including breads
30 and pastries, anhydrous dispersions and semi-solid food products such as tahini(a), ghee, vanaspati, peanut butter and peanut paste, praline and hazelnut spread. The products of the present invention are capable of stabilizing the dispersion when crystallized fat particles are present as in ghee and vanaspati, and are capable of stabilizing oil separation and protein as in the case of peanut butter and peanut paste,
35 praline and hazelnut spread. However, emulsifiers are typically used to prepare emulsions and in one preferred aspect, the present invention provides a food or feed

wherein the food or feed is an emulsion. The emulsion may be a single emulsion, such as an oil in water emulsion or a water in oil emulsion. Further the emulsion may be a double emulsion, such as an oil in water in oil emulsion or a water in oil in water emulsion

5

In respect of all emulsions it has been found that the present invention is particularly advantageous because we have further found that as well as being an effective emulsifier, the mono or di ester of glycerol and Moringa oil has particular advantages in respect of the stability of emulsions formed by its use as an emulsifier. The present
10 applicants have surprisingly found that an emulsion prepared using the Moringa mono and diglycerides may be sufficiently stable to be used in demanding application but which is not overly stable. Thus if it is desired, the emulsion may be separated into its component phases. Separating an emulsion into its component phases may find application in many different fields and in particular in the food industry. The present
15 invention may be used in one aspect to separate oil and water emulsions, such as water in oil emulsions, for example edible spreads. The oil phase thus separated may be reused in the production of further edible spreads. The water phase thus separated may be reliably analysed to provide information on the composition, in particular the salt content, of the initial spread.

20

Thus in a further aspect the present invention provides use of a mono or di ester of glycerol and Moringa oil to prepare a food or feed emulsion wherein the emulsion may be separated into its constituent phases.

25 In respect of double emulsions the present invention is further advantageous because long chain fatty acids and/or essential oils present in the double emulsion are effectively encapsulated by the emulsion provided by the Moringa monoglyceride. This degree of encapsulation protects the long chain fatty acids and/or essential oils from degradation. Yet further, we have found that because of the high affinity of the Moringa monoglyceride
30 for water, similar to the high affinity shown by polyglycerol polyricinoleic acid (PGPR) for water, the Moringa monoglyceride can exhibit PGPR like properties in double emulsions, for example the Moringa monoglyceride may protect salt and the like held within an internal water phase.

35 Preferred double emulsions may be selected from mayonnaise, low fat spread, peanut butter, hazelnut butter, chocolate spread, and spread containing hazelnut and cocoa.

Preferred feeds in accordance with the present invention may be selected from poultry feed, aqua culture feed, bovine feed and porcine feed. A preferred feed is a feed pellet for fish.

5

Polyglycerol Polyricinoleic Acid (PGPR)

The present inventors have identified that the mono or di ester of glycerol and Moringa oil has a significant number of emulsifying properties similar to that of polyglycerol polyricinoleic acid. These are discussed in detail herein. Therefore in aspects of the invention the present emulsifier may be used to replace PGPR in applications where PGPR is typically used. This replacement may be complete replacement or partial replacement. In respect of partial replacement, in that aspect the present invention provides a food or feed as defined herein further comprising polyglycerol polyricinoleic acid. In other words, the present invention provides a food or feed comprising (i) a foodstuff; (ii) an emulsifier composition comprising (a) polyglycerol polyricinoleic acid, and (b) a mono or di ester of glycerol and Moringa oil. Indeed, one skilled in the art will appreciate that the present emulsifier and the PGPR may be provided as an emulsifier composition for use in the preparation of emulsions. Thus, in one aspect, the present invention provides an emulsifier composition comprising (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil.

The use of Moringa monoglycerides in food applications could lead to significant benefits for the customer if these monoglycerides can be used to partially or completely replace polyglycerol polyricinoleic acid (PGPR) based products. Such benefits would likely include; improved production yield (attributed to less down time), allow re-work to occur more easily, and potentially enable the removal of E476 from labelling. It is not clear which of these benefits is most attractive to the customer, but each represents a significant advantage.

30

Mono or di ester of glycerol and Moringa oil may be prepared at concentrations which are suitable for use in foodstuffs according to recommended daily guidelines.

Alternatively, they may be prepared at higher concentrations and subsequently diluted to a concentration which is suitable for use in foodstuffs according to recommended daily guidelines. Where the composition is prepared at the higher concentration, the

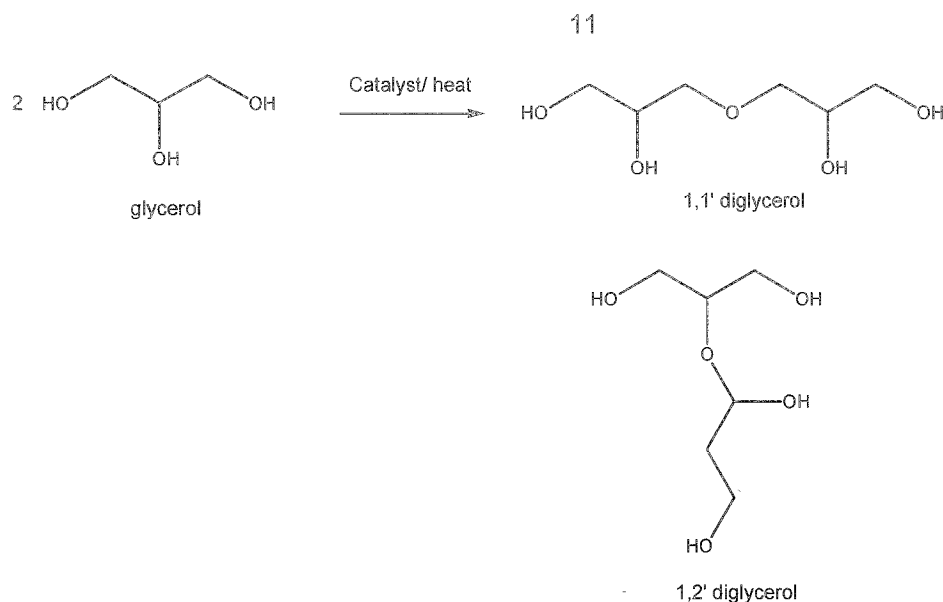
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composition may comprise (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 10wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 20wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 30wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 40wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 50 wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 60 wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 70wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 80wt. %. In one embodiment, the composition comprises (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil in a combined amount of at least 90wt. %. In one embodiment, the composition consists essentially of (a) polyglycerol polyricinoleic acid; and (b) a mono or di ester of glycerol and Moringa oil.

In this regard, "consisting essentially of" is defined herein as meaning that in addition to the components which are recited, other components may also be present in the composition, provided that the essential characteristics of the composition are not materially affected by their presence.

Polyglycerols

Polyglycerols are substances consisting of oligomer ethers of glycerol. Polyglycerols are usually prepared from an alkaline polymerisation of glycerol at elevated temperatures.



Scheme 1 - Overview of the production of polyglycerols

The processes for making polyglycerols are well known to the person skilled in the art and can be found, for example, in "Emulsifiers in Food Technology", Blackwell Publishing, edited by RJ Whithurst, page 110 to 130.

It will be understood that the degree of polymerisation can vary. It will be understood that polyglycerol is typically a mixture of polyglycerols of varying degrees of polymerisation. In one embodiment, the polyglycerol used to form the polyglycerol ester of a polymerised fatty acid is a mixture of polyglycerols selected from diglycerol, triglycerol, tetraglycerol, pentaglycerol, hexaglycerol, heptaglycerol, octaglycerol, nonaglycerol and decaglycerol. In one preferred embodiment triglycerol is the most abundant polyglycerol in the mixture of polyglycerols. In one preferred embodiment tetraglycerol is the most abundant polyglycerol in the mixture of polyglycerols. In one preferred embodiment the mixture of polyglycerols contains triglycerol in an amount of 30-50 wt% based on the total weight of polyglycerols and contains tetraglycerol in an amount of 10-30 wt% based on the total weight of polyglycerols..

In one embodiment, the polyglycerol is considered to be a diglycerol. In one embodiment, the polyglycerol is considered to be a triglycerol. In one embodiment, the polyglycerol is considered to be a tetraglycerol. In one embodiment, the polyglycerol is considered to be a pentaglycerol. In one embodiment, the polyglycerol is considered to be a hexaglycerol. In one embodiment, the polyglycerol is considered to be a heptaglycerol. In one embodiment, the polyglycerol is considered to be an octaglycerol.

In one embodiment, the polyglycerol is considered to be a nonaglycerol. In one embodiment, the polyglycerol is considered to be a decaglycerol.

Preferably the polyglycerol is considered to be a triglycerol. Preferably the polyglycerol
5 is considered to be a tetraglycerol.

In one embodiment, the polyglycerol moiety shall be composed of not less than 75% of di-, tri- and tetraglycerols and shall contain not more than 10% of polyglycerols equal to or higher than heptaglycerol.

10

Polyglycerols may be linear, branched or cyclic in structure. Typically, all three types of polyglycerol structure are present in the composition of the present invention.

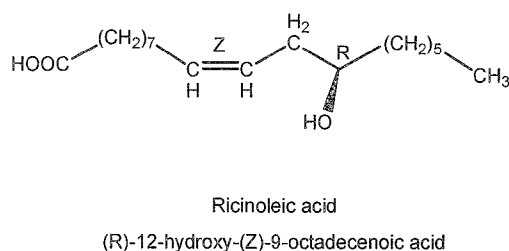
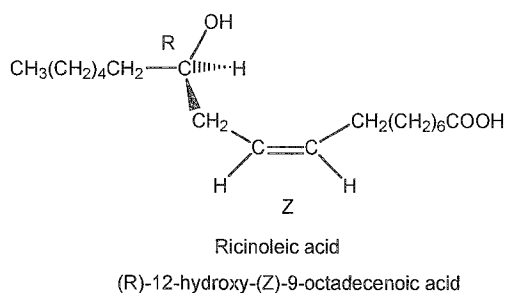
Fatty acids

15

Fatty acids are well known in the art. They typically comprise an "acid moiety" and a "fatty chain". The properties of the fatty acid can vary depending on the length of the fatty chain, its degree of saturation, and the presence of any substituents on the fatty chain. Examples of fatty acids are palmitic acid, stearic acid, oleic acid, and ricinoleic
20 acid.

The fatty acid used according to this aspect of the present invention is ricinoleic acid.

Ricinoleic acid is a chiral molecule. Two steric representations of ricinoleic acid are
25 given below:



Scheme 2 - Configurations of ricinoleic acid.

30

The ricinoleic acid used in the present invention may be prepared by any suitable means known to the person skilled in the art. Typically, fatty acids are produced from a parent oil via hydrolyzation and distillation.

5 BRIEF DESCRIPTION OF FIGURES

Figures 1 to 4 show graphs;

Figures 5 to 9 show images;

Figure 10 shows a graph;

10 Figures 11 to 13 show images;

Figures 14 and 15 show graphs;

Figures 16 to 18 show images; and

Figures 19 to 21 show graphs.

15 EXAMPLES

The present invention will now be defined with reference to the following non-limiting examples.

20 INTRODUCTION

The present examples provide evidence concerning interfacial tension measurements in respect of monoglycerides of Moringa oil and also compares differences between the performance of monoglyceride based on Moringa oil and the functionality of C₂₂ behenic acid rich monoglycerides (such as GRINDSTED® CRYSTALLIZER 110) typically used
25 as an emulsifier in demanding food systems.

EXPERIMENTAL

30 The key experimental techniques of rheology, microscopy, water droplet size determination and interfacial tension measurement are described below.

Rheology

35 Rotational rheometer

Investigation of bulk oil blends subjected to the effects of controlled cooling rate while under shear were analysed using a shear stress controlled rotational rheometer Rheometrics SR 5 (proRheo, Germany) controlled stress rheometer operating in simulated rate control mode. Target shear rate of 10 s⁻¹. Crystal history was removed
5 through melting and holding to 90°C for 15 minutes before loading onto the rheometer. A thermoelectric cooling plate using Peltier effect cooling, with parallel plate geometry (40mm diameter top plate. Gap = 1mm) and a temperature ramp 70°C to 25°C at either 1°C/min, 10°C/min, 30°C/min, was used. A 2 minute delay without shear at 70°C prior to thermo-cooling was also used.

10

The fat blend used in all cases comprised of a base of 70% palm stearine (35 IV) and 30% palm olein (56 IV), to which the emulsifiers GRINDSTED® CRYSTALLIZER 110, GRINDSTED® PGPR 90, and Monoglycerides of Moringa were added at 1%, 0.5% and 1% respectively.

15

Microscopy

Polarized light microscopy (PLM):

Introduction:

20 Polarized light microscopy images are useful to observe effects of environmental conditions on lipid crystallisation behaviour as a consequence of thermal manipulation. The treatment of several emulsions and bulk continuous systems to Isothermal and non-isothermal conditions can provide strong correlations to actual crystallisation behaviour within TAG continuous commercial food systems.

25

Method:

Several analyses of W/O emulsions and continuous bulk oil phase systems were observed using an Olympus BX60 optical microscope (Serial no: 6M02546), fitted with polarized filter (Olympus Optical Co. GmbH. Hamburg, Germany). The desired amount of
30 sample (~40 mg) is placed on a carrier glass slide which has been pre-cooled or preheated to ~5°C. A cover slip was then placed parallel to the plane of the carrier slide and centred on the drop of sample to ensure uniformity and desirability of sample thickness. The micrograph of the crystal was taken at 40x and 200x magnification unless otherwise indicated. A number of images were acquired each representing a typical field.

35

Induction heat /cool /micrograph images:

- Micrograph images were collected in polarised light using an Evolution Color-camera (MP 5.0 RTV 32-0041C-309) supplied from Media Cybernetics (Media Cybernetics, Inc.USA.) attached to the Olympus BX60 optical microscope with following parameters: Heat step 50°C/minute to 80°C, tempering for 2 minutes. Then cool 1°C/minute -
- 5 10°C/minute - 50°C/minute and 100°C/minute to 20°C.
- 1°C/minute every 30 seconds.
- 10°C/minute every 10 seconds.
- 50°C/minute every 3 seconds.
- 100°C/minute every 3 seconds.
- 10 More images were collected at 100°C/min to 20°C, using longer induction time whereby images were taken every 30 seconds for 5 minutes.

Water Droplet Size Determination

Droplet size distribution

15

Introduction:

- One of the important features of an emulsion is its Droplet Size Distribution (DSD). The droplet size influences many characteristics, for instance the rheology (Asano et al. 1999; Opedal et al 2009), and the stability of an emulsion (Basheva 1999) and emulsion
- 20 liquid membrane performance (Chakraborty et al. 2003). Droplet size distribution in low-fat spread is important with respect to appearance, flavour release and microbiological stability. In protein-containing low-fat spreads, stabilisers are added to secure emulsion stability. These also have a profound effect on water droplet size.

Method:

- Pulsed NMR analysis using a pulsed gradient unit Bruker Minispec mq 20, 20MHz low field pulsed pNMR Analyzer, Magnet unit ND2172, equipped with a Pulsed Gradient Unit 1059. High / low temperature probehead assembly mq-PA231 (-120°C - +200°C). Software: SSL, system status logging. CONTIN transformation. Pulsed gradient system
- 30 for 10mm tubes (10 x 180 x 0.6mm = diameter x length x thickness). Mq-SOFT EDMs Oil droplets / Water droplets and Diffusio. Bruker gas tempering unit for high and low temperature analysis: mq-BVT3000c (for minispec probe PA231). Measurements are performed at 20°C and field gradients of 2.0 T/m or higher.

Analytical principle:

35

A Hahn spin echo experiment with field gradient pulses involves calculating the reduction in spin echo amplitude compared with the Hahn spin echo amplitude without field gradient pulses (R).

- 5 Determining diffusion coefficient of water molecules If protons can move unhindered in the liquid, then free diffusion is taking place, and the diffusion coefficient D can be determined directly from R.

- Determining droplet size distribution in w/o emulsions If proton movement is restricted by the boundaries of a droplet, an R value plateau is obtained reflecting the droplet size. When measuring at several pulse lengths, the corresponding R plateau values give a fingerprint of the droplet size distribution. Measurements are performed at 5°C and with 8 R values. Log-normal particle size distribution is typically seen in w/o emulsions and is used in the mathematical calculation of droplet size distribution. Results are given as volume and number size distribution
- 10
- 15

2.5 % of droplet volume is smaller than "x" μm

50% of droplet volume is smaller than "x" μm .

97.5 % of droplet volume is smaller than "x" μm .

- 20 and derived from a log-scale using values of the following standardized normal distribution

$$\begin{array}{ccc} 2.5\% < \mu & 50\% < \mu & 97.5\% < \mu \\ (d_{\text{lower}}) & (d_{50,3}) & (d_{\text{upper}}) \end{array}$$

Interfacial Tension Measurement

- 25 **Tensiometry Materials and methods**

Solvent:

Refined, bleached and deodorized sunflower oil, iodine value 127, was obtained from AAK (Aarhus, Denmark). Purification was then carried out using the following procedure:

- 30 Mix 30g of Fluorisil PR60/100 mesh (Sigma-Aldrich Denmark A/S) with 500g Sunflower Oil in a vessel. The mixture was stirred for 60 min at 80°C, and protected from UV light. After cooling over 12hrs, the sunflower oil was passed slowly at room temperature through a glass column with filter paper (glass fiber GA55, 47 mm) into 800ml UV light

protected beaker. This procedure results in the sunflower oil having an interfacial tension at 20°C of 28-30mN/m (oil – water)

Preparation of samples

- 5 Oil phase: Emulsifiers were weighed for tensiometer and rheology measurements at 0.02% w/w (unless otherwise indicated) and the RBD sunflower oil balanced to 100%. The preparation is heated to 10°C above melting point of emulsifier, and held for 1 hour, then cooled to ambient temperature and deaerated (~12hrs). Water phase: Demineralised water is deaerated using a Desiccator (Sigma-Aldrich, Denmark A/S.
- 10 Copenhagen, Denmark). Both phases are ready to use after heating to 50°C.

Interfacial Tension

The interfacial tension of oil/water systems was measured on a Digital-Tensiometer, model K10ST (Krüss Germany), using the Wilhelmy plate method, and recorded

15 continuously by connecting a high resolution data recorder (PicoLog ADC-20, using PicoLog for windows 5.13.4 from Pico Technology Ltd, Cambridgeshire. United Kingdom) connected to the tensiometer. A second channel on the recorder was used to monitor the temperature of the oil/water system in the tensiometer. The oil/water phase was controlled by a programmable water bath (model: Thermo Haake® DC10-K10,

20 refrigerated circulator. Sigma-Aldrich, Denmark A/S. Copenhagen, Denmark), which allowed the temperature to be changed from 50°C to 5 °C. Prior to initializing measurement the tensiometer K10ST was calibrated for the oil phase to show more than 27mN/m at 20°C and held constant for 15 min, enabling both oil and instrument to reach equilibrium constant.

- 25 Measurements were started at 50 °C after preheating the oil phase and the water phase to 50 °C separately. Prior to commencing with a temperature sweep, the interfacial tension was measured at 50°C for 5 minutes to whereby a state of equilibrium between the oil and water phases is thought to be obtained. Then the temperature was decreased
- 30 to 5°C at 0.3°C/min and kept at 5 °C for 5 minutes.

MATERIALS

Moringa monoglyceride

The Moringa monoglyceride and distilled Moringa monoglyceride were prepared in several batches in accordance with the processes described below.

2472/173: Mono-diglyceride based on moringa oil. Interestification.

5 (Mono-diglyceride 173; Moringa Mono-diglyceride 173; Moringa 173; MM 173)

Refined moringa oil (Code: 126089, Batch Nr: DEO5040243, EO Ref: SO4903823/1, from Earth Oil Plantations Limited). 2550g. The moringa oil was extracted from *Moringa oleifera* (also known as *Moringa pterygosperma*).

10 Glycerol 625g.

1.300g 50% solution of NaOH.

Above ingredients were charged to a 5L 3-necked round bottomed flask, with mechanical stirring, heating mantel with temperature control, nitrogen blanketing,

15 condenser, in a set-up analogous to the below example:

The temperature was raised to 240°C under stirring and nitrogen blanketing. The mixture was heated at 240°C until it became clear. When clear, the mixture was heated for further 30 min.

20 The mixture was then neutralised with 1.25g H₃PO₄ (85%) at 240°C. After neutralisation the mixture was cooled to about 90°C.

The mixture was deodorised in order to remove the free glycerol. The set-up around the 3-necked flask was therefore changed to look like the below example of a deodorisation set-up:

25 Water vapours were introduced to the mixture via a glass tube at the bottom of the 3 necked flask below surface level of the mixture, a cold trap cooled by acetone/CO₂ bath was used and connected to a vacuum pump.

30 At 90°C full vacuum (<0,5 mm Hg) was supplied to the set-up from the vacuum pump. This causes thorough mixing of the product mixture. Then the mixture was heated to 140°C and kept at this temperature for 30 min. Water vapours were passing through the mixture thereby removing free glycerol which was condensed on the cold trap and collected in the receiver flask.

35 After 30 min the product was cooled to 90° and pressure equalised with nitrogen.

Optionally the filtered mono-diglyceride can be protected with antioxidants if the mono-diglyceride is the end product. Antioxidants were added and the mixture stirred for 15-30 min under nitrogen blanketing at 80-90°C.

Yield 2870g.

5

The mono-diglyceride was filtered through filteraid (Clarcell) and paper filter (AGF 165-110).

2472/191: Distilled monoglyceride based on moringa oil.

10 **(Mono-diglyceride 191; Moringa Mono-diglyceride 191; Moringa 191; MM 191)**

Mono-diglyceride (2472/173) 2480g.

The mono-diglyceride was distilled on a short path distillation apparatus.

15

The distillation temperature was 210°C.

Reservoir temp. before heated surface 85°C.

Condenser was 85°C.

Rotor speed 302 rpm.

20 Pressure: 1×10^{-3} mBar

Distillate 1373g

Residue 1107g

Time 212 min.

Flow: 701 g/h

25

The distillate was added antioxidant Grindox 349 0,68g.

Analysis of the distilled monoglyceride determined by GC:

	%
Glycerol	0.76
Diglycerol	0.07
Monoglyceride	91.15
Diglyceride	7.75
Triglyceride	0.00

Table 1: composition of monoglyceride based on moringa oil

30

The fatty acid composition of both the starting material, moringa oil, and the resulting monoglyceride was also analysed:

	Triglyceride (moringa oil)	Monoglyceride 2472/191
C12	0,2	<0,1
C14	0,1	0,1
C15	<0,1	<0,1
C16	5,9	6,5
C16:1	1,8	1,8
C18	5,5	5,8
C18:1	71,8	71,2
C18:2	1,6	1,5
C18:3	0	0,3
C20	3,3	3,4
C20:1	1,9	1,9
C22	6,3	6,0
C24	1,0	0,8

Table 2: Fatty acid composition of moringa oil and the resulting monoglyceride.

- 5 This analysis was done in order to confirm that the fatty acid composition of the monoglyceride had not changed too much from the starting material.

Moringa oil contains 10-12% of saturated fatty acids above C18. In order to keep these high melting fatty acids in the distilled monoglyceride the distillation temperature had to be chosen sufficiently high such that these at least were distilled. As can be seen from the above table this was accomplished. Transferring the highest boiling monoglyceride components however results in the monoglyceride as such having a higher content of diglyceride than is usually seen with distilled monoglycerides, but that is merely a consequence of the broad fatty acid composition in the moringa oil, and that the heavier monoglycerides were prioritised due to their also higher melting points.

2559/102: Mono-diglyceride based on moringa oil. Interesterification.

(Mono-diglyceride 102; Moringa Mono-diglyceride 102; Moringa 102; MM 102)

- 20 Refined moringa oil (Code: 126089, Batch Nr: DEO5040243, EO Ref: SO4903823/1, from Earth Oil Plantations Limited). **2072g.**

Glycerol **518g**

1.082g 50% solution of NaOH

The experiment was carried out as for above interesterification (2472/173).

5

After the interesterification, the mixture was neutralised with **1.04g** H_3PO_4 (85%) at 240°C . After neutralisation the mixture was cooled to about 90°C and the mixture was deodorised and filtered as for above interesterification (2472/173).

10 Yield: 2313g.

Analysis of mono-diglyceride:

	%
Glycerol	0.11
Diglycerol	0.05
Free fatty acids	0.2
Monoglyceride	53.16
Diglyceride	42.05
Triglyceride	4.39

Table 3: Composition of mono-diglyceride based on moringa oil

15 **2559/103: Mono-diglyceride based on moringa oil. Interesterification**
(Mono-diglyceride 103; Moringa Mono-diglyceride 103; Moringa 103; MM 103)
(repetition of 2559/102)

20 Refined moringa oil (Code: 126089, Batch Nr: DEO5040243, EO Ref: SO4903823/1,
from Earth Oil Plantations Limited). **2146g**.

Glycerol **537g**

1.110g 50% solution of NaOH

The experiment was carried out as for above interesterification (2472/173).

25

After the interesterification, the mixture was neutralised with **1.07g** H_3PO_4 (85%) at 240°C . After neutralisation the mixture was cooled to about 90°C and the mixture was deodorised and filtered as for above interesterification (2472/173).

Yield: 2412g.

Analysis of mono-diglyceride:

	%
Glycerol	0.16
Diglycerol	0.02
Free fatty acids	0.3
Monoglyceride	54.85
Diglyceride	39.59
Triglyceride	5.06

5 Table 4: Composition of mono-diglyceride based on moringa oil

2559/104: Distilled monoglyceride based on moringa oil.

(Mono-diglyceride 104; Moringa Mono-diglyceride 104; Moringa 104; MM 104)

- 10 The mono-diglyceride was distilled on a short path distillation apparatus as above (2472/191).

Mono-diglyceride (2559/102) + (2559/103) were both distilled.

The distillation temperature was 200-210°C.

- 15 Reservoir temp. before heated surface 85°C.

Condenser was 90°C.

Rotor speed 297 rpm.

Pressure: $4-5 \times 10^{-3}$ mBar

Distillate 2245g

- 20 Residue 1819g

Time 360 min.

Flow: 677 g/h

Analysis of distilled monoglyceride determined by GC:

	%
Glycerol	1.27
Diglycerol	0.08
Free fatty acids	0.4

Monoglyceride	82.55
Diglyceride	15.67
Triglyceride	0.02

Table 5: Composition of monoglyceride based on moringa oil

2559/105: Distilled monoglyceride above based on moringa oil with added antioxidant.

5 (Mono-diglyceride 105; Moringa Mono-diglyceride 105; Moringa 105; MM 105)

2559/104: 2245g

Grindox 349: 1.12g

10 2559/132: Distilled monoglyceride based on moringa oil.

(Mono-diglyceride 132; Moringa Mono-diglyceride 132; Moringa 132; MM 132)

Mono-diglyceride prepared analogously to above mono-diglycerides (2472/173) and with the following analysis was used as raw material for the distillation.

	%
Glycerol	0.16
Diglycerol	0.13
Free fatty acids	0.2
Monoglyceride	55.39
Diglyceride	39.50
Triglyceride	4.65

15 Table 6: Composition of mono-diglyceride used as raw material for distillation.

The mono-diglyceride was distilled on a short path distillation apparatus as above (2472/191).

20 The distillation temperature was 210°C.

Reservoir temp. before heated surface 85°C.

Condenser was 85°C.

Rotor speed 297 rpm.

Pressure: $1-2 \times 10^{-3}$ mBar

25 Distillate 1506g

Residue 1092g

Time 211 min.

Flow: 739 g/h

5 Analysis of distilled monoglyceride determined by GC:

	%
Glycerol	0.88
Diglycerol	0.15
Free fatty acids	0.2
Monoglyceride	86.92
Diglyceride	11.80
Triglyceride	0.03

Table 7: Composition of monoglyceride based on moringa oil

2559/134: Distilled monoglyceride based on moringa oil.

(Mono-diglyceride 134; Moringa Mono-diglyceride 134; Moringa 134; MM 134)

10

Mono-diglyceride prepared analogously to above mono-diglycerides (2472/173) and with the following analysis was used as raw material for the distillation.

	%
Glycerol	0.49
Diglycerol	0.11
Free fatty acids	0.2
Monoglyceride	54.51
Diglyceride	39.78
Triglyceride	4.92

Table 8: Composition of mono-diglyceride used as raw material for distillation.

15 The mono-diglyceride was distilled on a short path distillation apparatus as above (2472/191).

The distillation temperature was 185°C.

Reservoir temp. before heated surface 85°C.

20 Condenser was 85°C.

Rotor speed 290 rpm.

Pressure: $1-2 \times 10^{-3}$ mBar

Distillate 1407g

Residue 1444g

Time 223 min.

5 Flow: 767 g/h

Analysis of distilled monoglyceride determined by GC:

	%
Glycerol	0.52
Diglycerol	0.22
Free fatty acids	0.2
Monoglyceride	97.98
Diglyceride	1.06
Triglyceride	0.02

Table 9: Composition of monoglyceride based on moringa oil.

- 10 A summary of the analyses of samples 2559/132 and 2559/134 is given in Table 10 below.

	Monoglyceride	Monoglyceride	Triglyceride
	2559/132	2559/134	starting material
Distillation °C	210°C	185°C	
GL	0,88	0,52	
DIGL	0,15	0,22	
FFA	0,2	0,2	
MONO	86,92	97,95	
DI	11,80	1,06	
TRI	0,03	0,02	
C12	<0,1	<0,1	0,2
C14	0,1	0,1	0,1
C16	6,3	6,4	5,9
C16:1	1,9	1,9	1,8
C17	0,1	0,1	0,1
C18	5,5	5,7	5,5
C18:1	72,6	75,3	71,8
C18:2	1,5	1,5	1,6
C18:3	0,2	0,2	0,0
C20	3,2	2,9	3,3
C20:1	1,8	1,7	1,9

C20:u	0,2	0,2	0,1
C21	<0,1	0,0	
C22	5,8	3,6	6,3
C22:1	0,1	0,0	0,1
C23	<0,1	<0,1	1,0
C24	0,8	0,3	0,1

Table 10

2461/209: Mono-diglyceride based on moringa oil. Interesterification.

- 5 Refined moringa oil (Code: 126089, Batch Nr: DEO5040243, EO Ref: SO4903823/1, from Earth Oil Plantations Limited). **2100g**. The moringa oil was extracted from *Moringa oleifera* (also known as *Moringa pterygosperma*).

Glycerol **525g**.

0.76g 50% solution of NaOH.

10

Above ingredients were charged to a 5L 3-necked round bottomed flask, with mechanical stirring, heating mantel with temperature control, nitrogen blanketing, condenser, in a set-up analogous to the below example:

- 15 The temperature was raised to 240°C under stirring and nitrogen blanketing. The mixture was heated at 240°C until it becomes clear. When clear, the mixture was heated for further 30 min.

The mixture was then neutralised with **3.96g** H₃PO₄ (10%) in glycerol at 240°C. After neutralisation the mixture was cooled to about 90°C.

20

The mixture was deodorised in order to remove the free glycerol. The set-up around the 3-necked flask was therefore changed to look like the below example of a deodorisation set-up:

- 25 Water vapours were introduced to the mixture via a glass tube at the bottom of the 3 necked flask below surface level of the mixture, a cold trap cooled by acetone/CO₂ bath was used and connected to a vacuum pump.

At 90°C full vacuum (<0,5 mm Hg) was supplied to the set-up from the vacuum pump.

- 30 This caused thorough mixing of the product mixture. Then the mixture was heated to 140°C and kept at this temperature for 30 min. Water vapours were passing through the

mixture thereby removing free glycerol which was condensed on the cold trap and collected in the receiver flask.

After 30 min the product was cooled to 90° and pressure equalised with nitrogen.

- 5 Optionally the filtered mono-diglyceride can be protected with antioxidants if the mono-diglyceride is the end product. Antioxidants were added and the mixture stirred for 15-30 min under nitrogen blanketing at 80-90°C.

Yield 2626g.

- 10 The mono-diglyceride was filtered through filteraid (Clarcell) and paper filter (AGF 165-110).

Analysis of the monodiglyceride determined by GC:

	%
Glycerol	0.22
Diglycerol	0.05
Free fatty acids	0.30
Monoglyceride	54.71
Diglyceride	39.63
Triglyceride	5.13

- 15 **Moringa DISMO, 2763/015: Distilled monoglyceride based on moringa oil.**

Mono-diglyceride (2461/209) from above used.

The mono-diglyceride was distilled on a short path distillation apparatus.

20

The distillation temperature was 185°C.

Reservoir temp. before heated surface 80°C.

Condenser was 85°C.

Rotor speed 300 rpm.

- 25 Pressure: 2×10^{-3} mBar

Distillate 1187g

Residue 1090g

Time 180 min.

Flow: 759 g/h

The distillate was added antioxidant Grindox 349 0,88g.

5 Analysis of the distilled monoglyceride determined by GC:

	%
Glycerol	1.24
Diglycerol	0.14
Free fatty acids	0.3
Monoglyceride	88.02
Diglyceride	10.30
Triglyceride	0.00

GRINDSTED® PGPR 90 is a polyglycerol polyricinoleic acid available from DuPont (formerly Danisco A/S, Denmark). It is polyglycerol ester of polycondensed fatty acids from castor oil.

10

Palsgaard® PGPR 4150 is a polyglycerol polyricinoleic acid available from Palsgaard A/S, Denmark.

PGPR specification (DuPont formerly Danisco A/S, Denmark).

PGPR Analysis %	C16	C17	C18	C18:1	C18:2	C20	C18:1 Ricinoleic acid	C18:1 oleic acid	Un- knowns
PGPR 90	1.3	0.0	1.3	3.6	5.1	0.0	86.1	0.0	2.4

15

GRINDSTED® CRYSTALLIZER 110 is a distilled mono/diglyceride prepared from vegetable fatty acids wherein the fatty acid profile contains C₂₂ behenic acid present in an amount of 89 %. GRINDSTED® CRYSTALLIZER 110 is available from DuPont (formerly Danisco A/S, Denmark).

20

DIMODAN UJ is a distilled monoglyceride prepared from sunflower oil available from DuPont (formerly Danisco A/S, Denmark).

DIMODAN HP is a distilled monoglyceride prepared from edible, fully hydrogenated palm based oil available from DuPont (formerly Danisco A/S, Denmark).

- 5 DIMODAN P is a distilled monoglyceride prepared from edible, refined palm based oil available from DuPont (formerly Danisco A/S, Denmark).

RICEBRAN is a rice bran oil available as RBD Ricebran Oil available from (Thai Edible Oil Co., Ltd (Bangkok, Thailand). The content of this oil is given in Table 11 below.

Fatty acid and GC	Ricebran as distilled monoglyceride
Glycerol	0,2
Diglycerol	0,2
FFA	0,3
Mono	98,2
Di	1,1
Tri	0
FA :	
C14:0	0,4
C15:0	< 0,1
C16:0	20,5
C16:1:0	0,3
C17:0	< 0,1
C.18:0	2,1
C18:1	41,3
C18:2	32,5
C18:3	1,3
C20:0	0,7
C20:1	0,6
C22:0	0,2
C24:0	0,1
Unknown	0,6

- 10 Table11. Distilled Ricebran monoglyceride from RBD ricebran oil

CITREM LR10 is a citric acid ester monoglyceride made from edible, refined sunflower oil available from DuPont (formerly Danisco A/S, Denmark).

- 15 Soy lecithin is available from DuPont (formerly Danisco A/S, Denmark).

The specifications of the monoglycerides referred to above is given in Table 12.

DuPont, GRINDSTED					
DIMODAN®	RT	U/J	P	HP	CRYSTALLISER 110
C14:0	0.1	0.1		1	< 1
C16:0	6	7	44	55	1
C18:0	14	5	5	43	2
C18:1	75	28	39	0.1	
C18:2	2	58	10	0.2	
C18:3	0.3	0.1	0.3		
C20:0	< 1	1	0.2	0.7	5
C22:0	< 2	< 1	< 1	< 1	89
C24:0					< 2
<i>Saturated total</i>	23	12	49	100	100
<i>IV (app.)</i>	60	105	45	2	2

Table 12. Monodiglyceride specifications supplied from DuPont (formerly Danisco A/S, Denmark)

5 RESULTS & discussion

A course of experiments looking into the interfacial tension of Moringa monoglycerides, GRINDSTED® PGPR 90, GRINDSTED® CRYSTALLIZER 110 and other surfactant materials was undertaken to gain insight into their behaviour, and interaction at the interface. Results show that Moringa monoglycerides are behaving as GRINDSTED® PGPR 90 and have similar interfacially active properties. This physical behaviour is most unusual, given that the monoglycerides are low molecular weight, and highly unsimilar to the high molecular weight PGPR.

15 Interfacial Tensiometry

Initially, it was predicted that studies could reveal similarities between Moringa monoglycerides and GRINDSTED® CRYSTALLIZER 110 because of sharing similar fatty acid types of the more saturated C₂₂ (behenic) type. GRINDSTED® CRYSTALLIZER 110 is essentially built entirely on behenic, whereas the Moringa samples contain C₂₀, C₂₂, and C₂₄ fatty acid fractions. Our second interest was in the interaction of monoglycerides with PGPR. The reason for this interest is primarily because of the common utilisation of these types of surfactants together in low fat water-in-oil emulsions (<41% fat). The results of the interfacial tension measurements are given in Figure 1.

The results in Figure 1 show the tensiometry profiles of the emulsifier sample as they are cooled from 50°C to 5°C at a cooling rate of 0.3°C per minute. The control sample can be seen as the blue line at the top of Figure 1 referring to pure sunflower oil and water. The value of the interfacial tension at 50°C is about 30 mNm, and decreases to around 27mNm at 5°C. This contrasts sharply with the profile for GRINDSTED® CRYSTALLIZER 110, which starts at around 28mNm at 50°C, proceeding through a shallow decrease to a value of about 26mNm over a temperature range from 50°C to 20°C, and then dramatically decreases over a further 10°C range to a value of about 2mNm. GRINDSTED® PGPR 90 begins with a value of about 25mNm at 50°C, decreases sharply and then shallows out in profile, ending on a value of around 7mNm. Monoglycerides based on Moringa Oil show essentially the same profile trend as that seen for GRINDSTED® PGPR 90, i.e. showing an immediate decrease and then a shallow decrease which is parallel to the profile for GRINDSTED® PGPR 90, and ends on a value of around 13mNm. The profile is quite different and distinct from that of GRINDSTED® CRYSTALLIZER 110. Indeed grouping the other emulsifier samples which follow the profile of GRINDSTED® PGPR 90 they mirror the profile of the Moringa monoglycerides, albeit at a lower interfacial tension value. Only when the crystalliser molecule from GRINDSTED® CRYSTALLIZER 110 is present does the dramatic reduction in interfacial tension take place, an observation that is equally true for the crystalliser sample being mixed with either GRINDSTED® PGPR 90 or the monoglycerides of the Moringa Oil.

Hence, there appears to be distinct groupings in the profile behaviour of the interfacial tension measurements, and clear differences between GRINDSTED® CRYSTALLIZER 110, GRINDSTED® PGPR 90, and the monoglyceride based on Moringa Oil. However, although the interfacial values are different there appears to be parity of profile shape between GRINDSTED® PGPR 90 and the Moringa monoglycerides, this is shown more clearly in Figure 2.

As shown in Figure 1, the monoglycerides, although having quite different fatty acid profiles (not shown) are all grouped at around tension values of 20 – 30mNm, across the whole temperature range, whereas Moringa stands apart, This is clearly show in Fig 2. It is interesting to note the interaction of GRINDSTED® PGPR 90 and GRINDSTED® CRYSTALLIZER 110 or monoglycerides of Moringa and GRINDSTED® CRYSTALLIZER 110, where the effect of competitive adsorption seems to occur. It is possible that at a sufficient concentration GRINDSTED® PGPR 90 or monoglycerides of Moringa are able

to establish a micelle concentration, which is more surface active than GRINDSTED® CRYSTALLIZER110. It could be that GRINDSTED® CRYSTALLIZER 110 - the fully saturated (C_{22:0}) long chain fatty acid configuration are not able to adsorb to or form template crystallised network structures, either because of the lack of available potential to form solid crystal structures, (defined by the experimental procedure, the solvent is unsaturated sunflower oil) or because GRINDSTED® CRYSTALLIZER 110 concentration is insufficient. Therefore, we explored this aspect by interchanging the C₂₂ based distilled monoglyceride for one predominately rich in C₁₆ or C₁₈ because not only might the degree of saturation have different interaction, but also the chain length. However, in the case of Moringa monoglycerides, although having significant quantity of C₂₂, (~6%); our distilled monodiglyceride product (91.15% mono & 7.75% di) typically contained approximately 21.4% saturates of C₁₆, C₁₈, C₂₀, C₂₂ & C₂₄ - a broad spectrum. The Moringa monodiglyceride was the only monodiglyceride able to influence GRINDSTED® CRYSTALLIZER 110 and its interfacial tension, other than GRINDSTED® PGPR 90.

Rheology

We investigated rheological properties to show the functional behaviour of monoglycerides based on Moringa Oil and GRINDSTED® PGPR 90 to be similar over concentration ranges of up to 3%. At 3% significant differences were observed with the Moringa monoglycerides where increases in viscosity of up to 3 orders of magnitude were apparent for both rapeseed and peanut oil systems. This is shown in Figures 3 and 4 for rapeseed oil, and peanut oil respectively.

In rapeseed oil the common viscosity value for both Moringa monoglycerides and GRINDSTED® PGPR 90 below a concentration of 3% was essentially constant at 0.03 to 0.04Pas. For the samples measured in peanut oil the viscosity below 3% concentration again was similar and rose from 0.03 to 0.06Pas over the temperature range studied of 70°C to 25°C, where cooling was held constant at 1°C per minute. The dramatic increase in viscosity occurred at 32°C for rapeseed oil, and 30°C for peanut oil.

Given these results, we investigated this perceived similarity in the functionality of Moringa monoglycerides with GRINDSTED® PGPR 90.

Polarised light microscopy (crystal structures)

To understand functional similarity more fully, model systems were constructed, consisting of a base fat blend of 70% palm stearine, and 30% palm olein. More specifically the fat blend used to form the blank control sample contained 70% palm
5 stearine having an iodine value of 48, and 30% palm olein having an iodine value of 56. To the blank control sample each of GRINDSTED® CRYSTALLIZER 110, GRINDSTED® PGPR 90, and monoglycerides of Moringa were added individually. The aim was to probe the actual structure of these model systems by examination with polarised light microscopy under cooling in an attempt to observe the formation of fat
10 crystals. The results presented in Figure 5 show the end point micrograph, i.e. taken at a final temperature of 20°C after the samples have been cooled from 80°C at a rate of 1°C per minute.

Figure 5a shows the fat crystal build up of the control sample, where only the fat blend is
15 present. Figure 5b has the fat blend and GRINDSTED® CRYSTALLIZER 110 present, and small discrete fat crystal packets can be seen. At the magnification recorded these are unlikely to be individual fat crystals but rather pockets of crystallisation. Figure 5d shows the image of the fat blend with GRINDSTED® PGPR 90 alone, and the clear formation of fern-like structures, which in essence could easily be referred to as
20 crystalline dendritic structures as noted by Mullin (1993). Figure 5f shows the fat blend with added Moringa monoglycerides, and here it is essentially like viewing a composite image of Figures 5a and 5d together. There are elements present in Figure 5f that are clearly also present in Figures 5a and 5d, we see evidence of the bulk fat crystallisation, and also the obvious fern-like dendritic structures. Given that both aspects are now
25 present in a single sample, this may possibly provide evidence as to why the interfacial tension measurements from Figure 1 showed the GRINDSTED® PGPR 90 and Moringa monoglycerides as behaving similarly, albeit with different tensiometry values. Evident from Figure 5c and Figure 5e, both monoglycerides of Moringa and GRINDSTED® PGPR 90 appear to interact with GRINDSTED® CRYSTALLIZER 110 in a similar
30 fashion creating fat crystal structures reminiscent of each other. The other key observation is that Figure 5f, containing the Moringa monoglycerides is distinctly different from Figure 5b where the crystalliser molecule is present. This leads to summary conclusion on Figure 5 such that;

1. Monoglycerides of Moringa, containing ~6% of C₂₂ behenic acid behave distinctly
35 different to GRINDSTED® CRYSTALLIZER 110, which is a near pure source of C₂₂ behenic acid.

2. Monoglycerides of Moringa appear to have similar crystal structures, i.e. fern-like dendritic structures to GRINDSTED® PGPR 90, suggesting the likelihood of similarities in functionality.
3. Monoglycerides of Moringa appear to demonstrate similar interaction with
5 GRINDSTED® CRYSTALLIZER 110 as does GRINDSTED® PGPR 90 (also supported in Figure 2).

Having now established that a link between monoglycerides of Moringa and GRINDSTED® PGPR 90 in terms of crystal structure exists; that interfacial tensiometry
10 and oscillatory rheology for Moringa monoglycerides and GRINDSTED® PGPR 90 are similar, one final aspect of the model system investigation was required. Up until now, all cooling had been done either at 1°C per minute or slower, at 0.3°C per minute. In order to probe the effects being observed and to be able to comment on the prospect of any crystal structure benefit being transferred into final application, forced cooling on the
15 model systems was investigated where cooling as undertaken at 1°C, 10°C, 50°C and 100°C per minute. The purpose of carrying out these experiments was to gain data as close as possible to the cooling rates that may occur in typical plant process environments, where conservative estimates led us to suggested cooling rates of between 35°C and 45°C per minute when averaged over the entire plant. This can be
20 summarised as follows:

The crystal forming function of monoglycerides based on Moringa Oil is shown to give similar results when compared to GRINDSTED® PGPR 90, and GRINDSTED® CRYSTALLIZER 110, but to maintain its own characteristics throughout. This crystal
25 formation is seen to be preserved despite forced cooling up to 50°C per minute, conservatively estimated to be above the typical cooling rates of most production plants. This therefore suggests that the functionality within the final product of systems containing monoglycerides based on Moringa Oil is likely to be similarly maintained, and therefore this may carry over and offer final product benefits.

30

The results, shown below in Figures 6 to 9, clearly indicate the difference in crystal forming mechanics of the monoglycerides based on Moringa Oil, with ~6% C₂₂ behenic acid as opposed to GRINDSTED® CRYSTALLIZER 110 with ~89% C₂₂ behenic acid. The results also suggest a strong parallel in the crystal forming mechanics between the
35 monoglycerides based on Moringa Oil and GRINDSTED® PGPR 90, and it is this

similarity of crystal kinetics which in turn suggests that broad functional similarity will occur in application systems.

All the above evidence points to similar functionality of Moringa based Monoglycerides as GRINDSTED® PGPR 90, but the ultimate test was to place the Moringa based monoglycerides into a water-in-oil spread application. This was done in both 60% and 40% fat concentrations but for the sake of brevity only the 40% results will be summarised here. However, we can report that in all cases, the 60% w/o emulsions are as good as those composed with other standard commercial monodiglycerides.

Water droplet size, Confocal Laser Scanning Microscopy

A key factor in making a stable spread application is to be able to control the size of the water droplets, such that they are neither too big, nor too small, either case being undesirable. Water droplet size distribution as measured on the 40% fat spreads, and the results are given in Figure 10. Here, the key samples are nos. 12, 15, and 18, which correspond to Moringa monoglycerides at 0.3%, Moringa monoglycerides at 0.6% and Moringa monoglycerides 0.3% / GRINDSTED® PGPR 90 at 0.2% respectively.

Confocal images taken using Confocal Laser Scanning Microscopy (CLSM) technique show the differentiation between the fat phase (red) and the protein phase (green). It is in the green phase that the water droplets are apparent since the protein tends to concentrate in the water phase. Figure 11 shows the images of Moringa monoglycerides at 0.3% for the 40% fat spread, and clearly shows the small water droplet size. Figure 12 gives the analogous image, this time with Moringa monoglycerides at 0.3% and GRINDSTED® PGPR 90 at 0.2% where the water droplets are of analogous size. Comparing against the use of DIMODAN® UJ at 0.3% (Figure 13) concentration, and Figure 12, one finds the results gained from Moringa monoglycerides very favourable, and immediate support for the above claim from model system data that Moringa based monoglycerides use in spread applications would work.

With the water droplet size and the confocal images showing the same trend, the performance of the actual spread was tested via texture analysis, where hardness and stickiness were investigated, where the trends for both properties were the same. For brevity here only hardness will be presented – Figure 14.

DIMODAN® UJ at 0.3% (sample 11) and Moringa monoglycerides at 0.3% (sample 12) gave the hardest spreads followed by Moringa monoglycerides at 0.6% and the Moringa monoglycerides 0.3% / GRINDSTED® PGPR 90 0.2% combination. Despite forming the hardest samples, it was these spreads that gave the best evaluation in sensory characters, i.e. all being characterised as being, "very pleasant and smooth with good overall mouth feel." As mentioned above, the same trend was seen for stickiness, and these spreads were generally deemed to be very acceptable.

Validation

10

Validating these results required a new round of testing to be done where the experiments on the application systems were repeated. Water droplet size distribution and confocal images akin to those above are presented here.

15 Figure 15 shows the water droplet size distribution results for the repeat samples.

Here, with the exception of sample 5, which is for DIMODAN® UJ 0.3% and GRINDSTED® PGPR 90 0.2% all the water droplet size distribution data with the smallest water droplet sizes come from samples which contain Moringa monoglycerides, similar to the initial experiments.

Figure 16, 17 and 18 show the confocal images for the samples with Moringa monoglycerides at 0.3% concentration, Moringa monoglycerides 0.3% / GRINDSTED® PGPR 90 0.2% concentration, and DIMODAN® UJ at 0.3% concentration as was shown above. The images clearly show that the water droplet size distribution is very similar in each case – as before. This is taken as good indication that the functionality gained by the initial trials is reproducible, and therefore can be reported as a real effect.

Furthermore, the repeat hardness result for the validation studies, given in Figure 19, shows essentially the same trend as was seen for the original trials. Here, the sample made with Moringa monoglycerides 0.3% and Moringa monoglycerides 0.3% / GRINDSTED® PGPR 90 has the highest degree of hardness, and the Moringa monoglycerides at 0.3% appear to outperform the DIMODAN® UJ at 0.3% sample, where the difference is reported as being significant.

35

SUMMARY & DISCUSSION

The results summarised above based on model systems and spread application systems have shown the monoglycerides based on Moringa oil do have similarities structurally and in functional properties shown by similar interfacial surface response to

5 GRINDSTED® PGPR 90, but are inherently different from GRINDSTED® CRYSTALLIZER 110. This difference between the Moringa monoglycerides and the crystalliser molecules occurs despite the presence of C₂₂ behenic acid being present in both systems.

10 The interfacial tension measurements show Moringa monoglycerides to be behaving similar to GRINDSTED® PGPR 90, albeit at different values, and when this similarity is further probed via polarised light microscopy, clear structural parallels are drawn with the Moringa monoglycerides and GRINDSTED® PGPR 90. These structural similarities seem to hold even during force cooling, up to cooling rates of 50°C per minute.

15 In the low fat spread applications, the performance through the pilot plant, and subsequent storage gave no cause for concern for samples made with Moringa monoglycerides. These samples produced spreads that were stable to processing, and eminently acceptable to the commercial standards. This performance was also validated

20 with a repeat test, which gave essentially the same results – in each case showing the spreads produced with Moringa monoglycerides were acceptable and stable.

CONCLUSION

25 We have demonstrated in model systems and application systems the functionality of Moringa monoglycerides. Their behaviour is similar to GRINDSTED® PGPR 90, and despite containing some 6% of C₂₂ behenic acid, is different from GRINDSTED® CRYSTALLIZER 110 which is a rich source of C₂₂ behenic acid. This suggests a different mechanism of fat crystallisation between Moringa monoglycerides and

30 GRINDSTED® CRYSTALLIZER 110, and these differences are further highlighted by the interfacial tension measurements which show Moringa monoglycerides to possess essentially similar surface response behaviour as GRINDSTED® PGPR 90, albeit at a different level.

35 The respective structural differences and similarities are further confirmed in polarised light microscopy examination under slow and forced cooling.

- Finally, the incorporation of Moringa monoglycerides into low fat spread applications established their ability to form spreads which were stable to processing and storage conditions, but also performed well under texture and sensory analysis to produce
- 5 spreads that were highly acceptable to the commercial market. This property was repeated and validated.

Bakery Trial - Toast softness comparing Moringa DISMO with HP 75/B and PH 110

- 10 The following recipes were prepared

Straight Dough Recipe (grams)					
Ingredient Name		1	2	3	4
Reform flour		2000	2000	2000	2000
SAF - instant		30,00	30,00	30,00	30,00
Salt		30,00	30,00	30,00	30,00
Sucrose		30,00	30,00	30,00	30,00
AKO bake S100		20,00	20,00	20,00	20,00
Water		1220	1220	1220	1220
Calcium Propionate		6,000	6,000	6,000	6,000
Ascorbic acid		0,020	0,020	0,020	0,020
GRINDAMYL™ A1000 – diluted amylase 16,2 FAU / g		12,80	12,80	12,80	12,80
DIMODAN HP 75/B			6,000		
DIMODAN PH 110/B				6,000	
Moringa DISMO 2763/015		6,000			6,000
Calculated batch size		3354,82	3354,82	3354,82	3354,82
Entered batch size		2000,00	2000,00	2000,00	2000,00

Bakers Percentage - Straight Dough Recipe (%)					
Ingredient Name	Unit	1	2	3	4
Reform flour	%	100,00	100,00	100,00	100,00
SAF - instant	%	1,500	1,500	1,500	1,500
Salt	%	1,500	1,500	1,500	1,500
Sucrose	%	1,500	1,500	1,500	1,500
AKO bake S100	%	1,000	1,000	1,000	1,000
Water	%	61,00	61,00	61,00	61,00
Calcium Propionate	%	0,300	0,300	0,300	0,300
Ascorbic acid	PPM	10,00	10,00	10,00	10,00
GRINDAMYL™ A1000 - diluted	%	0,640	0,640	0,640	0,640
DIMODAN HP 75/B	%		0,300		
DIMODAN PH 110/B	%			0,300	
Moringa DISMO 2763/015	%	0,300			0,300
Total bakers %		167,74	167,74	167,74	167,74
Water					
Recommended %		58,00	58,00	58,00	58,00
Adjustment %		3,00	3,00	3,00	3,00
Actual %		61,00	61,00	61,00	61,00
Ascorbic Acid					
Recommended PPM		10,00	10,00	10,00	10,00
Adjustment PPM					
Actual PPM		10,00	10,00	10,00	10,00
Grindamyl A1000 (diluted)					

Recommended %	0,64	0,64	0,64	0,64
Adjustment %				
Actual %	0,64	0,64	0,64	0,64

Trial NO	1	2	3	4
Evaluation figures:	1			
Ambient Temp. (°C)	21.8	21.8	21.8	21.8
Flour Temp (°C)	20.0	20.0	20.0	20.0
Water Temp. (°C)	20.0	20.0	20.0	20.0
Dough Temp. (°C)	26.4	26.3	26.9	26.6
Proof Temp. (°C)	34	34	34	34
Proof Humidity (R°H)	85	85	85	85
Proof Time (min.)	60	60	60	60
Dry mixing (min.)	1.0	1.0	1.0	1.0
Slow mixing (min.)	11.0	11.0	11.0	11.0
Fast mixing (min.)				
Baking Temp. (°C)	205	205	205	205
Baking Time (min.)	30.0	30.0	30.0	30.0
Volume 1	3275.0	3425.0	3450.0	3325.0
Volume total (ccm)	3275.0	3425.0	3450.0	3325.0
Weight (g)	640.0	643.0	645.0	646.0
Specific Volume (ccm/g)	5.12	5.33	5.35	5.15

SAF instant is an instant dry yeast for baking

AKO bake S100 is a non-hydrogenated and refined vegetable bakery fat available from

5 AarhusKarlshamn AB, Sweden

GRINDAMYL™ A1000 is a fungal α -amylase produced by fermentation of a strain of *Aspergillus oryzae*

DIMODAN HP 75/B is a distilled monoglyceride made from edible, fully hydrogenated palm based oil

10 DIMODAN PH 110/B is a distilled palm-based monoglyceride

Procedure

Knead on Diosna spiral mixer

15

Water uptake for flour according to analysis 400 BU + 3%

1) Mix all ingredients for 1 minute slow - add water

2) Mix 1 minutes low speed -11 minutes medium speed (Freq.32) ("Standard softness"

20 prog.3.10)

- 3) Dough temperature must be app. 26-27°C
- 4) Rest dough for 10 minutes in cabinet at 30°C
- 5) Scale 4 dough pieces at 750 g
- 6) Rest dough pieces for 5 minutes at ambient
- 5 7) Mould on Glimek; 1:4 -2:4 - 3:14 - 4:12 - width: 10 outside
- 8) Put dough pieces in DK toast tins - 3 are sealed with lid - leave 1 open for volume measurement
- 9) Proofing: 60 minutes at 33°C, 85% rH - when using calcium propionate
50 minutes at 33°C, 85% rH - without use of calcium propionate
- 10 10) Bake for 30 minutes at 205°C with Steam (Miwe Roll-in prog. 2)
(in Bago oven bake 30 min. at 220°C. with 12 sec. steam, open steamer after 20 min.)
- 11) After baking take breads out of the tins
- 12) Cool breads for 70 minutes at ambient before weighing and measuring of volume
- 15 The recipes reduced above were then subject to sensory evaluation in accordance with the following scoring system.

Evaluation	Evaluation method	Lowest score	Highest score
Dough			
Dough development after mixing	Extend dough with fingers	Dough can not be stretched without breaking	Dough can be stretched obtaining papery thin dough without breakage
Stickiness after mixing	Cut a big slit in all dough, open the dough, touch the cut dough surface with fingers	Dry surface. The dough slips your fingers	The dough sticks to your fingers
Extensibility after resting	Extend dough with fingers	Dough can not be stretched without breaking	Dough can be stretched obtaining papery thin dough without breakage
Stickiness after resting	Cut a big slit in all dough, open the dough, touch the cut dough surface with fingers	Dry surface. The dough slips your fingers	The dough sticks to your fingers
Crust			
Crispiness of crust	Fracture crust using several fingers	Leathery crust	Crisp crust
Thickness of crust	Visual evaluation of crust thickness of a slice of the product	Thin crust	Thick crust

Surface cracks	Visual quantification of number of cracks on surface	No cracks, smooth/ blind surface	Numerous cracks
Crumb			
Crumb pore size	Visual evaluation of sliced bread, size of gas bubbles in crumb	Open crumb, big gas bubbles	Fine crumb, small gas bubbles
Crumb pore homogeneity	Visual evaluation of sliced bread, homogeneity of gas bubbles	Big variation in sizes of gas bubbles	Constant gas bubble size
Product shape			
Capping/	Visual evaluation of vertical cut surface	A very large hole directly under the crust.	No separation between crust and crumb.
Oven spring/ Energy	Visual evaluation amount of energy in the product	No energy	High level of energy

The results of this sensory evaluation is given in the table below.

Trial NO	1	2	3	4
Area of evaluation				
Dough				
Dough development after mixing	6	4	5	6
Stickiness after mixing	6	4	5	6
Extensibility after resting	6	4	5	6
Stickiness after resting	6	6	6	6
Crust				
Crispiness of crust	7	7	7	7
Thickness of crust	5	5	5	5
Surface cracks	5	5	5	5
Comments on crust properties				
Crumb				
Crumb pore size	7	5	5	8
Crumb pore homogeneity	7	6	6	8
Capping	10	10	10	10
Oven spring/Energy	6	7	7	6

- 5 The firmness and resilience of the samples was also measured. These data are shown in Figures 20 and 21.

It was observed that the lower volume of the 0.3% 2763/015 sample could be due to the form/ appearance of the sample, being a "soft fat" – not a powder .

The dough evaluation provided very similar results. The development and extensibility were slightly better for 2763/015. Stickiness after mixing slightly better for PH110 and HP75/B. The stickiness after resting of the samples was effectively the same.

5

The baked bread evaluation provided very similar results,. The crumb structure slightly better for 2763/015. The energy was slightly better for PH110 and PH75/B.

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5

Mullin, J.W. (1993) "Crystallisation" 3rd Ed. Butterworth – Heinemann, UK. Pp 292-293.

Various modifications and variations of the present invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention which are obvious to those skilled in chemistry, biology or related fields are intended to be within the scope of the following claims.

10
15

CLAIMS

1. A food or feed comprising
 - (i) a foodstuff
 - 5 (ii) a mono or di ester of glycerol and Moringa oil.
2. A food or feed according to claim 1 further comprising polyglycerol polyricinoleic acid.
3. A food or feed according to claim 1 or 2 wherein the food is an emulsion.
- 10 4. A food or feed according to any one of claim 1, 2 and 3 wherein the emulsion is an oil in water emulsion or a water in oil emulsion.
5. A food or feed according to any one of the preceding claims wherein the food or feed
15 is a food suitable for human consumption.
6. A food or feed according to claim 5 wherein the food is selected from spreads, bakery margarine, cake margarine, ice cream, liquid bread improvers.
- 20 7. A food or feed according to claim 6 wherein the food is selected from whipped frozen desserts.
8. A food or feed according to claim 7 wherein the whipped frozen dessert is an ice cream.
- 25 9. A food or feed according to claim 6 wherein the food is in the form of a double emulsion.
10. A food or feed according to claim 9 wherein the double emulsion is an oil in water in
30 oil emulsion or a water in oil in water emulsion
11. A food or feed according to claim 10 wherein the food is in the form of a double emulsion is selected from mayonnaise, low fat spread, peanut butter, hazelnut butter, chocolate spread, and spread containing hazelnut and cocoa.

12. A food or feed according to any one of claims 1 to 4 wherein the food or feed is a feed suitable for animal consumption.
13. A food or feed according to claim 12 wherein the feed is selected from poultry feed,
5 aqua culture feed, bovine feed and porcine feed.
14. A food or feed according to claim 13 wherein the feed is a feed pellet for fish.
15. An emulsifier composition comprising
10 (a) polyglycerol polyricinoleic acid.
(b) a mono or di ester of glycerol and Moringa oil.
16. A food or feed comprising
(i) a foodstuff
15 (ii) an emulsifier composition comprising
(a) polyglycerol polyricinoleic acid.
(b) a mono or di ester of glycerol and Moringa oil.
17. A process for preparing a food or feed comprising according to any one of claims 1 to
20 14 or 16, comprising the steps of contacting
(i) a foodstuff and (ii) a mono or di ester of glycerol and Moringa oil.
18. Use of a mono or di ester of glycerol and Moringa oil to prepare a food or feed.
- 25 19. Use according to claim 18 wherein the food or feed is an emulsion.
20. Use according to claim 19 for the preparation of an emulsion which is stable in use and which may be separated into constituent components if desired.
- 30 21. A food or feed as substantially described herein with reference to the examples.
22. An emulsifier composition as substantially described herein with reference to the examples.
- 35 23. A use as substantially described herein with reference to the examples.

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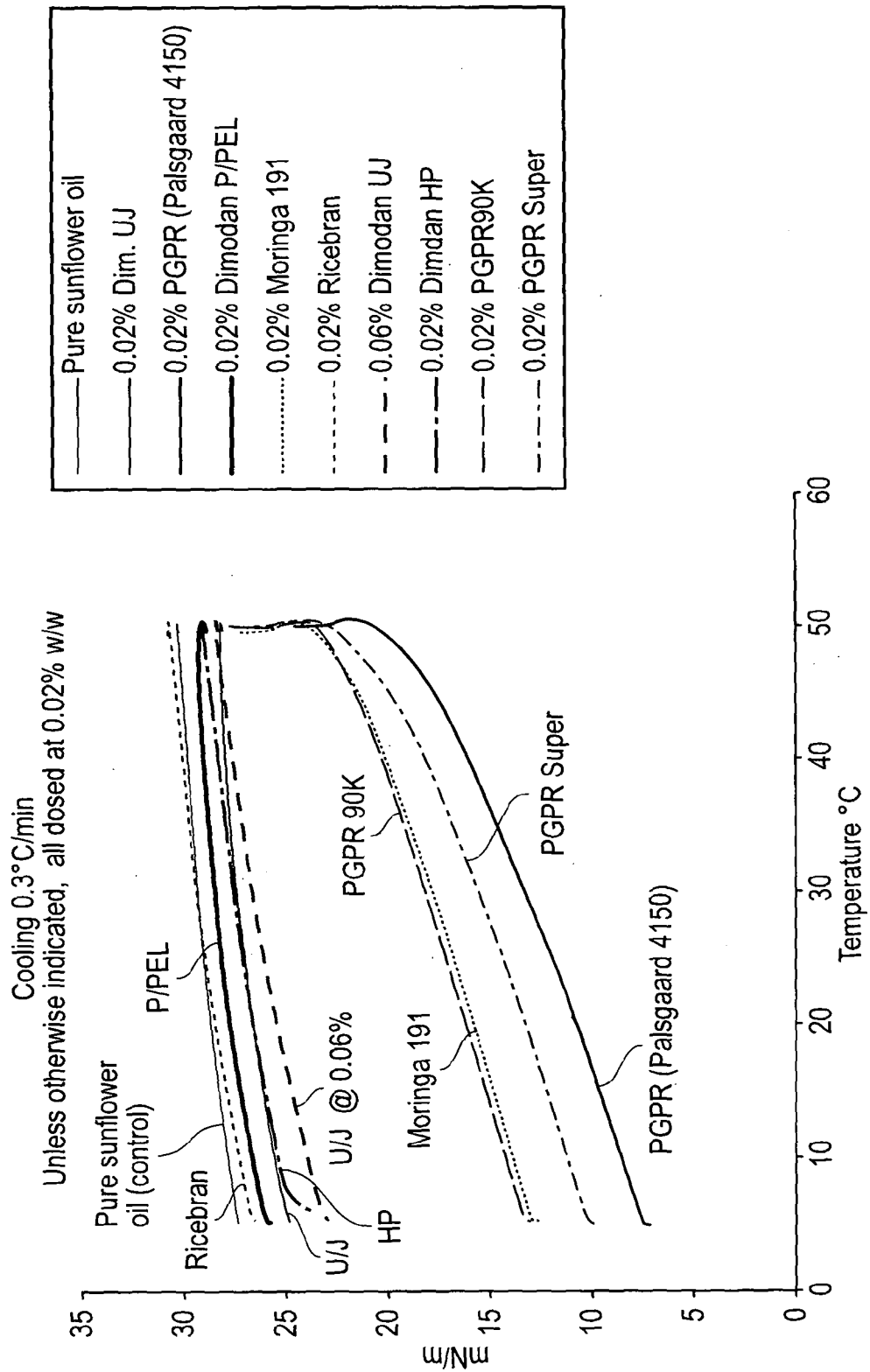


FIG. 1

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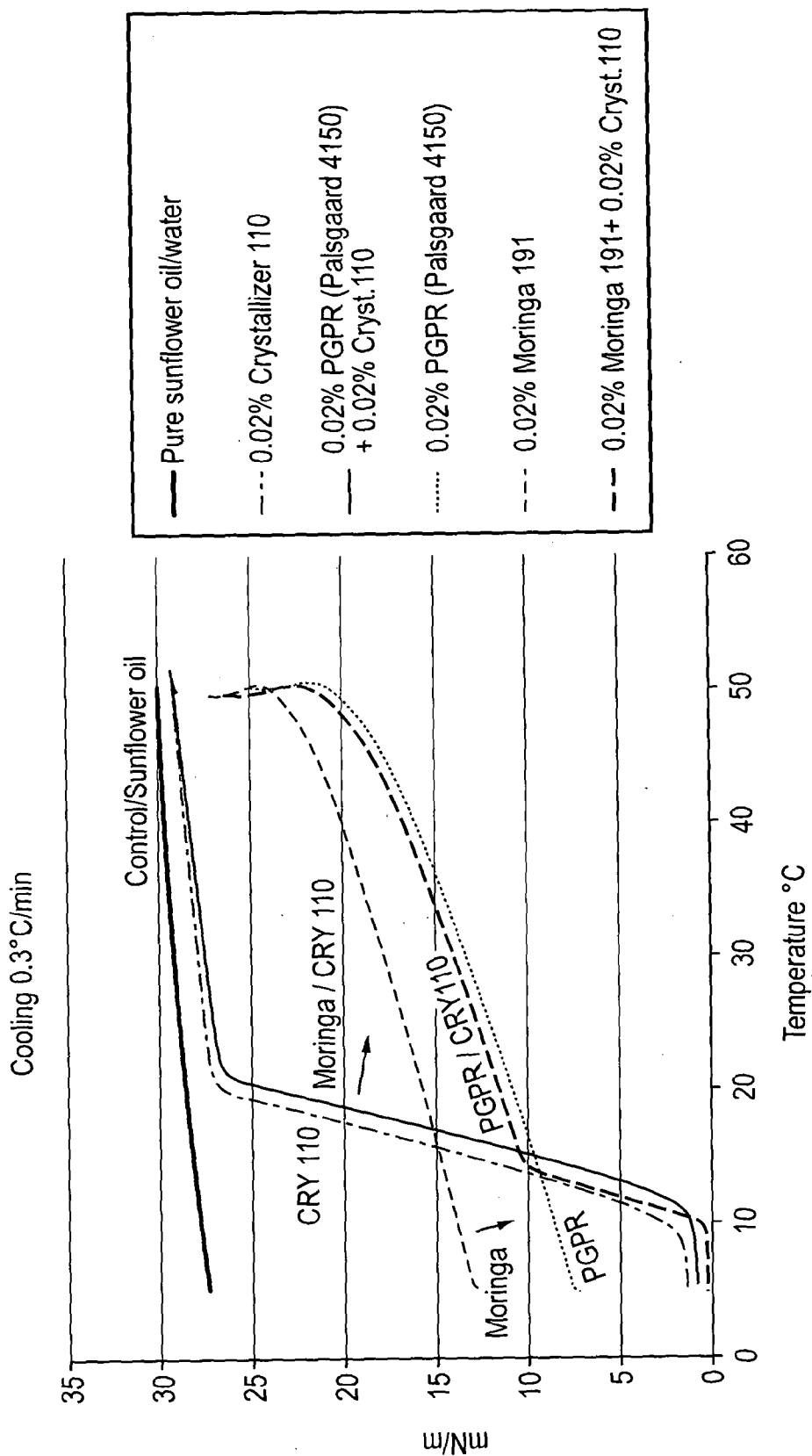


FIG. 2

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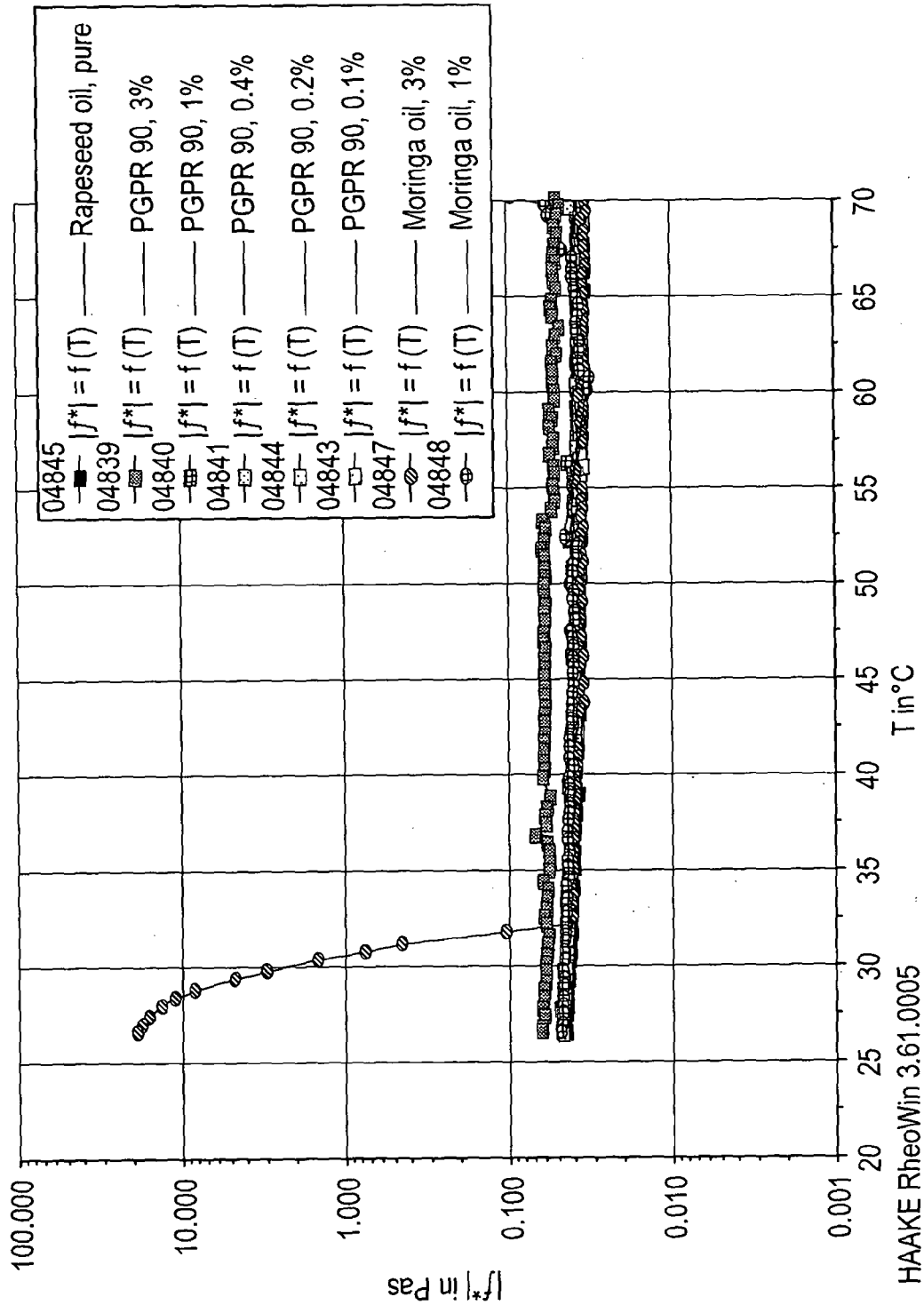


FIG. 3

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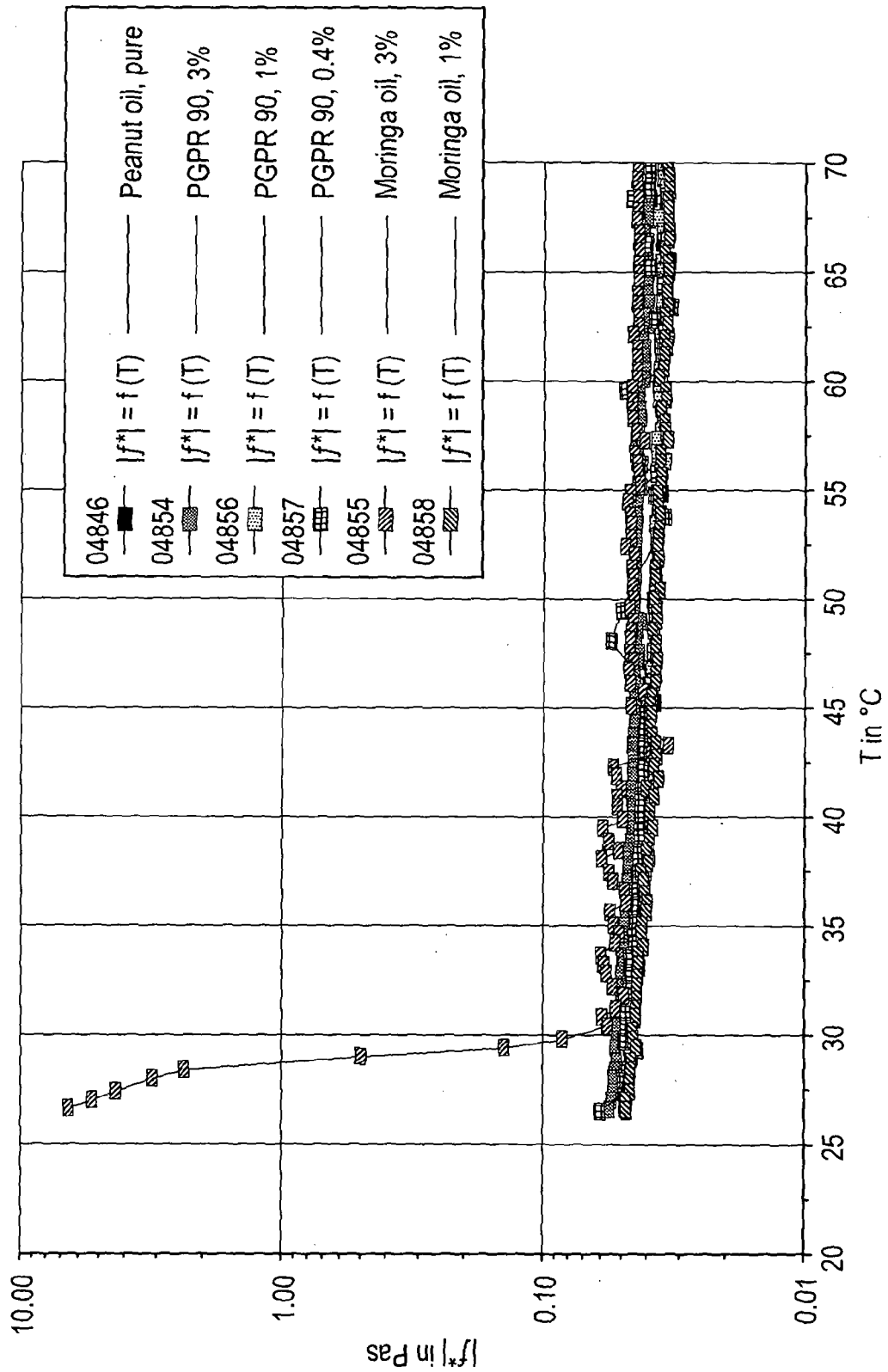


FIG. 4

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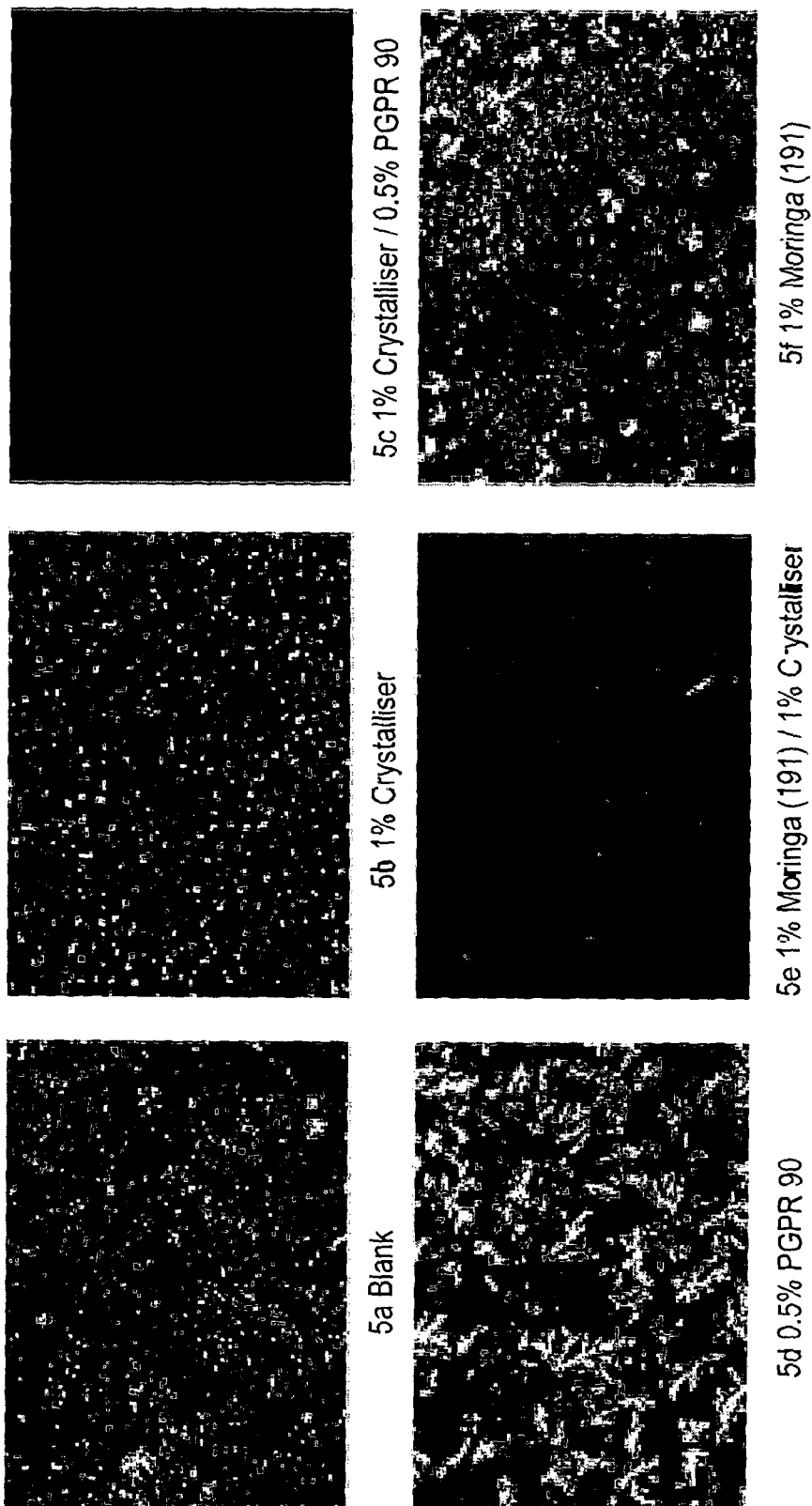
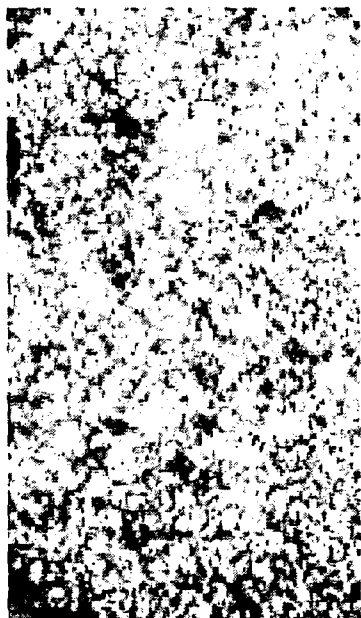


FIG. 5

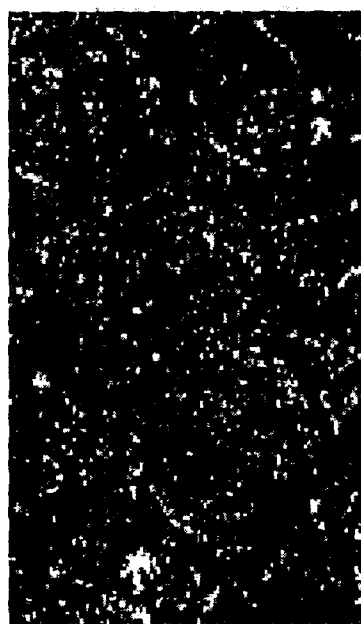
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Blank 10°C per minute



Blank 100°C per minute

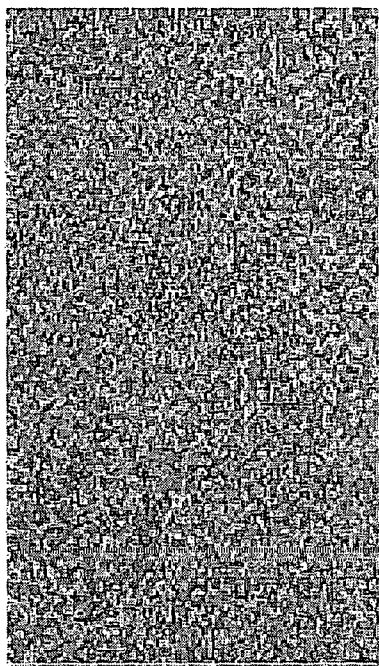


Blank 1°C per minute

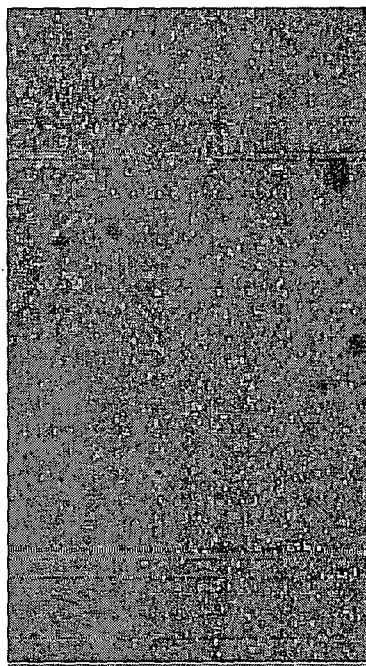
Blank 50°C per minute

FIG. 6

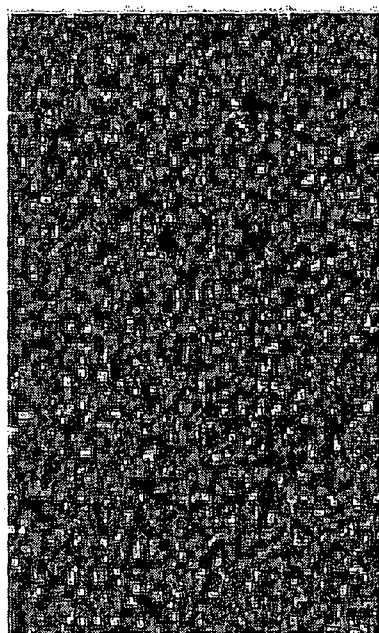
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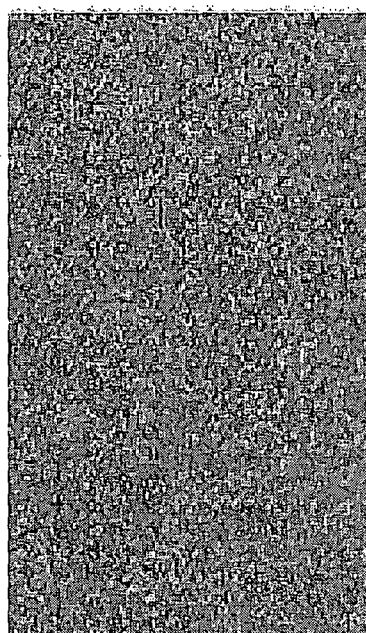
Crystalliser 110, 10°C per minute



Crystalliser 110, 100°C per minute



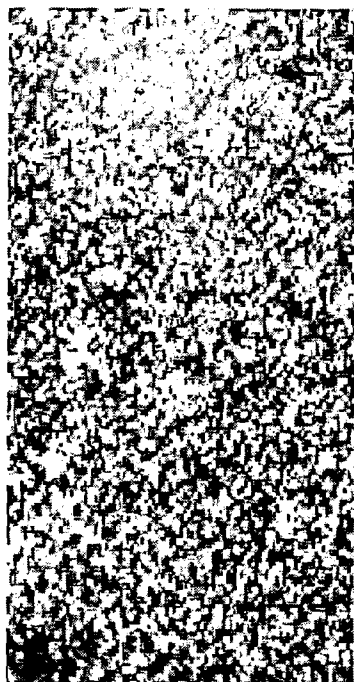
Crystalliser 110, 1°C per minute



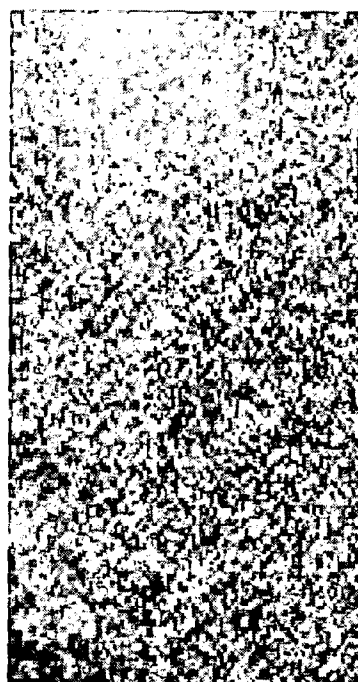
Crystalliser 110, 50°C per minute

FIG. 7

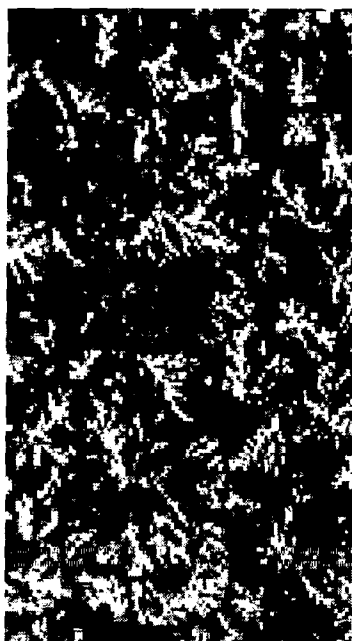
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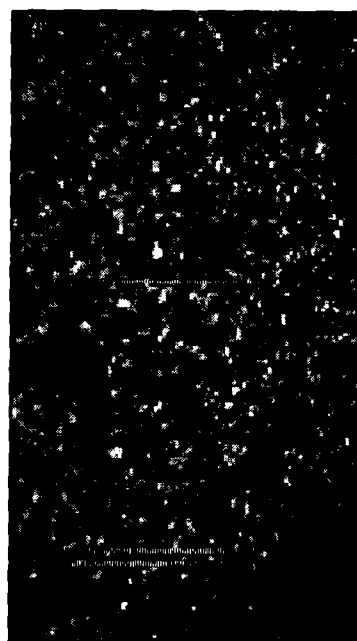
PGPR 90 10°C per minute



PGPR 90 100°C per minute



PGPR 90 1°C per minute



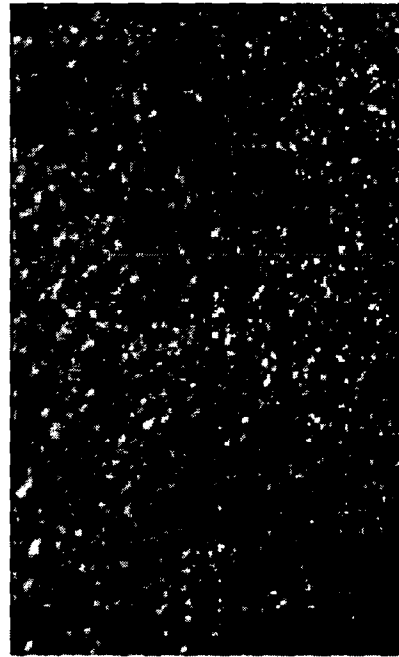
PGPR 90 50°C per minute

FIG. 8

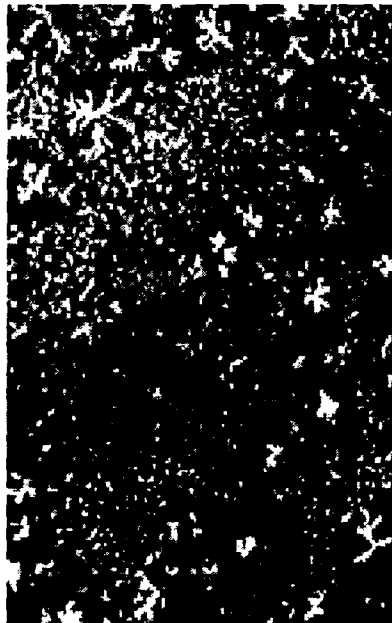
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Moringa 10°C per minute



Moringa 100°C per minute



Moringa 1°C per minute



Moringa 50°C per minute

FIG. 9

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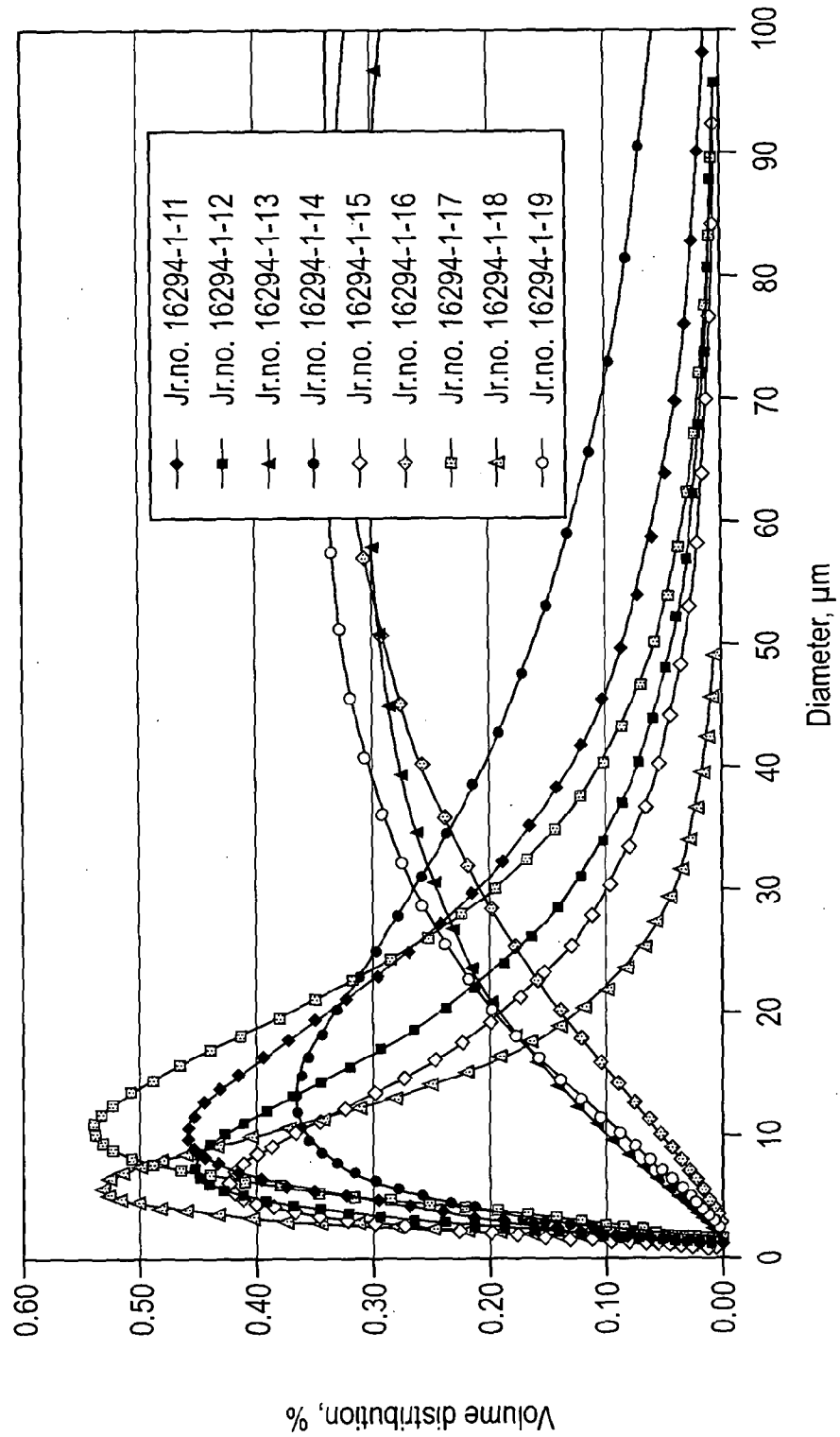
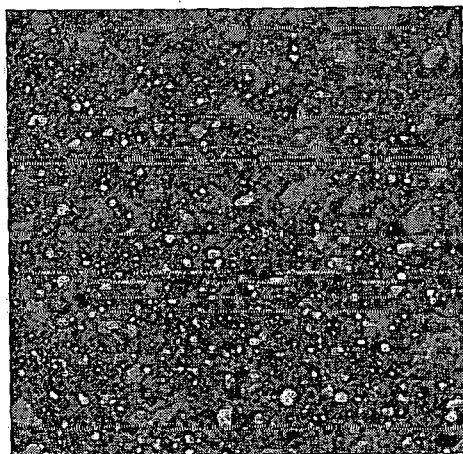


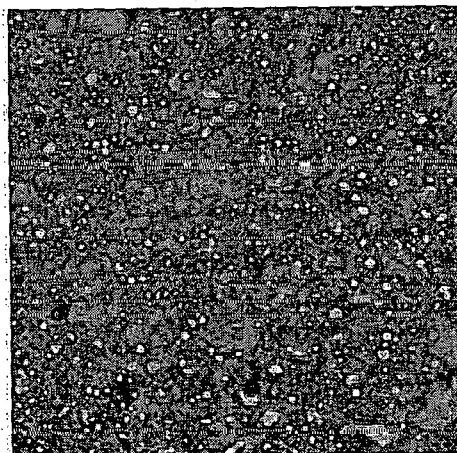
FIG. 10

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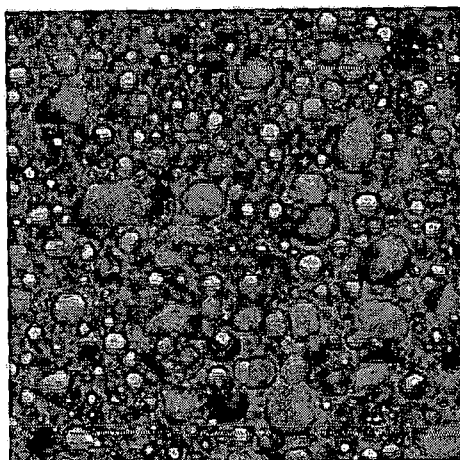
Jr. no. 16294-1-12 Image size: 375x375 and 188x188 μ m



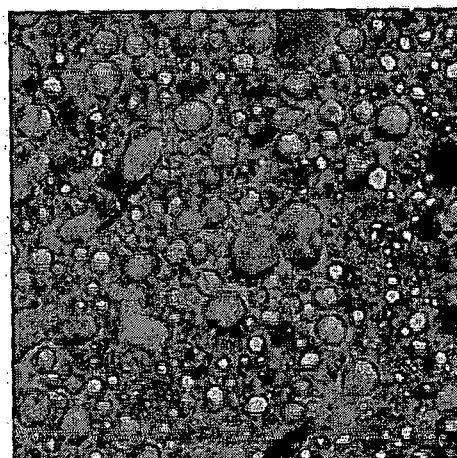
Jr. no. 16294-1_096129 -12x40



Jr. no. 16294-1_096130 -12x40



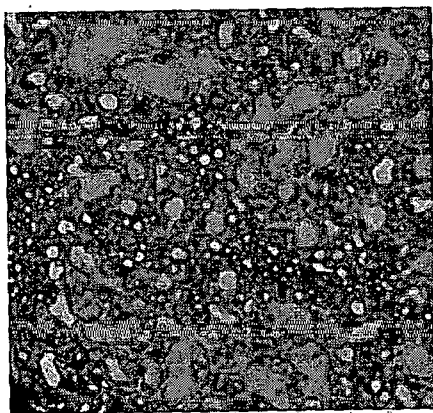
Jr. no. 16294-1_096134 -12x40z2



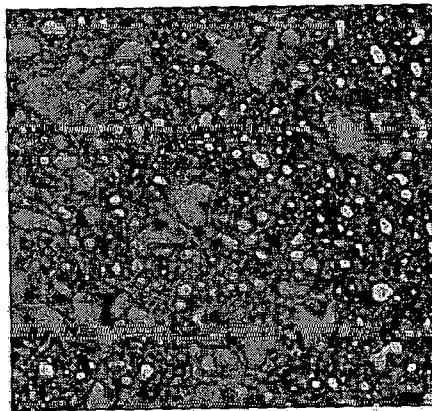
Jr. no. 16294-1_096136 -12x40z2

FIG. 11

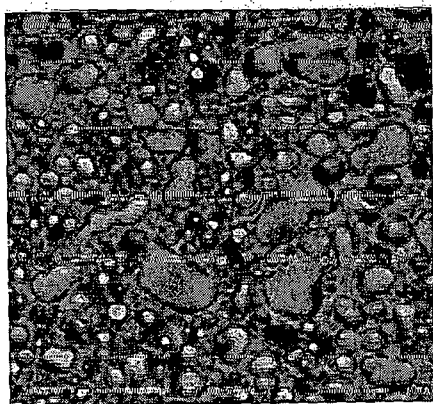
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Jr. no. 16294-1-18 Image size: 375x375 and 188x188 μ m

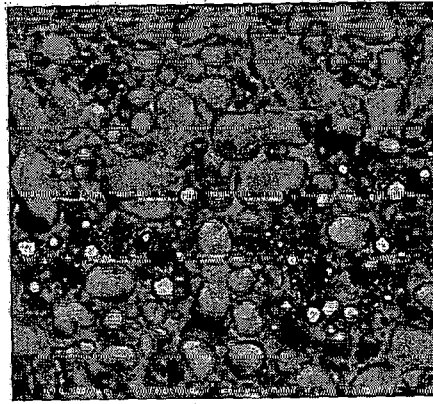
Jr. no. 16294-1_096178 -18x40



Jr. no. 16294-1_096179 -18x40



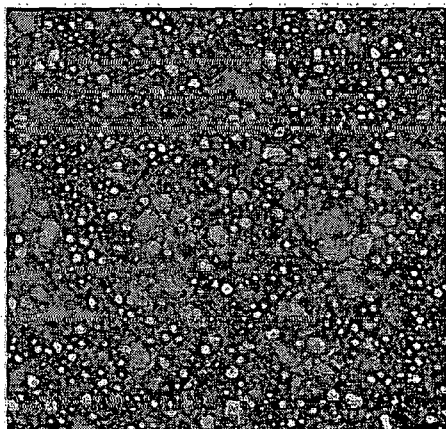
Jr. no. 16294-1_096181 -18x40z2



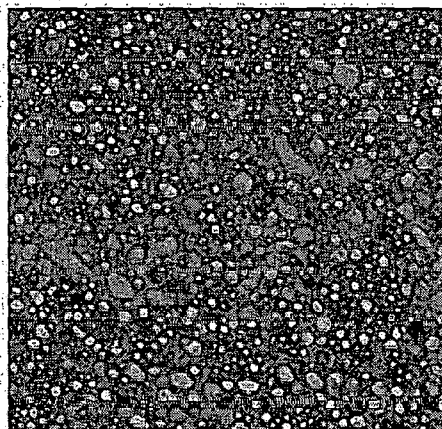
Jr. no. 16294-1_096184 -18x40z2

FIG. 12

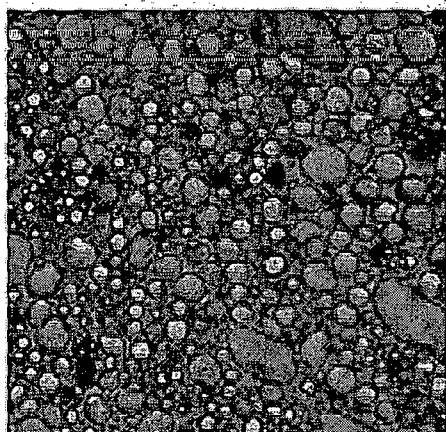
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Jr. no. 16294-1-11 Image size: 375x375 and 188x188 μ m

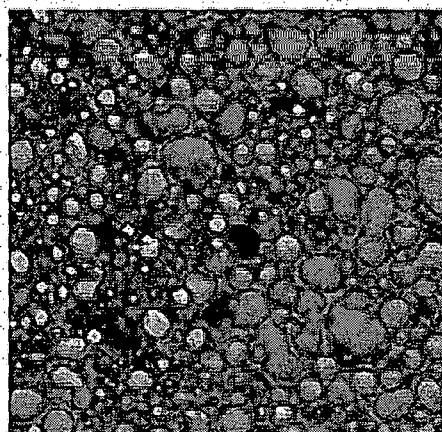
Jr. no. 16294-1_096122 -11x40



Jr. no. 16294-1_096124 -11x40



Jr. no. 16294-1_096125 -11x40z2



Jr. no. 16294-1_096126 -11x40z2

FIG. 13

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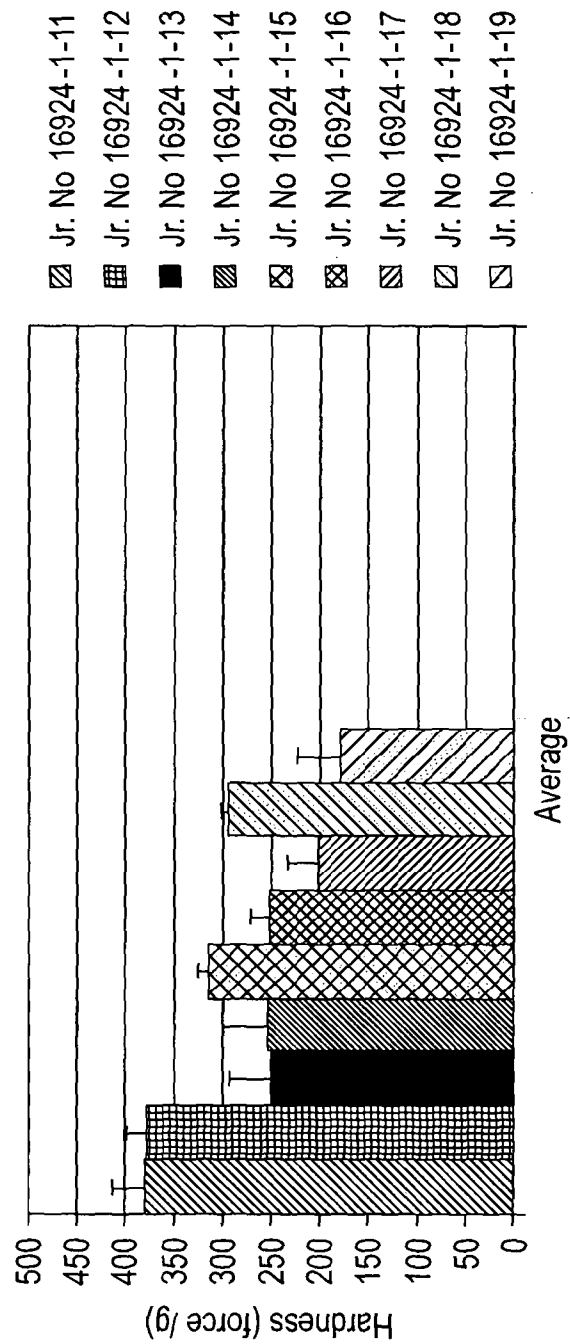


FIG. 14

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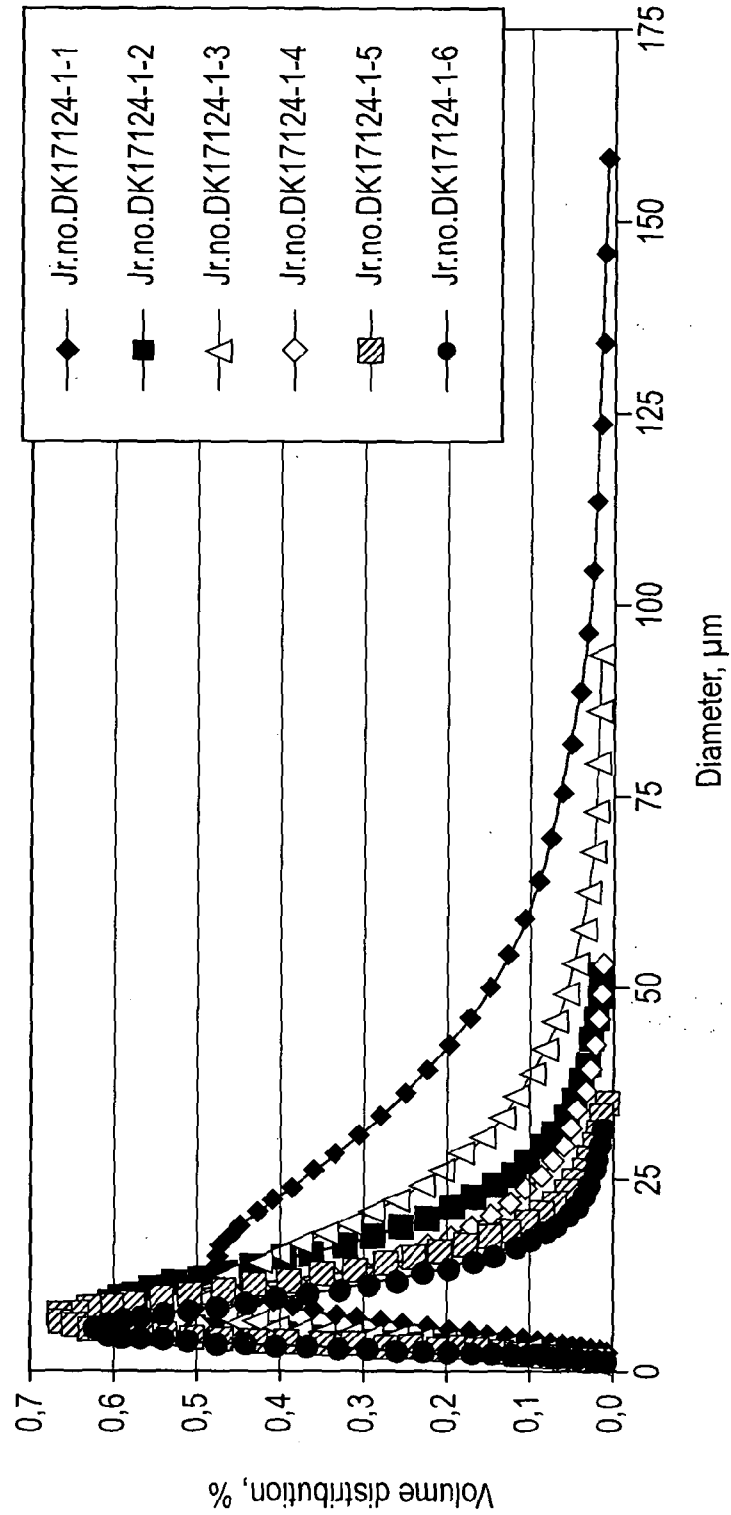
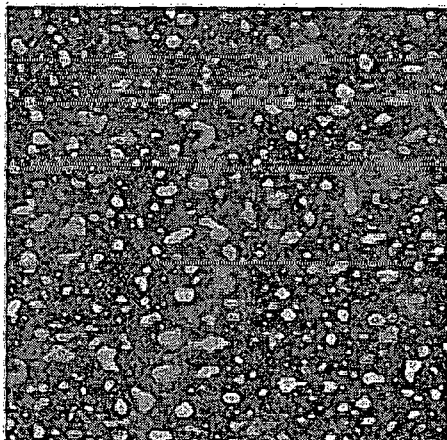
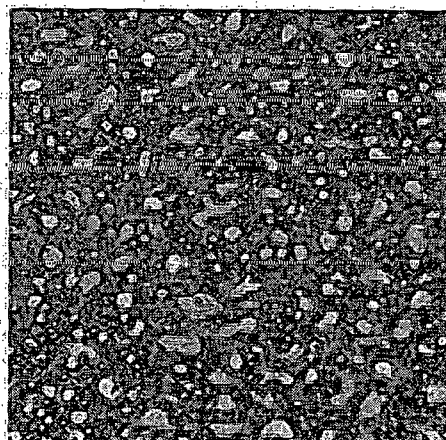


FIG. 15

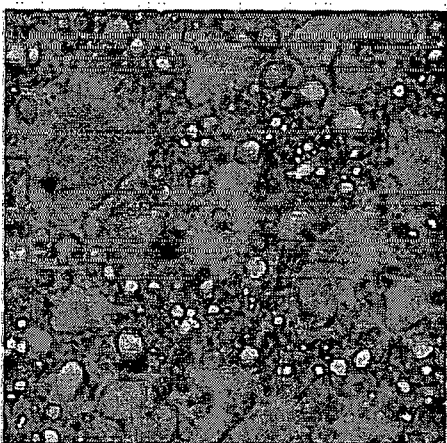
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Jr. no. 17124-1-2 Image size: 373x375 and 188x188 μ m

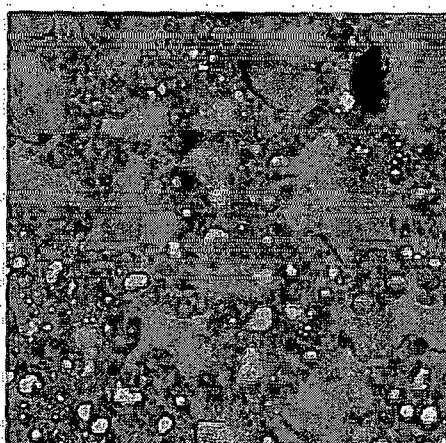
Jr. no. 17124_103373 -2x40



Jr. no. 17124_103375 -2x40



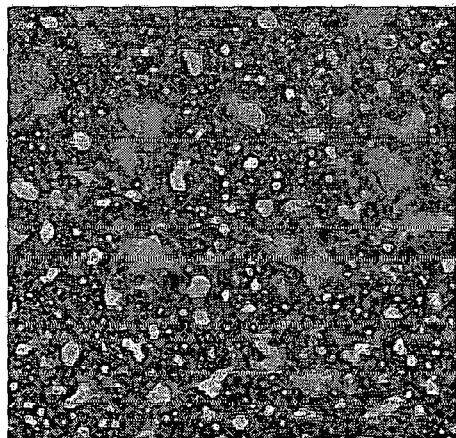
Jr. no. 17124_103378 -2x40z2



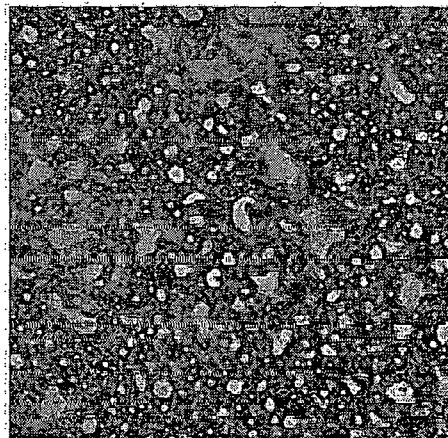
Jr. no. 17124_103379 -2x40z2

FIG. 16

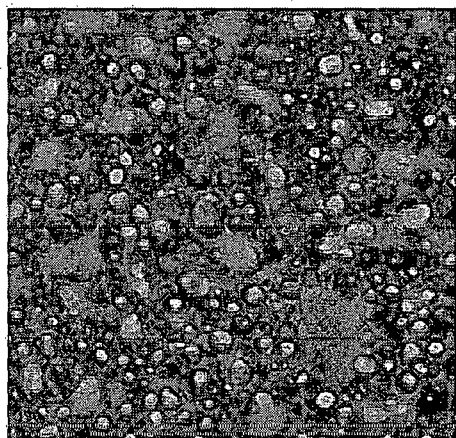
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Jr. no. 17124-1-6 Image size: 373x375 and 188x188 μ m

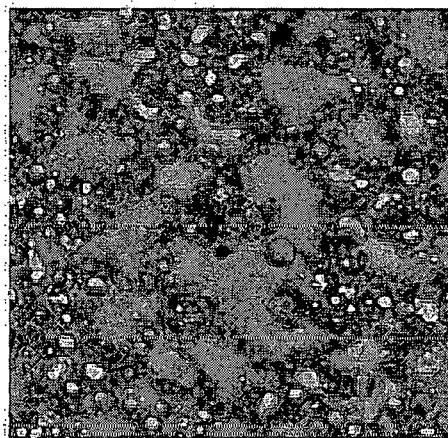
Jr. no. 17124_103405 -6x40



Jr. no. 17124_103407 -6x40



Jr. no. 17124_103408 -6x40z2

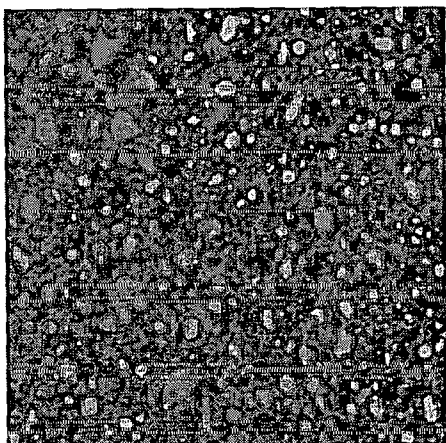


Jr. no. 17124_103410 -6x40z2

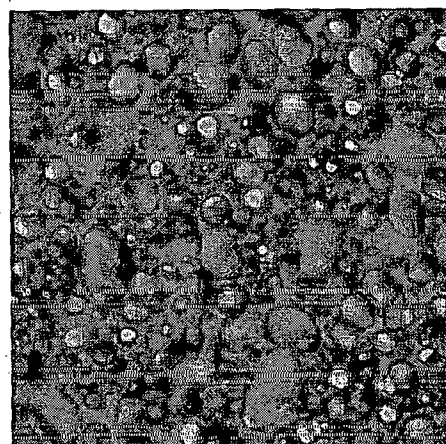
FIG. 17

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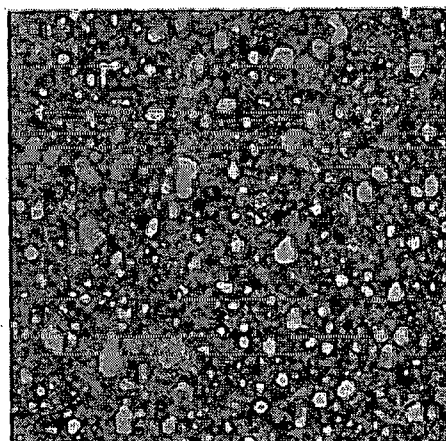
Jr. no. 17124-1-1 Image size: 373x375 and 188x188µm



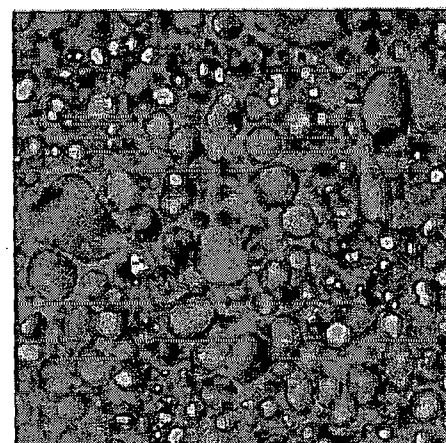
Jr. no. 17124_103368 -1x40



Jr. no. 17124_103371 -1x40z2



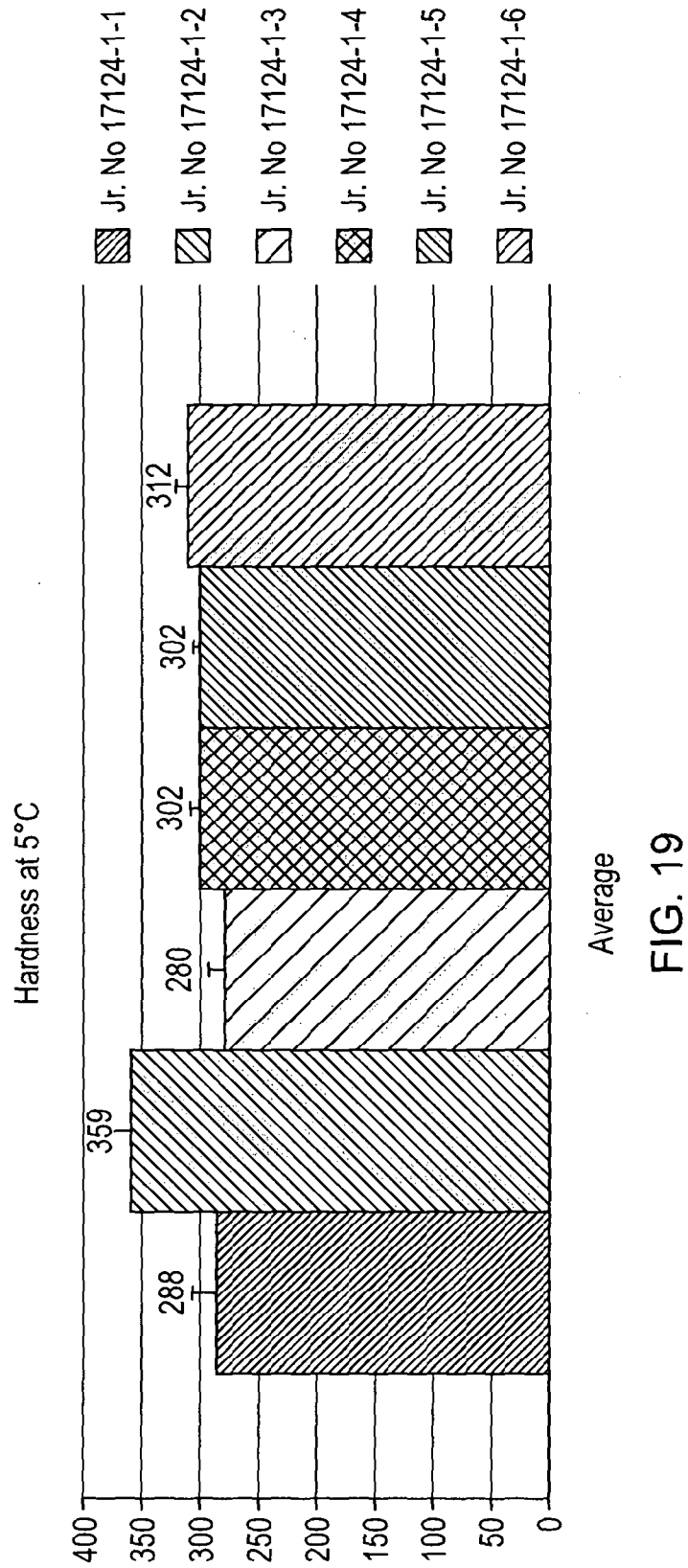
Jr. no. 17124_103366 -1x40



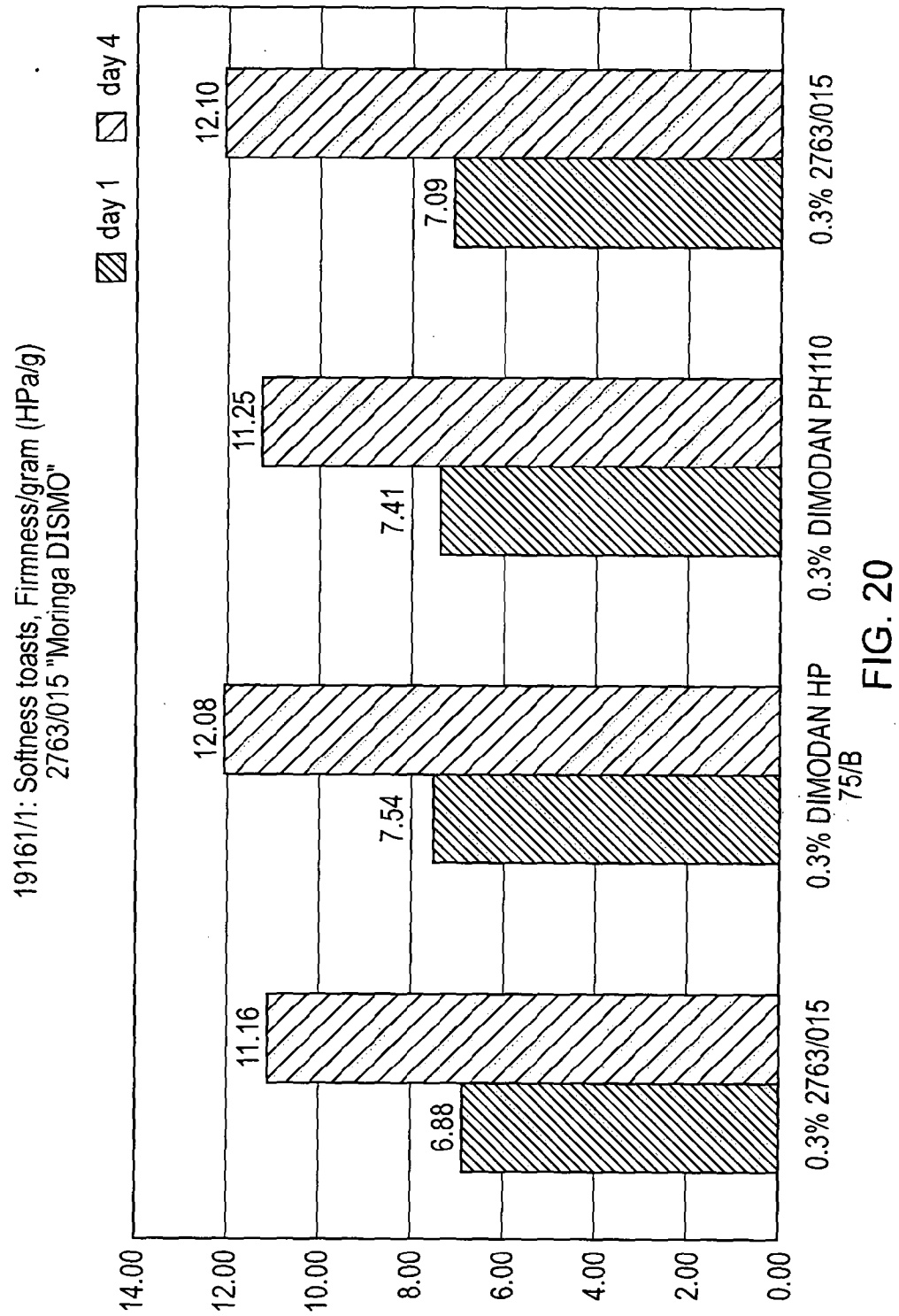
Jr. no. 17124_103370 -1x40z2

FIG. 18

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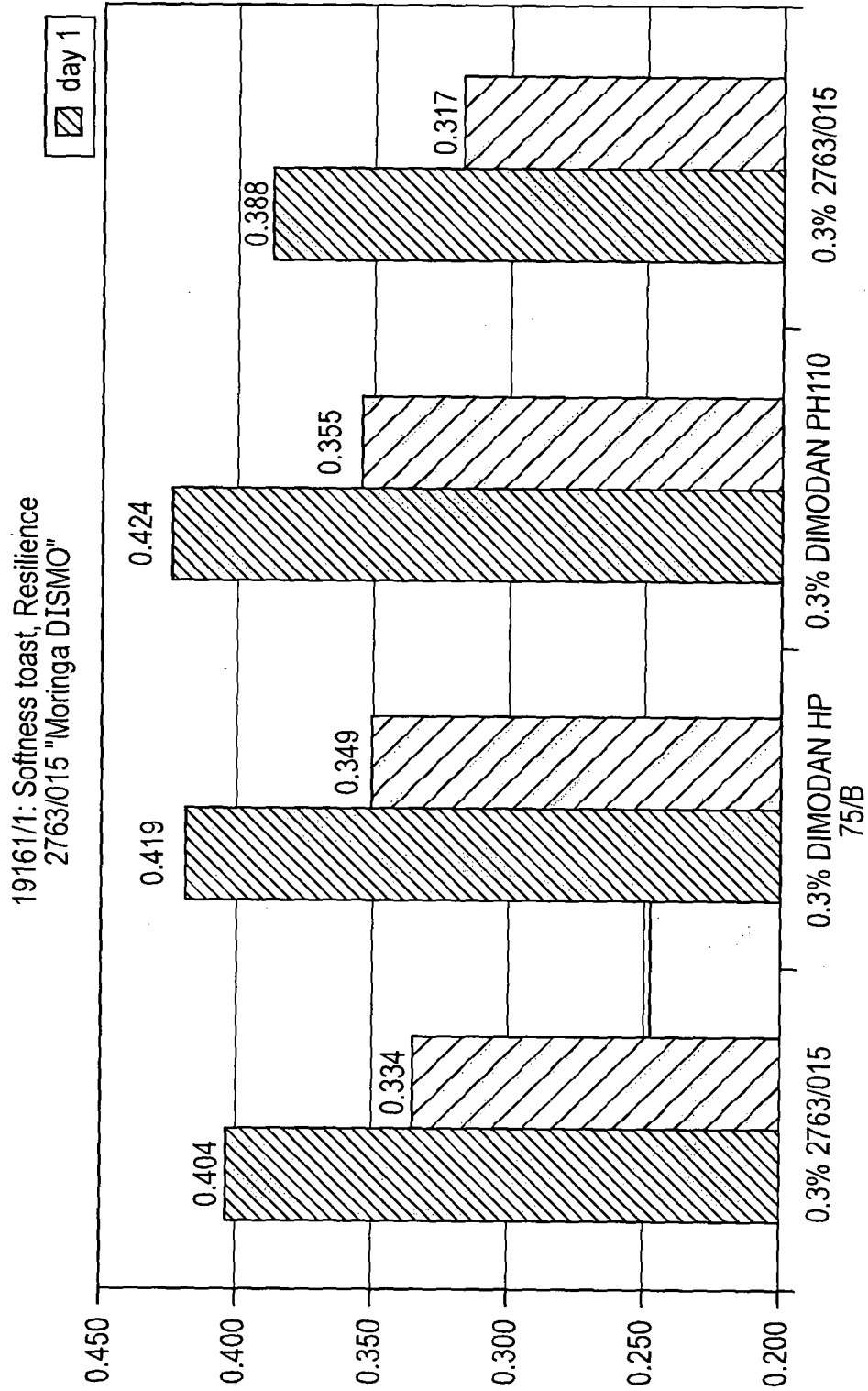


FIG. 21

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/051291

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	A23L1/035 A23G9/32	A21D2/16 A23G1/30
	A23D7/00	A23L1/24 A23L1/38
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) A23L A21D A23D A23G		
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, FSTA, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE FSTA [Online] INTERNATIONAL FOOD INFORMATION SERVICE (IFIS), FRANKFURT-MAIN, DE; 2011, AL-DABBAS M M ET AL: "Chemical composition and oil components in seeds of Moringa peregrina (Forssk) Fiori.", XP002684763, Database accession no. FS-2011-04-Ne0653 abstract & AL-DABBAS M M ET AL: "Chemical composition and oil components in seeds of Moringa peregrina (Forssk) fiori", CROP RESEARCH, vol. 40, no. 1--3, 2010, page 161, ----- -/-	1-23
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
8 October 2012		19/10/2012
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Rinaldi, Francesco

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2012/051291

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	STAVROS LALAS ET AL: "Frying Stability of Moringa stenopetala Seed Oil", PLANT FOODS FOR HUMAN NUTRITION, KLUWER ACADEMIC PUBLISHERS, DO, vol. 61, no. 2, 30 June 2006 (2006-06-30), pages 93-102, XP019406104, ISSN: 1573-9104, DOI: 10.1007/S11130-006-0022-8 abstract page 101, left-hand column, paragraph 1 -----	1-23
X	US 6 667 047 B2 (BROWN JAMES H [US] ET AL) 23 December 2003 (2003-12-23) Formula 7 (column 15-16) -----	15
A	CN 101 508 936 A (INST OF RESOURCE INSECTS CHINE [CN]) 19 August 2009 (2009-08-19) abstract claim 1 -----	1-23

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2012/051291

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6667047	B2	23-12-2003	NONE

CN 101508936	A	19-08-2009	NONE
