

Powdered cereal compositions comprising non-replicating
probiotic microorganisms

The present invention relates to the field of powdered cereal compositions to be reconstituted in milk, infant formula or
5 water. In particular, the present invention relates to powdered cereal compositions to be administered to infants or young children. The powdered cereal compositions may be used to strengthen the immune system and/or to treat or prevent
10 inflammatory disorders. For example these benefits can be provided by probiotic micro-organisms. An embodiment of the present invention relates to a powdered cereal composition comprising non-replicating probiotic-micro-organisms, for
example bioactive heat treated probiotic micro-organisms.

Breast feeding is the optimal nutrition for newborn infants.

15 Newborn infants are, consequently, usually fed by breastfeeding or - in cases where this is impossible or insufficient - by liquid infant feeding formulas, which resemble the content of the milk of the mother as closely as possible. Breastfeeding and/or infant formula administration
20 will typically continue during the first year of the infant's life.

However, typically at the age of 4-6 months infants develop an interest and a readiness for other foods. Signs for this are that an infant starts to be able to sit and control head
25 movements. It will be able to move food from the front of the mouth to the back, so that the tongue coordination will allow the infant to swallow from a spoon.

The introduction of solid foods is important for the infant to build a positive relationship with food. This is the first

step to a growing, happy baby, and to developing lifelong healthy eating habits.

At this stage it is recommended that an infant begins consuming infant cereals.

- 5 Infant cereals will help the infant to experience taste, texture, and nutrition. However the infant's digestive tract is still developing and will have to deal with a new challenge: solid food.

- 10 Probiotics as part of gut flora help the stomach tolerate foods much easier and can also boost the immune system, for example. A new innovative product in this respect is, for example, Nestlé Baby Cereal comprising *Bifidobacterium lactis* cultures. These cultures maintain a healthy digestive tract flora and help support healthy growth and development.

- 15 Generally, probiotics are considered safe for infants. However under special circumstances it might be advisable not to use probiotics for infants without the consent of a doctor, for example if the infant is suffering from a compromised immune system.

- 20 There is hence a need in the art for a powdered cereal composition that offers the benefits probiotics can provide, and that can be consumed without any concern also by infants or young children with a compromised immune system.

The present inventors have addressed this need.

- 25 It was consequently the objective of the present invention to provide a powdered cereal composition that is easy to digest and well tolerated by infants and young children, allows to experience taste, texture and nutrition and offers the

probiotic benefits, while being simple to produce in industrial scale and ideally will not lose activity with longer shelf life or at increased temperatures.

5 The present inventors were surprised to see that they could achieve this objective by the subject matter of the independent claim. The dependant claims further develop the idea of the present invention.

The present inventors provide a powdered cereal composition comprising non-replicating probiotic micro-organisms.

10 The inventors were surprised to see that, e.g., in terms of an immune boosting effect and/or in terms of an anti-inflammatory effect non-replicating probiotic microorganisms may even be more effective than replicating probiotic microorganisms.

This is surprising since probiotics are often defined as "live
15 micro-organisms that when administered in adequate amounts confer health benefits to the host" (FAO/WHO Guidelines). The vast majority of published literature deals with live probiotics. In addition, several studies investigated the health benefits delivered by non-replicating bacteria and most
20 of them indicated that inactivation of probiotics, e.g. by heat treatment, leads to a loss of their purported health benefit (Rachmilewitz, D., et al., 2004, Gastroenterology 126:520-528; Castagliuolo, et al., 2005, FEMS Immunol.Med.Microbiol. 43:197-204; Gill, H. S. and K. J. Rutherford, 2001, Br.J.Nutr. 86:285-289; Kaila, M., et al.,
25 1995, Arch.Dis.Child 72:51-53.). Some studies showed that killed probiotics may retain some health effects (Rachmilewitz, D., et al., 2004, Gastroenterology 126:520-528; Gill, H. S. and K. J. Rutherford, 2001, Br.J.Nutr. 86:285-289),
30 but clearly, living probiotics were regarded in the art so far as more performing.

Consequently, the inventors now provide a powdered cereal composition comprising non-replicating probiotic micro-organisms. These non-replicating probiotic micro-organisms are still bioactive.

- 5 One embodiment of the present invention is a powdered cereal based composition to be reconstituted in water, milk, or infant formula comprising at least 25 weight-% cereal and having an energy density of at least 0.8 kcal/g and containing after reconstitution at least 2g/100kcal protein, less than
10 4.5g/100kcal fat, and less than 7.5g/100kcal added sweetening agents with less than 3.75g/100kcal fructose, wherein the powdered cereal based composition further comprises non-replicating probiotic micro-organisms.

- Any milk may be used for the reconstitution. Examples are
15 bovine milk, human milk, goat milk, and soy milk, for example. Milk powder products may be used in reconstituted form as well. Specialized nutritional products, such as infant feeding formulas may also be used in reconstituted form to reconstitute the powdered cereal based composition.

- 20 The composition may be an infant cereal or a cereal milk drink, for example.

The powdered cereal composition may be to be administered to infants and/or young children up to the age of 6 years, for example.

- 25 Infant cereals are known in the art. Infant cereals are compositions containing cereals to be administered to infants. They are usually to be administered using a spoon, and may be offered as dry cereal for infants, for example. The codex alimentarius offers guidance on what ingredients an infant
30 cereal should contain.

An "infant" means a person of not more than 12 months of age.

Cereal milk drinks are processed cereal based foods based on cereals and, optionally, legumes, that are to be diluted with water, milk, or any other liquid that meets the requirements
5 of the local regulatory body and have a texture appropriate for drinking at the age group for which the product is intended.

Typically, the caloric density as well as the amounts and kinds of proteins, carbohydrates and lipids present in the
10 powdered cereal composition should be carefully adjusted to the needs of the infant or young child and are dependent on the stage of development and age.

It is well known that the requirement for nutrition changes with the development and age, and the composition of the
15 powdered cereal composition ideally reflects this change.

In one embodiment of the present invention, the powdered cereal based composition in accordance with one of the preceding claims contains after reconstitution about 2g-5.5g/100kcal protein, and less than 5g/100kcal added
20 sweetening agents with less than 2.5g/100kcal fructose.

The sweetening agents may be carbohydrates and are, for example, selected from the group consisting of sucrose, glucose, fructose, glucose syrup, honey and combinations thereof.

25 Due to the sugar content of the cereals, e.g., after hydrolysis, the amount of total sugar considered as mono- and disaccharides in the final composition may exceed 5g/100kcal.

The powdered cereal based composition may contain less than 40g mono- and disaccharides, preferably less than 35g mono- and disaccharides per 100g powdered composition.

5 The powdered cereal based composition may be fortified with vitamins and minerals, for example.

For example the composition may be fortified with vitamin B1, vitamin A, vitamin D, vitamin E, vitamin C, vitamin B1, vitamin B2, niacin, pyridoxine, folic acid, vitamin B12, biotin, iron, zinc, calcium, and combinations thereof.

10 For example, the powdered cereal based composition may comprise at least 50µg vitamin B1 per 100 kcal, 60-180 µg vitamin A per 100 kcal, and/or 1-3 µg vitamin D per 100 kcal.

As cereals wholegrain cereal flours, refined cereal flours or combinations thereof may be used. For example, wheat flour,
15 rice flour, semolina from wheat, and maize maltodextrin, and combinations thereof may be used.

The powdered cereal compositions may be prepared from a single grain - such as rice cereal or wheat cereal - because single grain compositions are less likely to cause allergic
20 reactions.

The compositions may also contain vanillin. Vanillin has the advantage that its taste is well liked and it has additional antioxidant properties. Typically, the compositions of the present invention contain 0.01-7mg vanillin per 100g
25 reconstituted product.

Honey, fruits or vegetables may be added to vary taste and/or texture. Fruits and/or vegetables may be added in the form of flakes, powders and/or pieces.

The powdered cereal composition of the present invention may further contain prebiotics. Prebiotics may support the growth of probiotics before they are rendered non-replicating. "Prebiotic" means non-digestible food substances that promote the growth of health beneficial micro-organisms and/or probiotics in the intestines. They are not broken down in the stomach and/or upper intestine or absorbed in the GI tract of the person ingesting them, but they are fermented by the gastrointestinal microbiota and/or by probiotics. Prebiotics are for example defined by Glenn R. Gibson and Marcel B. Roberfroid, Dietary Modulation of the Human Colonic Microbiota: Introducing the Concept of Prebiotics, J. Nutr. 1995 125: 1401-1412.

The prebiotics that may be used in accordance with the present invention are not particularly limited and include all food substances that promote the growth of probiotics or health beneficial micro-organisms in the intestines. Preferably, they may be selected from the group consisting of oligosaccharides, optionally containing fructose, galactose, mannose; dietary fibers, in particular soluble fibers, soy fibers; inulin; or mixtures thereof. Preferred prebiotics are fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), isomalto-oligosaccharides (IMO), xylo-oligosaccharides (XOS), arabino-xylo oligosaccharides (AXOS), mannan-oligosaccharides (MOS), oligosaccharides of soy, glycosylsucrose (GS), lactosucrose (LS), lactulose (LA), palatinose-oligosaccharides (PAO), malto-oligosaccharides, gums and/or hydrolysates thereof, pectins and/or hydrolysates thereof. For example, powdered cereal compositions may contain oligofructose, inulin or a combination thereof.

Typically, powdered cereal compositions are to be mixed with water, milk, or infant formula before consumption. For

example, 15g of an powdered cereal composition of the present invention may be to be mixed with 90 mL of water.

The powdered cereal composition according to the present invention may comprise non replicating probiotic micro-organisms in any effective amount, for example in an amount
5 corresponding to about 10^6 to 10^{12} cfu/g dry weight.

"Non-replicating" probiotic micro-organisms include probiotic bacteria which have been heat treated. This includes micro-organisms that are inactivated, dead, non-viable and/or
10 present as fragments such as DNA, metabolites, cytoplasmic compounds, and/or cell wall materials.

"Non-replicating" means that no viable cells and/or colony forming units can be detected by classical plating methods. Such classical plating methods are summarized in the
15 microbiology book: James Monroe Jay, Martin J. Loessner, David A. Golden. 2005. Modern food microbiology. 7th edition, Springer Science, New York, N.Y. 790 p. Typically, the absence of viable cells can be shown as follows: no visible colony on agar plates or no increasing turbidity in liquid growth medium
20 after inoculation with different concentrations of bacterial preparations ('non replicating' samples) and incubation under appropriate conditions (aerobic and/or anaerobic atmosphere for at least 24h).

Probiotics are defined for the purpose of the present
25 invention as "Microbial cell preparations or components of microbial cells with a beneficial effect on the health or well-being of the host." (Salminen S, Ouwehand A. Benno Y. et al "Probiotics: how should they be defined" Trends Food Sci. Technol. 1999:10 107-10).

The possibility to use non-replicating probiotic micro-organisms offers several advantages. In severely immunocompromised infants or young children, the use of live probiotics may be limited in exceptional cases due to a
5 potential risk to develop bacteremia. Non-replicating probiotics may be used without any problem.

Additionally, the provision of non-replicating probiotic micro-organisms allows the hot reconstitution while retaining health benefit.

10 The compositions of the present invention comprise non-replicating probiotic micro-organisms in an amount sufficient to at least partially produce a health benefit. An amount adequate to accomplish this is defined as "a therapeutically effective dose". Amounts effective for this purpose will
15 depend on a number of factors known to those of skill in the art such as the weight and general health state of the infant or young child, and on the effect of the food matrix.

In prophylactic applications, compositions according to the invention are administered to a consumer susceptible to or
20 otherwise at risk of a disorder in an amount that is sufficient to at least partially reduce the risk of developing that disorder. Such an amount is defined to be "a prophylactic effective dose". Again, the precise amounts depend on a number of factors such as the infant's or young child's state of
25 health and weight, and on the effect of the food matrix.

Those skilled in the art will be able to adjust the therapeutically effective dose and/or the prophylactic effective dose appropriately.

In general the composition of the present invention contains non-replicating probiotic micro-organisms in a therapeutically effective dose and/or in a prophylactic effective dose.

Typically, the therapeutically effective dose and/or the prophylactic effective dose is in the range of about 0,005 mg - 1000 mg non-replicating, probiotic micro-organisms per daily dose.

In terms of numerical amounts, the "short-time high temperature" treated non-replicating micro-organisms may be present in the composition in an amount corresponding to between 10^4 and 10^{12} equivalent cfu/g of the dry composition. Obviously, non-replicating micro-organisms do not form colonies, consequently, this term is to be understood as the amount of non replicating micro-organisms that is obtained from 10^4 and 10^{12} cfu/g replicating bacteria. This includes micro-organisms that are inactivated, non-viable or dead or present as fragments such as DNA or cell wall or cytoplasmic compounds. In other words, the quantity of micro-organisms which the composition contains is expressed in terms of the colony forming ability (cfu) of that quantity of micro-organisms as if all the micro-organisms were alive irrespective of whether they are, in fact, non replicating, such as inactivated or dead, fragmented or a mixture of any or all of these states.

Preferably the non-replicating micro-organisms are present in an amount equivalent to between 10^4 to 10^9 cfu/g of dry composition, even more preferably in an amount equivalent to between 10^5 and 10^9 cfu/g of dry composition.

The probiotics may be rendered non-replicating by any method that is known in the art.

The technologies available today to render probiotic strains non-replicating are usually heat-treatment, γ -irradiation, UV light or the use of chemical agents (formalin, paraformaldehyde).

- 5 It would be preferred to use a technique to render probiotics non-replicating that is relatively easy to apply under industrial circumstances in the food industry.

Most products on the market today that contain probiotics are heat treated during their production. It would hence be
10 convenient, to be able to heat treat probiotics either together with the produced product or at least in a similar way, while the probiotics retain or improve their beneficial properties or even gain a new beneficial property for the consumer.

- 15 However, inactivation of probiotic micro-organisms by heat treatments is associated in the literature generally with an at least partial loss of probiotic activity.

The present inventors have now surprisingly found, that rendering probiotic micro-organisms non-replicating, e.g., by
20 heat treatment, does not result in the loss of probiotic health benefits, but - to the contrary - may enhance existing health benefits and even generate new health benefits.

Hence, one embodiment of the present invention is a powdered cereal composition wherein the non-replicating probiotic
25 micro-organisms were rendered non-replicating by a heat-treatment.

Such a heat treatment may be carried out at at least 71.5 °C for at least 1 second.

Long-term heat treatments or short-term heat treatments may be used.

In industrial scales today usually short term heat treatments, such as UHT-like heat treatments are preferred. This kind of heat treatment reduces bacterial loads, and reduces the processing time, thereby reducing the spoiling of nutrients.

The inventors demonstrate for the first time that probiotics micro-organisms, heat treated at high temperatures for short times exhibit anti-inflammatory immune profiles regardless of their initial properties. In particular either a new anti-inflammatory profile is developed or an existing anti-inflammatory profile is enhanced by this heat treatment.

It is therefore now possible to generate non replicating probiotic micro-organisms with anti-inflammatory immune profiles by using specific heat treatment parameters that correspond to typical industrially applicable heat treatments, even if live counterparts are not anti-inflammatory strains.

Hence, for example, the heat treatment may be a high temperature treatment at about 71.5-150 °C for about 1-120 seconds. The high temperature treatment may be a high temperature/short time (HTST) treatment or a ultra-high temperature (UHT) treatment.

The probiotic micro-organisms may be subjected to a high temperature treatment at about 71.5-150 °C for a short term of about 1-120 seconds.

More preferred the micro-organisms may be subjected to a high temperature treatment at about 90 - 140°C, for example 90°-120°C, for a short term of about 1-30 seconds.

This high temperature treatment renders the micro-organisms at least in part non-replicating.

The high temperature treatment may be carried out at normal atmospheric pressure but may be also carried out under high
5 pressure. Typical pressure ranges are from 1 to 50 bar, preferably from 1-10 bar, even more preferred from 2 to 5 bar. Obviously, it is preferred if the probiotics are heat treated in a medium that is either liquid or solid, when the heat is applied. An ideal pressure to be applied will therefore depend
10 on the nature of the composition which the micro-organisms are provided in and on the temperature used.

The high temperature treatment may be carried out in the temperature range of about 71.5-150 °C, preferably of about 90-120 °C, even more preferred of about 120-140 °C.

15 The high temperature treatment may be carried out for a short term of about 1-120 seconds, preferably, of about 1-30 seconds, even more preferred for about 5-15 seconds.

This given time frame refers to the time the probiotic micro-organisms are subjected to the given temperature. Note, that
20 depending on the nature and amount of the composition the micro-organisms are provided in and depending on the architecture of the heating apparatus used, the time of heat application may differ.

Typically, however, the composition of the present invention
25 and/or the micro-organisms are treated by a high temperature short time (HTST) treatment, flash pasteurization or a ultra high temperature (UHT) treatment.

A UHT treatment is Ultra-high temperature processing or a ultra-heat treatment (both abbreviated UHT) involving the at

least partial sterilization of a composition by heating it for a short time, around 1-10 seconds, at a temperature exceeding 135°C (275°F), which is the temperature required to kill bacterial spores in milk. For example, processing milk in this way using temperatures exceeding 135° C permits a decrease of bacterial load in the necessary holding time (to 2-5 s) enabling a continuous flow operation.

There are two main types of UHT systems: the direct and indirect systems. In the direct system, products are treated by steam injection or steam infusion, whereas in the indirect system, products are heat treated using plate heat exchanger, tubular heat exchanger or scraped surface heat exchanger. Combinations of UHT systems may be applied at any step or at multiple steps in the process of product preparation.

A HTST treatment is defined as follows (High Temperature/Short Time): Pasteurization method designed to achieve a 5-log reduction, killing 99,9999% of the number of viable micro-organisms in milk. This is considered adequate for destroying almost all yeasts, molds and common spoilage bacteria and also ensure adequate destruction of common pathogenic heat resistant organisms. In the HTST process milk is heated to 71.7°C (161°F) for 15-20 seconds.

Flash pasteurization is a method of heat pasteurization of perishable beverages like fruit and vegetable juices, beer and dairy products. It is done prior to filling into containers in order to kill spoilage micro-organisms, to make the products safer and extend their shelf life. The liquid moves in controlled continuous flow while subjected to temperatures of 71.5°C (160°F) to 74°C (165°F) for about 15 to 30 seconds.

For the purpose of the present invention the term "short time high temperature treatment" shall include high-temperature

short time (HTST) treatments, UHT treatments, and flash pasteurization, for example.

Since such a heat treatment provides non-replicating probiotics with an improved anti-inflammatory profile, the powdered cereal composition of the present invention may be for use in the prevention or treatment of inflammatory disorders.

The inflammatory disorders that can be treated or prevented by the composition prepared by the use of the present invention are not particularly limited. For example, they may be selected from the group consisting of acute inflammations such as sepsis; burns; and chronic inflammation, such as inflammatory bowel disease, e.g., Crohn's disease, ulcerative colitis, pouchitis; necrotizing enterocolitis; skin inflammation, such as UV or chemical-induced skin inflammation, eczema, reactive skin; irritable bowel syndrome; eye inflammation; allergy, asthma; and combinations thereof.

If long term heat treatments are used to render the probiotic micro-organisms non-replicating, such a heat treatment may be carried out in the temperature range of about 70-150 °C for about 3 minutes - 2 hours, preferably in the range of 80-140°C from 5 minutes - 40 minutes.

While the prior art generally teaches that bacteria rendered non-replicating by long-term heat-treatments are usually less efficient than live cells in terms of exerting their probiotic properties, the present inventors were able to demonstrate that heat-treated probiotics are superior in stimulating the immune system compared to their live counterparts.

The present invention relates also to a powdered cereal composition comprising probiotic micro-organisms that were

rendered non-replicating by a heat treatment at at least about 70 °C for at least about 3 minutes.

The immune boosting effects of non-replicating probiotics were confirmed by *in vitro* immunoprofiling. The *in vitro* model used
5 uses cytokine profiling from human Peripheral Blood Mononuclear Cells (PBMCs) and is well accepted in the art as standard model for tests of immunomodulating compounds (Schultz et al., 2003, Journal of Dairy Research 70, 165-173; Taylor et al., 2006, Clinical and Experimental Allergy,
10 36, 1227-1235; Kekkonen et al., 2008, World Journal of Gastroenterology, 14, 1192-1203)

The *in vitro* PBMC assay has been used by several authors/research teams for example to classify probiotics according to their immune profile, i.e. their anti- or pro-
15 inflammatory characteristics (Kekkonen et al., 2008, World Journal of Gastroenterology, 14, 1192-1203). For example, this assay has been shown to allow prediction of an anti-inflammatory effect of probiotic candidates in mouse models of intestinal colitis (Foligne, B., et al., 2007, World
20 J.Gastroenterol. 13:236-243). Moreover, this assay is regularly used as read-out in clinical trials and was shown to lead to results coherent with the clinical outcomes (Schultz et al., 2003, Journal of Dairy Research 70, 165-173; Taylor et al., 2006, Clinical and Experimental Allergy, 36, 1227-1235).

25 Allergic diseases have steadily increased over the past decades and they are currently considered as epidemics by WHO. In a general way, allergy is considered to result from an imbalance between the Th1 and Th2 responses of the immune system leading to a strong bias towards the production of Th2
30 mediators. Therefore, allergy can be mitigated, down-regulated or prevented by restoring an appropriate balance between the Th1 and Th2 arms of the immune system. This implies the

necessity to reduce the Th2 responses or to enhance, at least transiently, the Th1 responses. The latter would be characteristic of an immune boost response, often accompanied by for example higher levels of IFN γ , TNF- α and IL-12.

5 (Kekkonen et al., 2008, World Journal of Gastroenterology, 14, 1192-1203; Viljanen M. et al., 2005, Allergy, 60, 494-500)

The powdered cereal composition of the present invention allows it hence to treat or prevent disorders that are related to a compromised immune defence.

10 Consequently, the disorders linked to a compromised immune defence that can be treated or prevented by the composition prepared by the use of the present invention are not particularly limited.

For example, they may be selected from the group consisting of
15 infections, in particular bacterial, viral, fungal and/or parasite infections; phagocyte deficiencies; low to severe immunodepression levels such as those induced by stress or immunodepressive drugs, chemotherapy or radiotherapy; natural states of less immunocompetent immune systems such as those of
20 the neonates; allergies; and combinations thereof.

The powdered cereal composition described in the present invention allows it also to enhance a response to vaccines, in particular to oral vaccines.

Any amount of non-replicating micro-organisms will be
25 effective. However, it is generally preferred, if at least 90 %, preferably, at least 95 %, more preferably at least 98 %, most preferably at least 99 %, ideally at least 99.9 %, most ideally all of the probiotics are non-replicating.

In one embodiment of the present invention all micro-organisms are non-replicating.

Consequently, in the powdered cereal composition of the present invention at least 90 %, preferably, at least 95 %, more preferably at least 98 %, most preferably at least 99 %, ideally at least 99.9 %, most ideally all of the probiotics are non-replicating.

All probiotic micro-organisms may be used for the purpose of the present invention.

For example, the probiotic micro-organisms may be selected from the group consisting of bifidobacteria, lactobacilli, propionibacteria, or combinations thereof, for example *Bifidobacterium longum*, *Bifidobacterium lactis*, *Bifidobacterium animalis*, *Bifidobacterium breve*, *Bifidobacterium infantis*, *Bifidobacterium adolescentis*, *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus paracasei*, *Lactobacillus salivarius*, *Lactobacillus reuteri*, *Lactobacillus rhamnosus*, *Lactobacillus johnsonii*, *Lactobacillus plantarum*, *Lactobacillus fermentum*, *Lactococcus lactis*, *Streptococcus thermophilus*, *Lactococcus lactis*, *Lactococcus diacetylactis*, *Lactococcus cremoris*, *Lactobacillus bulgaricus*, *Lactobacillus helveticus*, *Lactobacillus delbrueckii*, *Escherichia coli* and/or mixtures thereof.

The infant cereal in accordance with the present invention may, for example comprise non-replicating probiotic micro-organisms selected from the group consisting of *Bifidobacterium longum* NCC 3001, *Bifidobacterium longum* NCC 2705, *Bifidobacterium breve* NCC 2950, *Bifidobacterium lactis* NCC 2818, *Lactobacillus johnsonii* La1, *Lactobacillus paracasei* NCC 2461, *Lactobacillus rhamnosus* NCC 4007, *Lactobacillus reuteri* DSM17983, *Lactobacillus reuteri* ATCC55730,

Streptococcus thermophilus NCC 2019, *Streptococcus thermophilus* NCC 2059, *Lactobacillus casei* NCC 4006, *Lactobacillus acidophilus* NCC 3009, *Lactobacillus casei* ACA-DC 6002 (NCC 1825), *Escherichia coli* Nissle, *Lactobacillus*
 5 *bulgaricus* NCC 15, *Lactococcus lactis* NCC 2287, or combinations thereof.

All these strains were either deposited under the Budapest treaty and/or are commercially available.

The strains have been deposited under the Budapest treaty as
 10 follows:

Bifidobacterium longum NCC 3001:	ATCC BAA-999
Bifidobacterium longum NCC 2705:	CNCM I-2618
Bifidobacterium breve NCC 2950	CNCM I-3865
Bifidobacterium lactis NCC 2818:	CNCM I-3446
15 Lactobacillus paracasei NCC 2461:	CNCM I-2116
Lactobacillus rhamnosus NCC 4007:	CGMCC 1.3724
Streptococcus themophilus NCC 2019:	CNCM I-1422
Streptococcus themophilus NCC 2059:	CNCM I-4153
Lactococcus lactis NCC 2287:	CNCM I-4154
20 Lactobacillus casei NCC 4006:	CNCM I-1518
Lactobacillus casei NCC 1825:	ACA-DC 6002
Lactobacillus acidophilus NCC 3009:	ATCC 700396

Lactobacillus bulgaricus NCC 15: CNCM I-1198

Lactobacillus johnsonii La1 CNCM I-1225

Lactobacillus reuteri DSM17983 DSM17983

Lactobacillus reuteri ATCC55730 ATCC55730

5 Escherichia coli Nissle 1917: DSM 6601

Strains named ATCC were deposited with the ATCC Patent Depository, 10801 University Blvd., Manassas, VA 20110, USA.

Strains named CNCM were deposited with the COLLECTION
NATIONALE DE CULTURES DE MICROORGANISMES (CNCM), 25 rue du
10 Docteur Roux, F-75724 PARIS Cedex 15, France.

Strains named CGMCC were deposited with the China General Microbiological Culture Collection Center, Institute of Microbiology, Chinese Academy of Sciences, Zhongguancun, P.O.Box2714, Beijing 100080, China.

15 Strains named ACA-DC were deposited with the Greek Coordinated Collections of Microorganisms, Dairy Laboratory, Department of Food Science and Technology, Agricultural University of Athens, 75, Iera odos, Botanikos, Athens, 118 55, Greece.

Strains named DSM were deposited with the DSMZ-Deutsche
20 Sammlung von Mikroorganismen und Zellkulturen GmbH, Inhoffenstr. 7 B, 38124 Braunschweig, GERMANY.

Those skilled in the art will understand that they can freely combine all features of the present invention described herein, without departing from the scope of the invention as
25 disclosed.

Further advantages and features of the present invention are apparent from the following Examples and Figures.

Figures 1 A and B show the enhancement of the anti-inflammatory immune profiles of probiotics treated with "short-time high temperatures".

Figure 2 shows non anti-inflammatory probiotic strains that become anti-inflammatory, i.e. that exhibit pronounced anti-inflammatory immune profiles *in vitro* after being treated with "short-time high temperatures".

Figures 3 A and B show probiotic strains in use in commercially available products that exhibit enhanced or new anti-inflammatory immune profiles *in vitro* after being treated with "short-time high temperatures".

Figures 4 A and B show dairy starter strains (i.e. Lcl starter strains) that exhibits enhanced or new anti-inflammatory immune profiles *in vitro* upon heat treatment at high temperatures.

Figure 5 shows a non anti-inflammatory probiotic strain that exhibits anti-inflammatory immune profiles *in vitro* after being treated with HTST treatments.

Figure 6: Principal Component Analysis on PBMC data (IL-12p40, IFN- γ , TNF- α , IL-10) generated with probiotic and dairy starter strains in their live and heat treated (140°C for 15 second) forms. Each dot represents one strain either live or heat treated identified by its NCC number or name.

Figure 7 shows IL-12p40 / IL-10 ratios of live and heat treated (85°C, 20min) strains. Overall, heat treatment at 85°C for 20 min leads to an increase of IL-12p40 / IL-10 ratios as opposed to "short-time high temperature" treatments of the present invention (Figures 1, 2, 3, 4 and 5).

Figure 8 shows the enhancement of *in vitro* cytokine secretion from human PBMCs stimulated with heat treated bacteria.

Figure 9 shows the percentage of diarrhea intensity observed in OVA-sensitized mice challenged with saline (negative control), OVA-sensitized mice challenged with OVA (positive control) and OVA-sensitized mice challenged with OVA and treated with heat-treated or live *Bifidobacterium breve* NCC2950. Results are displayed as the percentage of diarrhea intensity (Mean $\pm$ SEM calculated from 4 independent experiments) with 100 % of diarrhea intensity corresponding to the symptoms developed in the positive control (sensitized and challenged by the allergen) group.

Example 1:

Methodology

15 Bacterial preparations:

The health benefits delivered by live probiotics on the host immune system are generally considered to be strain specific. Probiotics inducing high levels of IL-10 and/or inducing low levels of pro-inflammatory cytokines *in vitro* (PBMC assay) have been shown to be potent anti-inflammatory strains *in vivo* (Foligné, B., et al., 2007, World J.Gastroenterol. 13:236-243).

Several probiotic strains were used to investigate the anti-inflammatory properties of heat treated probiotics. These were *Bifidobacterium longum* NCC 3001, *Bifidobacterium longum* NCC 2705, *Bifidobacterium breve* NCC 2950, *Bifidobacterium lactis* NCC 2818, *Lactobacillus paracasei* NCC 2461, *Lactobacillus rhamnosus* NCC 4007, *Lactobacillus casei* NCC 4006, *Lactobacillus acidophilus* NCC 3009, *Lactobacillus casei* ACA-DC 6002 (NCC 1825), and *Escherichia coli* Nissle. Several starter culture strains including some strains commercially used to

produce Nestlé Lcl fermented products were also tested: *Streptococcus thermophilus* NCC 2019, *Streptococcus thermophilus* NCC 2059, *Lactobacillus bulgaricus* NCC 15 and *Lactococcus lactis* NCC 2287.

- 5 Bacterial cells were cultivated in conditions optimized for each strain in 5-15L bioreactors. All typical bacterial growth media are usable. Such media are known to those skilled in the art. When pH was adjusted to 5.5, 30% base solution (either NaOH or Ca(OH)₂) was added continuously. When adequate,
10 anaerobic conditions were maintained by gassing headspace with CO₂. *E. coli* was cultivated under standard aerobic conditions.

Bacterial cells were collected by centrifugation (5,000 × g, 4°C) and re-suspended in phosphate buffer saline (PBS) in adequate volumes in order to reach a final concentration of
15 around 10⁹ -10¹⁰ cfu/ml. Part of the preparation was frozen at -80°C with 15% glycerol. Another part of the cells was heat treated by:

- Ultra High Temperature: 140°C for 15 sec; by indirect steam injection.
- 20 - High Temperature Short Time (HTST): 74°C, 90°C and 120°C for 15 sec by indirect steam injection
- Long Time Low Temperature (85°C, 20 min) in water bath

Upon heat treatment, samples were kept frozen at -80°C until use.

- 25 *In vitro* immunoprofiling of bacterial preparations:

The immune profiles of live and heat treated bacterial preparations (i.e. the capacity to induce secretion of specific cytokines from human blood cells *in vitro*) were assessed. Human peripheral blood mononuclear cells (PBMCs)

were isolated from blood filters. After separation by cell density gradient, mononuclear cells were collected and washed twice with Hank's balanced salt solution. Cells were then resuspended in Iscove's Modified Dulbecco's Medium (IMDM, Sigma) supplemented with 10% foetal calf serum (Bioconcept, Paris, France), 1% L-glutamine (Sigma), 1% penicillin/streptomycin (Sigma) and 0.1% gentamycin (Sigma). PBMCs (7×10^5 cells/well) were then incubated with live and heat treated bacteria (equivalent 7×10^6 cfu/well) in 48 well plates for 36h. The effects of live and heat treated bacteria were tested on PBMCs from 8 individual donors splitted into two separated experiments. After 36h incubation, culture plates were frozen and kept at -20°C until cytokine measurement. Cytokine profiling was performed in parallel (i.e. in the same experiment on the same batch of PBMCs) for live bacteria and their heat-treated counterparts.

Levels of cytokines (IFN- γ , IL-12p40, TNF- α and IL-10) in cell culture supernatants after 36h incubation were determined by ELISA (R&D DuoSet Human IL-10, BD OptEIA Human IL12p40, BD OptEIA Human TNF α , BD OptEIA Human IFN- γ) following manufacturer's instructions. IFN- γ , IL-12p40 and TNF- α are pro-inflammatory cytokines, whereas IL-10 is a potent anti-inflammatory mediator. Results are expressed as means (pg/ml) +/- SEM of 4 individual donors and are representative of two individual experiments performed with 4 donors each. The ratio IL-12p40 / IL-10 is calculated for each strain as a predictive value of *in vivo* anti-inflammatory effect (Foligné, B., et al., 2007, World J.Gastroenterol. 13:236-243).

Numerical cytokine values (pg/ml) determined by ELISA (see above) for each strain were transferred into BioNumerics v5.10 software (Applied Maths, Sint-Martens-Latem, Belgium). A Principal Component Analysis (PCA, dimensioning technique) was performed on this set of data. Subtraction of the averages

over the characters and division by the variances over the characters were included in this analysis.

Results

Anti-inflammatory profiles generated by Ultra High Temperature (UHT) / High Temperature Short Time (HTST)-like treatments

The probiotic strains under investigation were submitted to a series of heat treatments (Ultra High Temperature (UHT), High Temperature Short Time (HTST) and 85°C for 20 min) and their immune profiles were compared to those of live cells *in vitro*.

Live micro-organisms (probiotics and/or dairy starter cultures) induced different levels of cytokine production when incubated with human PBMC (Figures 1, 2, 3, 4 and 5). Heat treatment of these micro-organisms modified the levels of cytokines produced by PBMC in a temperature dependent manner.

"Short-time high temperature" treatments (120°C or 140°C for 15'') generated non replicating bacteria with anti-inflammatory immune profiles (Figures 1, 2, 3 and 4). Indeed, UHT-like treated strains (140°C, 15 sec) induced less pro-inflammatory cytokines (TNF- α , IFN- γ , IL-12p40) while

maintaining or inducing additional IL-10 production (compared to live counterparts). The resulting IL-12p40 / IL-10 ratios were lower for any UHT-like treated strains compared to live cells (Figures 1, 2, 3 and 4). This observation was also valid for bacteria treated by HTST-like treatments, i.e. submitted

to 120°C for 15 sec (Figures 1, 2, 3 and 4), or 74°C and 90°C for 15 sec (Figure 5). Heat treatments (UHT-like or HTST-like treatments) had a similar effect on *in vitro* immune profiles of probiotic strains (Figures 1, 2, 3 and 5) and dairy starter cultures (Figure 4). Principal Component Analysis on PBMC data generated with live and heat treated (140°C, 15'') probiotic and dairy starter strains revealed that live strains are spread all along the x axis, illustrating that strains exhibit

very different immune profiles *in vitro*, from low (left side) to high (right side) inducers of pro-inflammatory cytokines. Heat treated strains cluster on the left side of the graph, showing that pro-inflammatory cytokines are much less induced by heat treated strains (Figure 6). By contrast, bacteria heat treated at 85°C for 20 min induced more pro-inflammatory cytokines and less IL-10 than live cells resulting in higher IL-12p40 / IL-10 ratios (Figure 7).

Anti-inflammatory profiles are enhanced or generated by UHT-like and HTST-like treatments.

UHT and HTST treated strains exhibit anti-inflammatory profiles regardless of their respective initial immune profiles (live cells). Probiotic strains known to be anti-inflammatory *in vivo* and exhibiting anti-inflammatory profiles *in vitro* (*B. longum* NCC 3001, *B. longum* NCC 2705, *B. breve* NCC 2950, *B. lactis* NCC 2818) were shown to exhibit enhanced anti-inflammatory profiles *in vitro* after "short-time high temperature" treatments. As shown in Figure 1, the IL-12p40 / IL-10 ratios of UHT-like treated *Bifidobacterium* strains were lower than those from the live counterparts, thus showing improved anti-inflammatory profiles of UHT-like treated samples. More strikingly, the generation of anti-inflammatory profiles by UHT-like and HTST-like treatments was also confirmed for non anti-inflammatory live strains. Both live *L. rhamnosus* NCC 4007 and *L. paracasei* NCC 2461 exhibit high IL-12p40 / IL-10 ratios *in vitro* (Figures 2 and 5). The two live strains were shown to be not protective against TNBS-induced colitis in mice. The IL-12p40 / IL-10 ratios induced by *L. rhamnosus* NCC 4007 and *L. paracasei* NCC 2461 were dramatically reduced after "short-time high temperature" treatments (UHT or HTST) reaching levels as low as those obtained with *Bifidobacterium* strains. These low IL-12p40 / IL-10 ratios are due to low levels of IL-12p40 production combined with no

change (*L. rhamnosus* NCC 4007) or a dramatic induction of IL-10 secretion (*L. paracasei* NCC 2461) (Figure 2).

As a consequence:

- Anti-inflammatory profiles of live micro-organisms can be enhanced by UHT-like and HTST-like heat treatments (for instance *B. longum* NCC 2705, *B. longum* NCC 3001, *B. breve* NCC 2950, *B. lactis* NCC 2818)
- Anti-inflammatory profiles can be generated from non anti-inflammatory live micro-organisms (for example *L. rhamnosus* NCC 4007, *L. paracasei* NCC 2461, dairy starters *S. thermophilus* NCC 2019) by UHT-like and HTST-like heat treatments.
- Anti-inflammatory profiles were also demonstrated for strains isolated from commercially available products (Figures 3 A & B) including a probiotic *E. coli* strain.

The impact of UHT/HTST-like treatments was similar for all tested probiotics and dairy starters, for example lactobacilli, bifidobacteria and streptococci.

UHT/HTST-like treatments were applied to several lactobacilli, bifidobacteria and streptococci exhibiting different *in vitro* immune profiles. All the strains induced less pro-inflammatory cytokines after UHT/HTST-like treatments than their live counterparts (Figures 1, 2, 3, 4, 5 and 6) demonstrating that the effect of UHT/HTST-like treatments on the immune properties of the resulting non replicating bacteria can be generalized to all probiotics, in particular to lactobacilli and bifidobacteria and specific *E. coli* strains and to all dairy starter cultures in particular to streptococci, lactococci and lactobacilli.

Example 2:

Methodology

Bacterial preparations:

- 5 Five probiotic strains were used to investigate the immune boosting properties of non-replicating probiotics: 3 bifidobacteria (*B. longum* NCC3001, *B. lactis* NCC2818, *B. breve* NCC2950) and 2 lactobacilli (*L. paracasei* NCC2461, *L. rhamnosus* NCC4007).
- 10 Bacterial cells were grown on MRS in batch fermentation at 37°C for 16-18h without pH control. Bacterial cells were spun down (5,000 x g, 4°C) and resuspended in phosphate buffer saline prior to be diluted in saline water in order to reach a final concentration of around 10E10 cfu/ml. *B. longum* NCC3001, *B.*
- 15 *lactis* NCC2818, *L. paracasei* NCC2461, *L. rhamnosus* NCC4007 were heat treated at 85°C for 20 min in a water bath. *B. breve* NCC2950 was heat treated at 90°C for 30 minutes in a water bath. Heat treated bacterial suspensions were aliquoted and kept frozen at -80°C until use. Live bacteria were stored at -
- 20 80°C in PBS-glycerol 15% until use.

In vitro immunoprofiling of bacterial preparations

- The immune profiles of live and heat treated bacterial preparations (i.e. the capacity to induce secretion of specific cytokines from human blood cells *in vitro*) were
- 25 assessed. Human peripheral blood mononuclear cells (PBMCs) were isolated from blood filters. After separation by cell density gradient, mononuclear cells were collected and washed twice with Hank's balanced salt solution. Cells were then resuspended in Iscove's Modified Dulbecco's Medium (IMDM,
- 30 Sigma) supplemented with 10% foetal calf serum (Bioconcept,

Paris, France), 1% L-glutamine (Sigma), 1% penicillin/streptomycin (Sigma) and 0.1% gentamycin (Sigma). PBMCs (7×10^5 cells/well) were then incubated with live and heat treated bacteria (equivalent 7×10^6 cfu/well) in 48 well plates for 36h. The effects of live and heat treated bacteria were tested on PBMCs from 8 individual donors splitted into two separate experiments. After 36h incubation, culture plates were frozen and kept at -20°C until cytokine measurement. Cytokine profiling was performed in parallel (i.e. in the same experiment on the same batch of PBMCs) for live bacteria and their heat-treated counterparts.

Levels of cytokines (IFN- γ , IL-12p40, TNF- α and IL-10) in cell culture supernatants after 36h incubation were determined by ELISA (R&D DuoSet Human IL-10, BD OptEIA Human IL12p40, BD OptEIA Human TNF, BD OptEIA Human IFN- γ) following manufacturer's instructions. IFN- γ , IL-12p40 and TNF- α are pro-inflammatory cytokines, whereas IL-10 is a potent anti-inflammatory mediator. Results are expressed as means (pg/ml) $\pm$ SEM of 4 individual donors and are representative of two individual experiments performed with 4 donors each.

In vivo effect of live and heat treated Bifidobacterium breve NCC2950 in prevention of allergic diarrhea

A mouse model of allergic diarrhea was used to test the Th1 promoting effect of *B. breve* NCC2950 (Brandt E.B et al. JCI 2003; 112(11): 1666-1667). Following sensitization (2 intraperitoneal injections of Ovalbumin (OVA) and aluminium potassium sulphate at an interval of 14 days; days 0 and 14) male Balb/c mice were orally challenged with OVA for 6 times (days 27, 29, 32, 34, 36, 39) resulting in transient clinical symptoms (diarrhea) and changes of immune parameters (plasma concentration of total IgE, OVA specific IgE, mouse mast cell

protease 1, i.e MMCP-1). *Bifidobacterium breve* NCC2950 live or heat treated at 90°C for 30min, was administered by gavage 4 days prior to OVA sensitization (days -3, -2, -1, 0 and days 11, 12, 13 and 14) and during the challenge period (days 23 to 39). A daily bacterial dose of around 10^9 colony forming units (cfu) or equivalent cfu/mouse was used.

Results

Induction of secretion of 'pro-inflammatory' cytokines after heat treatment

The ability of heat treated bacterial strains to stimulate cytokine secretion by human peripheral blood mononuclear cells (PBMCs) was assessed *in vitro*. The immune profiles based on four cytokines upon stimulation of PBMCs by heat treated bacteria were compared to that induced by live bacterial cells in the same *in vitro* assay.

The heat treated preparations were plated and assessed for the absence of any viable counts. Heat treated bacterial preparations did not produce colonies after plating.

Live probiotics induced different and strain dependent levels of cytokine production when incubated with human PBMCs (Figure 8). Heat treatment of probiotics modified the levels of cytokines produced by PBMCs as compared to their live counterparts. Heat treated bacteria induced more pro-inflammatory cytokines (TNF- α , IFN- γ , IL-12p40) than their live counterparts do. By contrast heat treated bacteria induced similar or lower amounts of IL-10 compared to live cells (Figure 8). These data show that heat treated bacteria are more able to stimulate the immune system than their live counterparts and therefore are more able to boost weakened immune defences. In other words the *in vitro* data illustrate

an enhanced immune boost effect of bacterial strains after heat treatment.

In order to illustrate the enhanced effect of heat-treated *B. breve* NCC2950 (compared to live cells) on the immune system,
 5 both live and heat treated *B. breve* NCC2950 (strain A) were tested in an animal model of allergic diarrhea.

As compared to the positive control group, the intensity of diarrhea was significantly and consistently decreased after treatment with heat treated *B. breve* NCC2950 ($41.1 \% \pm 4.8$)
 10 whereas the intensity of diarrhea was lowered by only $20 \pm 28.3 \%$ after treatment with live *B. breve* NCC2950. These results demonstrate that heat-treated *B. breve* NCC2950 exhibits an enhanced protective effect against allergic diarrhea than its live counterpart (Figure 9).

15 As a consequence, the ability of probiotics to enhance the immune defences was shown to be improved after heat treatment.

Example 3:

A ready to eat infant cereal is prepared by mixing 15g of the formulation with 90 mL water. The dry composition may be
 20 prepared by any method known to those of skill in the art.

For infants at the age of 6-12 months:

Ingredients : Wheat flour, Semolina (Wheat) Mineral (Iron), Vitamins [C, Niacin, B6, Thiamin], Maize Maltodextrin.

Energy	228 kJ/15g
Protein	1,7g/15g

Fat	0,3 g/15g
Carbohydrates	11,3 /15g (3,6 g from sugar)
probiotics	10^8 cfu/15g heat treated (85°C for 20 min) <i>Bifidobacterium longum</i> NCC 3001

Claims:

1. Powdered cereal based composition to be reconstituted in water, milk, or infant formula comprising at least 25 weight-% cereal and having an energy density of at least 0.8 kcal/g and containing after reconstitution at least 2g/100kcal protein, less than 4.5g/100kcal fat, and less than 7.5g/100kcal added sweetening agents with less than 3.75g/100kcal fructose, wherein the powdered cereal based composition further comprises non-replicating probiotic micro-organisms.
2. Powdered cereal based composition in accordance with claim 1, wherein the sweetening agents are selected from the group consisting of sucrose, glucose, fructose, glucose syrup, honey and combinations thereof.
3. Powdered cereal based composition in accordance with one of the preceding claims containing after reconstitution about 2g-5.5g/100kcal protein, and less than 5g/100kcal added sweetening agents with less than 2.5g/100kcal fructose.
4. Powdered cereal based composition in accordance with one of the preceding claims containing less than 40g mono- and disaccharides, preferably less than 35g mono- and disaccharides per 100g powdered composition.
5. Powdered cereal based composition in accordance with one of the preceding claims further comprising at least 50µg vitamin B1 per 100 kcal, 60-180 µg vitamin A per 100 kcal, and/or 1-3 µg vitamin D per 100 kcal.
6. Powdered cereal based composition in accordance with one of the preceding claims, further comprising prebiotics, for example oligofructose and inulin.
7. Powdered cereal based composition in accordance with one of the preceding claims comprising non replicating

probiotic micro-organisms in an amount corresponding to about 10^6 to 10^{12} cfu.

8. Powdered cereal based composition in accordance with one of the preceding claims wherein the non-replicating probiotic micro-organisms were rendered non-replicating by a heat-treatment, preferably by a high temperature treatment at at least 71.5 °C for at least 1 second.

9. Powdered cereal based composition in accordance with claim 8, wherein the heat treatment is a high temperature treatment at about 71.5-150 °C for about 1-120 seconds, and preferably is a high temperature/short time (HTST) treatment or a ultra-high temperature (UHT) treatment.

10. Powdered cereal based composition in accordance with claim 9 for use in the prevention or treatment of inflammatory disorders.

11. Powdered cereal based composition in accordance with claim 8, wherein the heat treatment is carried out in the temperature range of about 70-150 °C for about 3 minutes - 2 hours, preferably in the range of 80-140°C from 5 minutes - 40 minutes.

12. Powdered cereal based composition in accordance with claim 11 for use in the prevention or treatment disorders related to a compromised immune defence.

13. Powdered cereal based composition in accordance with one of the preceding claims wherein at least 90 %, preferably, at least 95 %, more preferably at least 98 %, most preferably at least 99 %, ideally at least 99.9 %, most ideally all of the probiotics are non-replicating.

14. Powdered cereal based composition in accordance with one of the preceding claims wherein the probiotic micro-organisms are selected from the group consisting of bifidobacteria, lactobacilli, propionibacteria, or combinations thereof, for example *Bifidobacterium longum*, *Bifidobacterium lactis*, *Bifidobacterium animalis*,

Bifidobacterium breve, *Bifidobacterium infantis*,
Bifidobacterium adolescentis, *Lactobacillus acidophilus*,
Lactobacillus casei, *Lactobacillus paracasei*,
Lactobacillus salivarius, *Lactobacillus reuteri*,
5 *Lactobacillus rhamnosus*, *Lactobacillus johnsonii*,
Lactobacillus plantarum, *Lactobacillus fermentum*,
Lactococcus lactis, *Streptococcus thermophilus*,
Lactococcus lactis, *Lactococcus diacetylactis*, *Lactococcus*
cremoris, *Lactobacillus bulgaricus*, *Lactobacillus*
10 *helveticus*, *Lactobacillus delbrueckii*, *Escherichia coli*
and/or mixtures thereof.

15. Powdered cereal based composition in accordance with
one of the preceding claims wherein the probiotic micro-
organisms are selected from the group consisting of
15 *Bifidobacterium longum* NCC 3001, *Bifidobacterium longum*
NCC 2705, *Bifidobacterium breve* NCC 2950, *Bifidobacterium*
lactis NCC 2818, *Lactobacillus johnsonii* Lal,
Lactobacillus paracasei NCC 2461, *Lactobacillus rhamnosus*
NCC 4007, *Lactobacillus reuteri* DSM17983, *Lactobacillus*
20 *reuteri* ATCC55730, *Streptococcus thermophilus* NCC 2019,
Streptococcus thermophilus NCC 2059, *Lactobacillus casei*
NCC 4006, *Lactobacillus acidophilus* NCC 3009,
Lactobacillus casei ACA-DC 6002 (NCC 1825), *Escherichia*
coli Nissle, *Lactobacillus bulgaricus* NCC 15, *Lactococcus*
25 *lactis* NCC 2287, or combinations thereof.

16. Powdered cereal based composition in accordance with
one of the preceding claims containing about 0,005 mg -
1000 mg non-replicating micro-organisms per daily dose.