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- (71) **Applicant** (for all designated States except US): **N.V. Nutricia** [NL/NL]; Eerste Stationsstraat 186, NL-2712 HM Zoetermeer (NL).
- (72) **Inventors; and**
- (75) **Inventors/Applicants** (for US only): **BARTOSIK, Magdalena** [PL/PL]; Chabrów 34/43, PL-45-221 Opole (PL). **FOULHAC, Jean Paul** [FR/FR]; Brochat, FR-19240 Allassac (FR). **HUIJS, Geertje Katrien** [NL/NL]; Leonard Roggeveenstraat 29, NL-6708 SL Wageningen (NL). **LACARDE, Marianne** [FR/FR]; 2, rue de la Reine, FR-19270 Ussac (FR). **PILIPÓW, Jadwiga** [PL/PL]; Drzymaly 2/4, PL-45-342 Opole (PL).
- (74) **Agent:** **BOT, David**; J.W. Frisolaan 13, NL-2517 JS The Hague (NL).

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(54) **Title:** CONTINUOUS PROCESS FOR PRODUCING STERILE, VISCOUS INFANT FOOD PRODUCTS WITH PARTICLES

(57) **Abstract:** This invention relates to a continuous process for producing a packaged, sterile, viscous infant food product containing particles with a diameter in the range of from 3 to 25 mm, the process comprising sterilizing a viscous infant food mixture with particles such that an F0 value of at least 10 is achieved. The invention further relates to an infant food product obtainable by such process and to the use of such infant food product for feeding an infant of an age of between about 6 months and 36 months.



CONTINUOUS PROCESS FOR PRODUCING STERILE, VISCOUS INFANT FOOD PRODUCTS WITH PARTICLES

FIELD OF THE INVENTION

5 The present invention relates to a continuous process for producing a packaged, sterile, viscous infant food product containing particles, to an infant food product obtainable by such process and to the use of such infant food product.

BACKGROUND OF THE INVENTION

10 During the first six months of an infant's life, exclusive breastfeeding is recommended as it provides all the nutrients an infant needs. Alternatively, infant milk formula is the best breast milk substitute for children who are not in the position of being breastfed. For infants older than six months, the recommended feeding is continued breastfeeding in addition to complementary foods. The purpose of
15 introducing complementary (solid) foods alongside an infant's milk feeds is *i*) to provide extra energy and nutrients when breast milk or infant formula no longer supplies them in sufficient amounts, in order to sustain normal growth and to promote optimal health and development; *ii*) to give infants the opportunity to learn new tastes and textures, based on family foods, at a time when they are receptive to them. Ideally,
20 complementary foods should provide a variety of foods in the weaning diet. Adequate complementary foods are rich in energy, protein and micronutrients; they are easy to eat and digest; they are hygienically prepared. When complementary foods contain pieces, those should be of a size and consistency adapted to the infant's age to avoid choking and to give the infant the opportunity to develop his liking of a variety of foods
25 and to learn chewing and swallowing.

 There are commonly accepted stages of infant development that are used to classify the type of complementary foods. Each stage (1, 2, 3, and 4) corresponds to introducing new variety of ingredients, tastes and textures, including increasing the dimensions of solid food pieces.

30 Infant food has to meet very high standards regarding microbiological safety, because infants are more vulnerable and more prone to infections than adults. Therefore the heating steps involved in producing infant food are thorough, potentially affecting the taste and texture of the product. Traditionally, industrially-produced infant food

products are pre-cooked, filled in jars and sterilized in retort (autoclave). This process is slow and involves long sterilization times, bringing a lot of heat damage to the product. A more recent process for producing sterile infant food products is the heating of the product outside the package at a high temperature for a very short time, a so-called Ultra High Temperature (UHT) treatment, followed by cooling and packaging the sterilized product in an aseptic environment. This process is quicker and gives less heat damage than the retort process. Commonly used equipment for UHT treatment comprises a tubular heat exchanger, wherein the product flows through a tube and is heated by hot tube walls (convective heating), a holding tube wherein the heated product is maintained for a certain time at the heating temperature, followed by means for cooling and packaging under aseptic conditions. Such UHT process by convective heat exchange is typically used for low viscosity liquid food products.

An alternative UHT system for (infant) food products uses direct steam injection. In such a process, steam is directly injected into the tube through which the product is flowing, allowing direct heat transfer from the condensing steam to the product. Conventional direct steam injection UHT equipment possesses only one injector through which steam is injected into the tube. With the use of a single injector, heat transfer from the steam to the food product is not optimal. In order to decrease heating time and to avoid local under or overheating, UHT equipment with multiple-steam injectors and agitators has been introduced. An example of equipment for UHT processing of food products using multiple steam injection and an agitator is a machine named RotaTherm® that is manufactured by Gold Peg International. In WO 2008/046080 it is disclosed that this machine, although effective for non-viscous liquid products, is less effective for semi-solid products and for products with solid particles. It is mentioned that in order to ensure even heating in products with particulates, high rotating speeds would be required, resulting in damage to the particulates.

In infant food products with particles, high agitation would be problematic, since at the relatively severe sterilization conditions needed, such high agitation would easily result in disintegration of the particles.

The severity of a sterilization process is typically expressed as the F0 value. The F0 value is defined as the number of equivalent minutes of steam sterilization at a

temperature of 121.1 °C delivered to a unit of product, regardless of the actual temperature and time used in the sterilization process.

SUMMARY OF THE INVENTION

5 It has now been found that viscous infant food products comprising particles can be sterilized by using UHT with multiple-steam injection at relatively high sterilization severity whilst maintaining better quality in terms of taste, color, shelf-life stability, and preservation of nutritional ingredients as compared to UHT-treated products at comparably sterilization severity and whilst avoiding particle disintegration.

10 Accordingly, the present invention relates to a continuous process for producing a packaged, sterile, viscous infant food product containing particles with a diameter in the range of from 3 to 25 mm, the process comprising the following steps:

- a) providing a mixture of two or more infant food ingredients, the mixture having a viscous continuous phase and particles with a diameter in the range of from 3
15 to 25 mm;
- b) sterilizing the mixture provided in step a) with an F0 value of at least 10 for the continuous phase of the mixture by:
 - b1) continuously supplying the mixture to a vertically extending tubular
20 cooking chamber having a lower end and an upper end, the cooking chamber having an inlet at its lower end, an outlet at its upper end, and being provided with at least three steam injectors, wherein the cooking chamber is equipped with an axially-extending rotatable agitator;
 - b2) injecting steam having a temperature in the range of from 135°C to
25 200°C into the cooking chamber through the steam injectors and rotating the agitator at a speed in the range of from 50 to 700 rpm to obtain heated mixture;
 - b3) continuously discharging the heated mixture having a temperature in the
range of from 128 to 145°C from the cooking chamber through its outlet
30 into a holding tube having an inlet at a first end that is in fluid connection with the outlet of the cooking chamber and an outlet at its opposite end; and
 - b4) continuously discharging the mixture from the holding tube through its
outlet into an indirect cooling system,

wherein the residence time of the mixture in the cooking chamber is in the range of from 10 to 120 seconds, the residence time of the heated mixture in the holding tube is in the range of from 30 to 240 seconds;

- c) cooling the mixture to a temperature in the range of from 10 to 60 °C in the indirect cooling system to obtain a sterile, cooled mixture; and
- d) aseptically packaging the sterile, cooled mixture to obtain sterile, packaged infant food product.

Moreover, it has been found that even at very severe sterilizing conditions, i.e. F0 values above 30 or even above 40, the products produced by the process according to the invention have a better quality than those produced with a comparable F0-value with a convective UHT process. This is all the more surprising, since at very high F0 values, the benefits of a multiple-steam injection UHT process, i.e. a process with relatively rapid heating of the mixture to be sterilized, are typically lower than at lower F0-values. At high F0-values, the contribution of the heating phase to the total heat charge is relatively low compared to the contribution of the holding phase, i.e. the phase in which the product is maintained at the heating temperature.

It has further been found that in the process according to the invention, short heating times and homogeneous heating can be achieved at relatively low rotating speeds of the agitator. Thus, the risk of disintegration of the particles is minimized.

The invention further relates to an infant food product obtainable by the process as defined hereinabove.

The invention provides infant food products which are looking more natural, are tasting fresher, and/or have a better nutritional value with lower amounts of furan being produced and show a better preservation of vitamins and anti-oxidants as compared to infant food products prepared by convective UHT, whilst particle integrity is maintained. This is advantageous for accustoming infants to new tastes and textures which are similar to natural and fresh food, at a time when they are still receptive to such new tastes and textures, instead of accustoming infants to the taste and texture of less natural and overly processed food. In this way, not only the food provided to the infant is healthier, but also the imprinting of taste preferences later in life, i.e. the sensoric imprinting, will be directed to more natural and healthy food. This will result in healthier eating habits later in life. Thus, the infant food products according to the invention are particularly suitable for infants as from the so-called weaning period, i.e.

the period in which they have to learn chewing and swallowing and to develop the liking of a variety of foods.

Accordingly, in an even further aspect, the invention relates to use of the infant food product as defined hereinabove for feeding an infant of an age of between about 6 months and 36 months.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the cooking values (F_c , in minutes) of a large number of food products that were processed using the “RotaTherm”, “Static Retort”, “Rotative Retort” or “Tubular” methods as described in Example 3.

Figure 2 shows the cooking values (F_c , in minutes) of three food products (“Green Bean”, “Green Vegetables and Salmon” and “Poultry in White Sauce”) that were processed using the “RotaTherm”, “Static Retort”, “Rotative Retort” or “Tubular” methods as described in Example 4.

DETAILED DESCRIPTION OF THE INVENTION

In the process according to the invention, first a mixture of two or more infant food ingredients is provided in step a). The mixture has a viscous continuous phase and particles with a diameter in the range of from 3 to 25 mm. The mixture provided is subsequently sterilized, cooled and aseptically packaged in steps b), c), and d), respectively, in order to obtain a packaged, sterile, viscous infant food product. The mixture comprises particles with a diameter in the range of from 3 to 25 mm, preferably of from 5 to 20 mm, more preferable of from 8 to 15 mm. Reference herein to a viscous continuous phase, mixture or product is to a phase, mixture or product with a viscosity of at least 120 mPa, preferably at least 150 mPa, more preferably at least 180mPa. In view of processability, the viscosity is preferably below 400 mPa, more preferably below 300 mPa. Reference herein to the diameter of the particles is to the diameter of the smallest sphere in which the food particle would fit.

The two or more infant food ingredients may be any food ingredients known to be suitable for infant food. Examples of suitable infant food ingredients are those found in the Codex Alimentarius guidelines, as well as those found in the guidelines of the European Union Commission Directives on baby foods. Suitable infant food ingredients include vegetables, fruits, cereals or cereal-based ingredients, source of

proteins including of animal origin such as for example meat, fish, or egg, or of vegetable origin such as legumes or beans, soy-containing products, dairy products such as for example cheese, cream or milk, herbs, spices, thickeners such as starch or rice flour.

5 Suitable ingredients include, but are not limited to, potato, bean, carrot, broccoli, zucchini, onion, celery, cauliflower, eggplant, asparagus, radish, yam, turnip, cabbage, corn, mushroom, tomato, olive, capsicum, apricot, nectarine, peach, mango, strawberry, raspberry, blueberry, apple, banana, orange, kiwifruit, pear, melon, grape, oat, barley, triticale, wheat, quinoa, pasta, chicken, turkey, duck, beef, pork, salmon,
10 tuna, white fish, egg, lentil, soy bean, tofu, cheese, cream, and milk.

 The ingredients may be in any suitable form when mixed with the other ingredients. The ingredients may for example be in fresh, frozen, dried, or pre-cooked form. Not all ingredients need to be in the same form when mixed to form the mixture. It is preferred to pre-cook particulate ingredients prior to mixing them with the other
15 ingredients. Ingredients that need relatively long cooking in order to achieve its optimum texture, such as for example rice, pasta, or dehydrated potato are preferably subjected to separate precooking prior to being mixed with the other ingredients.

 Mixtures comprising at least one dairy ingredient are particularly suitable to be processed in the process according to the invention, since less fouling of the equipment
20 occurs in the process according to the invention as compared to convective UHT.

 In some suitable embodiments, the food product produced using the process of the present invention may comprise green bean, carrot, vanilla custard, cheese spread, green vegetables and salmon, at least 7 vegetables in the form of a soup, meat balls and vegetables in the form of a soup, pistou vegetable soup, vegetables and pasta, zucchini
25 and macaroni, poultry in a white source, or milky rice (rice and milk).

 In the process according to the invention, the mixture provided in step a) is sterilised in such a way that an F0 value of at least 10 is achieved for the continuous phase of the mixture. An F0 value of 10 means that the sterilization effectiveness of the process is equivalent to 10 minutes at 121.1 °C, regardless of the actual temperature
30 and time used in the sterilization process.

 The sterilization (step b)) is carried out by continuously supplying the mixture provided in step a) to a vertically extending tubular cooking chamber equipped with multiple steam injectors and a rotatable agitator in step b1); heating the mixture to a

obtain heated mixture by injecting steam in the cooking chamber and mixing the steam into the mixture by rotating the agitator in step b2); continuously supplying heated mixture into a holding tube in step b3); and continuously discharging mixture from the holding tube into an indirect cooling system in step b4).

5 The process according to the invention is a continuous process, meaning that a continuous stream of the mixture provided in step a) is flowing through respectively the cooking chamber, the holding tube and the indirect cooling system, which are fluidly connected with each other in series. It will be appreciated that the residence times in the cooking chamber and in the holding tube will be set, at given dimensions of the
10 cooking chamber and the holding tube by the speed at which the mixture is supplied to the cooking chamber and discharged from the cooling system. The speed is chosen such that the residence time in the cooking chamber is in the range of from 10 to 120 seconds and the residence time in the holding tube is in the range of from 30 to 240 seconds.

15 The mixture may be supplied to the cooking chamber by any suitable means known in the art, such as for example a volumetric pump or a positive displacement pump.

 The cooking chamber is a vertically extending tubular chamber having a lower end and an upper end. It has an inlet at its lower end and an outlet at its upper end. The
20 chamber is provided with at least three steam injectors. The injectors are typically spaced-apart from each other and are preferably evenly distributed over the length of the chamber between the inlet and the outlet. More preferably, the cooking chamber is provided with an even number of steam injectors that are evenly distributed over the length of the chamber in pairs, wherein each pair is located at a certain height of the
25 chamber with one injector of a pair located diametrically opposite to the other one. Preferably, the injectors are such that they, during normal operation, radially inject steam into the cooking chamber. The cooking chamber is further equipped with an axially-extending rotatable agitator. Suitable cooking chambers are commercially available. An example of a suitable cooking chamber is the RotaTherm Continuous
30 Cooker, manufactured and sold by Gold Peg International Party Ltd (Moorabbin, Victoria, Australia).

 In the cooking chamber, the mixture is heated by injecting steam having a temperature in the range of from 135°C to 200°C through the steam injectors into the

chamber whilst mixing steam and food mixture by rotating the agitator at a speed in the range of from 50 to 700 rpm. Injecting steam into the cooking chamber through multiple steam injectors distributed over the length of the chamber and at the same time mixing the mixture with the steam by rotating the agitator, ensures that plug flow in the cooking chamber is maintained. Plug flow results in homogeneous heating of the mixture, thus avoiding the formation of hot spots and cold spots and preventing overheating or undercooking of the food product. Avoiding the formation of cold spots has the further advantage that the food particles are more homogeneously heated from the outside surface to the core.

It will be appreciated that for a given mixture, the time needed to heat the mixture to a certain temperature and the homogeneity of such heating will, *inter alia*, depend on the size and capacity of the chamber, the number of steam injectors, the temperature of the steam injected, the shape and the rotation speed of the agitator.

The cooking chamber may be of any size (diameter and length) or capacity suitable for its intended purpose and that is well within the skills of the skilled person to choose. Preferably, the cooking chamber is at least 1 m in length and no more than 80 m in length, more preferably at least 1.5 m in length and no more than 20 m in length, even more preferably at least 1.5 m in length and no more than 10 m in length, still more preferably 2 m in length.

Preferably, the cooking chamber is provided with at least 4 steam injectors, more preferably at least 6, even more preferably at least 8, still more preferably at least 10. A number of steam injectors of at least 12 is particularly preferred. Preferably, the number of steam injectors does not exceed 30, more preferably the number of steam injectors does not exceed 20.

The steam injected into the cooking chamber has a temperature in the range of from 135°C to 200°C, preferably of from 140°C to 180°C, more preferably of from 140°C to 175°C, even more preferably of from 150°C to 170°C.

The agitator is rotated at a speed in the range of from 50 to 700 rpm. The rotation speed is chosen such that disintegration of the particles is avoided. Preferably, the rotation speed is in the range of from 100 to 600 rpm, more preferably at a speed in the range of from 150 to 400 rpm, even more preferably at a speed in the range of from 150 to 300 rpm. A rotation speed in the range of from 150 to 250 rpm is particularly

preferred. Typically, the smaller the particles in the food mixture, the higher the rotation speed can be without destroying the particles.

The agitator may be any agitator suitable for evenly mixing the injected steam with the food mixture in order to homogeneously heat the food mixture, without destroying the particles. Preferably, the agitator is suitable for maintaining plug flow of the viscous food mixture through the cooking chamber. The agitator may for example be a single shaft without arms. Preferably, the agitator is a single shaft provided with radially extending arms with rounded edges. A single shaft without arms is particularly suitable for producing infant food products containing delicate food particles that are soft and fragile and are prone to damage, such as meatballs. A single shaft provided with radially extending arms with rounded edges is particularly suitable for producing infant food products containing food particles that are less fragile and less prone to damage, such as for example carrot cubes or pasta or rice. Such single shaft provided with radially extending arms preferably has multiple arms evenly distributed along the length of the shaft. Preferably, the arms are bended in downstream direction. Reference herein to downstream is with regard to the direction of the flow of the food mixture through the cooking chamber. A particularly preferred agitator is a single shaft with multiple radially extending arms with rounded edges bended in downstream direction.

The residence time of the mixture in the cooking chamber is in the range of from 10 to 120 seconds, preferably is in the range of from 15 to 90 seconds, more preferably is in the range of from 20 to 80 seconds, even more preferably is in the range of from 30 to 70 seconds.

The conditions in the cooking chamber, i.e. the temperature of the steam injected, the rotation speed and the speed at which the mixture provided in step a) is supplied to the cooking chamber, are chosen such that the temperature of the heated mixture discharged from the cooking chamber is in the range of from 128 to 145 °C. The preferred temperature at which the mixture is discharged from the holding tube will inter alia depend on the desired F0 and the composition of the mixture. The temperature at which the mixture is discharged from the holding tube may for example preferably be in the range of from 132 to 140 °C, even more preferably of from 132 to 138 °C. Alternatively, this temperature may preferably be in the range of from 135 to 143 °C, more preferably, of from 138 to 142 °C.

It will be appreciated that the effect of the process conditions on the temperature of the mixture discharged from the cooking chamber will *inter alia* depend on the number of steam injectors, the shape of the agitator, the size of the cooking chamber and the viscosity and composition of the mixture supplied to the cooking chamber. It is within the skills of the skilled person to choose the equipment and the process conditions such that for a given food mixture, the mixture discharged from the cooking chamber has the desired temperature (the target temperature).

The mixture discharged from the cooking chamber is supplied to the holding tube. In the holding tube, the temperature of the mixture is maintained at substantially the same temperature as at which it is discharged from the cooking chamber. Typically, the mixture will be discharged from the holding tube at a temperature that is at most 3 °C below the temperature at which it is supplied to the holding tube, preferably at most 2 °C below, more preferably at most 1 °C below the temperature at which it is supplied to the holding tube.

The residence time of the mixture in the holding tube is in the range of from 30 to 240 seconds, preferably of from 40 to 200 seconds, more preferably of from 60 to 180 seconds, even more preferably of from 60 to 150 seconds. A residence time in the holding tube in the range of from 60 to 120 seconds is particularly preferred.

The temperature and residence time in the holding tube are the most relevant parameters that determine the severity of the sterilization. Sterilization step b) is carried out with such severity that the continuous phase of the food mixture has an F0 value of at least 10.

An F0 value is a measure of the severity of a sterilization process. It is the sterilization-equivalence of the microbial reduction at 121.1 degrees Celsius in minutes. To calculate the F0 values achieved in a sterilization process at a different temperature than 121.1 degrees Celsius, the following equation is used:

$$F0 = \tau * 10^{((T - T_{\text{ref}}) / z)} \quad (1)$$

wherein T is the actual process temperature in degrees Celsius, T_{ref} is the reference temperature of 121.1 degrees Celsius, z is a constant with value of 10 degrees Celsius for steam sterilization and τ is the residence time in minutes at the process temperature.

Thus, for steam sterilisation the actual equation used for calculation F0 value is $F0 = \tau * 10^{((T - 121.1) / 10)}$.

The F0 value for the continuous phase of the mixture sterilised in the process according to the invention can be calculated by using as T the average temperature of the mixture in the holding tube in degrees Celsius, i.e. the average of the temperature of the mixture supplied to and the mixture discharged from the holding tube, and as τ the residence time of the mixture in the holding tube in minutes (holding time). The average residence time in the holding tube can be calculated as the ratio of the volume of the holding tube and the flow rate of the mixture in the holding tube. In the process according to the invention, the viscous mixture flowing through the holding tube will exhibit laminar flow, meaning that the mixture will flow at a lower velocity near the tube wall than in the centre of the tube. It is known in the art that with laminar flow, the linear velocity in the centre of the tube is at most twice the average velocity. Therefore, the minimum F0 value to which the entire continuous phase of the mixture has been subjected in the sterilisation process in the process of the invention is calculated based on a residence time that is half the average residence time in the holding tube, according to equation (2):

$$F0 = \tau/2 * 10^{((T - 121.1) / 10)} \quad (2)$$

wherein T and τ are the average temperature in degrees Celsius and residence time in minutes, respectively, in the holding tube. Reference herein to the F0 value of the continuous phase is therefore to the F0 value as calculated with equation (2).

The sterilization (step b)) is carried out such that a F0 value of the continuous phase of the mixture of at least 10 is achieved. Preferably, the F0 value achieved for the continuous phase is at least 20, more preferably at least 30, even more preferably at least 40. Preferably, the F0 value of the continuous phase of the mixture does not exceed 50.

The mixture is continuously discharged from the holding tube into an indirect cooling system. In the indirect cooling system, the mixture is cooled by indirect heat exchange to a temperature in the range of from 10 to 60 °C, preferably of from 10 to 40°C, more preferably of from 20 to 40°C, even more preferably of from 20 to 30°C.

The sterile, cooled mixture thus obtained is aseptically packaged to obtain a sterile, packaged infant food product.

Indirect cooling, also known as convective cooling, is known in the art. Indirect cooling is used to prevent disintegration of the particles in the mixture.

5 The aseptic packaging may be carried out with any method known to be suitable for aseptic packaging of infant food products. Suitable materials for aseptic packaging of infant food products are known in the art and include plastic bowls or plates, pouches, bottles or Tetra Pak ®carton boxes. Plastic containers such as for example polypropylene containers are particularly preferred. The packaging material is typically
10 sterilized prior to filling it with the sterilized food product in order to avoid contamination.

 In the process according to the invention, the process conditions and the size and shape of the equipment are specifically and optimally adapted for each infant food product recipe, taking into account the type of infant food ingredients used. In
15 particular, the size and softness of the food particles present in the infant food product are taken into account. In particular the shape of rotatable agitator, the rotation speed of the agitator, the number of steam injectors, the temperature of the injected steam, the residence time of the mixture in the cooking chamber and in the holding tube, the temperature to which the mixture is heated in the cooking chamber are specifically
20 adapted for each infant food product in order to achieve the desired sterilization severity.

 The infant food product obtained by the process according to the invention contains particles. Such product is particularly suitable for infants of an age as from 4 months, i.e. when they start eating complementary foods, preferably of an age as from
25 6 months. Reference herein to an infant is to a human subject of an age of 36 months or below.

 The infant food product obtained by a process according to the process of the invention is sterilised and meets very high microbiological safety standards. The product is stable at ambient conditions, i.e. at room temperature, without applying
30 vacuum or conditioned atmosphere. It has been found that the sterile infant food product obtained is not only stable at ambient conditions, but also has taste, colour and nutritional characteristics closer to home-cooked (non-sterilised) infant food than infant food products sterilized by convective tubular heat exchange, or other commercially

available sterilised infant food products. Sensory analysis showed that products obtained by the process according to the invention are preferred in taste compared to products obtained by convective tubular heat exchange using the same ingredients: the products obtained according to the invention have less off-taste, less acidity, less sourness and have clearer colors. Furthermore, the perceived freshness or organoleptic properties of food products obtained by the process according to the invention were improved in comparison to those prepared by conventional techniques. These benefits are of particular relevance for infant food products since off-taste, acidity and sourness might prevent the infant to appreciate the food and to eat it.

EXAMPLES

The process and product according to the invention are illustrated by means of the following non-limiting examples.

Example 1: Production of “Melted Zucchini and Little Macaroni” according to the invention in comparison with a product obtained using the same ingredients and UHT-processed with conventional tubular heat exchanger.

This recipe is intended for infants aged 12 months and older (Stage 3-4). This infant food product was produced with the process according to the invention using a RotaTherm®, an equipment manufactured and sold by Gold Peg International Party Ltd (Moorabbin, Victoria, Australia). Such apparatus is a continuous direct steam injection cooking system comprising a vertically extending cooking chamber in the form of a column in which the product enters at the bottom and exits at the top. The cooking chamber was equipped with an axially extending rotatable agitator able to deliver variable levels of mechanical stirring of the product during the cooking process. The motor driving the rotating agitator was positioned below the cooking chamber and able to rotate the agitator at various speeds. The agitator was provided with arms with rounded edges that were bended in downstream direction (cactus shape). The cooking chamber was provided with a plurality of steam injectors for radially injecting steam into the cooking chamber. The steam injectors were spaced apart at regular intervals along the length of the cooking chamber. Frozen zucchini, frozen spinach, frozen green peas, frozen celeriac, potato flakes and dried onions were pre-mixed. The pre-mix was used to make a sauce to which further ingredients including corn starch, skimmed milk, macaronis, carrot cubes of a size of 6x6x6mm, onions and water were

added to obtain an ingredient mixture with a viscous continuous phase and particles. Injection of steam during the process resulted in the addition of 17kg of water (in the form of steam) per 100kg of finish product. There was no flashing out of the water at the end of the process.

- 5 The ingredient mixture, pre-heated to a temperature of 85°C, was supplied to the RotaTherm®, whilst the speed of the agitator was adjusted to 200 rpm. Steam with a temperature of 150°C was injected through five steam injectors. The residence time of the mixture in the cooking chamber was 36 seconds. The mixture was discharged from the cooking chamber and supplied to the holding tube at a temperature of 139°C.
- 10 The residence time of the mixture in the holding tube (holding time) was 82 seconds. Thus, an F0 value of at least 42 for the continuous phase was achieved.

- As a control and for comparison, the same ingredients as the ones used to produce the food product according to the invention were UHT-processed using a conventional convective tubular heat exchanger (herein referred to as “control process”). The control process was carried out such that the same F0 value for the continuous phase was achieved. The product thus obtained is referred to as the “control product” and corresponds to a commercially available product produced and sold by the applicant.
- 15

Product colour using spectrophotometry:

- 20 Colour is one of the first sensory stimuli the consumer experiences when purchasing and/or opening a package containing an infant food product. The visual stimulus given by the colour of industrially-produced food is often interpreted by consumers as an indication of high quality. It is therefore essential that the natural colours of the ingredients used to prepare infant food products are as much as possible retained in the final product after sterilising.
- 25

- Colour retention after processing of the ingredients was therefore evaluated for the process according to the invention and as a comparison for the “control process”. Colour measurements using a spectrophotometer provided with the SpectraMagix software (Minolta) was performed on the initial mix of ingredients (before processing according to the present invention) and on the final product obtained by the process according to the invention. The same colour measurements were performed on the initial mix of the same ingredients and on the final “control product” obtained by the “control process”. The colour parameters L, a, b were measured and used to calculate
- 30

the resulting Delta E, indicative of colour differences between two measurements, as known in the art. The colour retention was better in the final product obtained by the process according to the invention as compared to the “control product”.

Sensory evaluation

5 Twelve months after production of the infant food product according to the invention, sensory analysis was performed by 15 assessors, to compare the organoleptic properties of the product obtained by the process according to the invention versus the “control product” obtained from the same ingredients using conventional convective UHT tubular heat exchange. The samples were individually coded for each panellist
10 and presented in individual random order. Sensory evaluation was performed in sensory laboratory equipped with individual booths using the EyeQuestion software (Logic8 B.V., Elst, The Netherlands).

Compared to the “control product”, the product according to the invention displayed higher intensity of vegetable feeling, lighter colour, less off odours, less sour
15 taste, less salty taste, less off odours and less water separation. The product according to the invention had higher freshness ratings, higher savoury feeling and was judged closer to home-made food compared to the “control product”.

Example 2: Production of “Basquaise Poultry with Vegetables” according to the
20 **invention in comparison with a product obtained using the same ingredients and UHT-**
processed with conventional tubular heat exchanger.

This recipe is intended for infants aged 18 months and older (Stage 4). This infant food product was produced according to the invention using the equipment as described in Example 1.

25 Frozen turkey, frozen red pepper, frozen zucchini, potato flakes and dried onions were pre-mixed and this pre-mix was used to make a sauce to which further ingredients were added. The further ingredients included tomato concentrate, corn starch, spinach, rice, carrot cubes of a size of 6x6x6mm, chicken cubes of a size of 6x6x6mm onions and water. Injection of steam during the process resulted in the
30 addition of 17kg of water (in the form of steam) per 100kg of finish product. There was no flashing out of the water at the end of the process.

The ingredient mixture, pre-heated to a temperature of 85°C, was supplied to the RotaTherm®, whilst the speed of the agitator was adjusted to 200 rpm. Steam with

a temperature of 153°C was injected through five steam injectors. The residence time of the mixture in the cooking chamber was 36 seconds. The mixture was discharged from the cooking chamber and supplied to the holding tube at a temperature of 139°C. The residence time of the mixture in the holding tube (holding time) was 82 seconds.

5 Thus, an F0 value of at least 42 for the continuous phase was achieved.

As a control and for comparison, the same ingredients as the ones used to produce the food product according to the invention were UHT-processed using a conventional convective tubular heat exchanger (herein referred to as “control process”). The control process was carried out such that the same F0 value for the continuous phase was achieved. The product thus obtained is referred to as the “control product” and corresponds to a commercially available product produced and sold by the applicant.

Product colour using spectrophotometry:

Colour retention after processing of the ingredients was therefore evaluated for the process according to the invention and as a comparison for the “control process”. Colour measurements using a spectrophotometer provided with the SpectraMagix software (Minolta) was performed on the initial mix of ingredients (before processing according to the present invention) and on the final product processed according to the invention. The same colour measurements were performed on the initial mix of the same ingredients and on the final “control product”. The colour parameters L, a, b were measured and used to calculate the resulting Delta E, indicative of colour differences between two measurements, as known in the art. The colour retention was better in the final product obtained by the process according to the invention than in the “control product”.

25 Sensory evaluation

Twelve months after production of the infant food product according to the invention, sensory analysis was performed by 15 assessors, to compare the organoleptic properties of the product obtained according to the invention versus the “control product” obtained from the same ingredients using conventional UHT tubular heat exchanger. The samples were individually coded for each panellist and presented in individual random order. Sensory evaluation was performed in sensory laboratory equipped with individual booths using the EyeQuestion software (Logic8 B.V., Elst, The Netherlands).

Compared to the “control product”, the product according to the invention displayed higher intensity of vegetable feeling, fresher appearance, lighter colour, less off taste, less sour taste, less bitterness and was less thick and starchy. The product according to the invention had higher savoury feeling, had a higher ingredients recognition rate and was judged closer to home-made food compared to the “control product”.

Example 3: Production of further products according to the invention and comparison with conventional processing techniques.

10 A number of different food products were produced and processed according to the invention using the equipment as described in Example 1 (“RotaTherm”). For comparison, a number of the food products of the same ingredients were also processed using three different conventional techniques (herein referred to as “Rotative Retort”, “Static Retort” and “Tubular”).

15 “Rotative Retort” and “Static Retort” refers to autoclave sterilisation technique (in “Rotative Retort”, the product is rotating during the autoclave process while in “Static Retort” the product is not rotated). “Tubular” refers to UHT treatment using a tubular heat exchanger and cooling and packaging under aseptic conditions.

The cooking values of the food products and F0 of the processing techniques
20 were measured and compared. The comparison is shown in the graph in Figure 1. In Figure 1, the cooking values (Fc) of the food products (in minutes) is plotted on the x-axis against the FO value (in minutes) on the y-axis. The food products that were processed using the “RotaTherm” technique are illustrated with open squares and indicated with ‘a’, the “Tubular” food products are illustrated with crosses and
25 indicated with ‘b’ the “Rotative Retort” food products are illustrated with open circles and indicated with ‘c’, and the “Static Retort” food products are illustrated with open dashes and indicated with ‘d. As can be seen in Figure 1, the cooking values (Fc) for the “RotaTherm” processed food products were significantly lower than food products processed by the other three techniques.

30 Cooking value is an indication of the freshness or perceived freshness of a food by a consumer. These results demonstrate that the technology of the present invention can be used to process a large range of food products with an improved quality (e.g. perceived freshness) compared to conventional processing techniques.

Example 4: Production of “Green Bean”, “Green Vegetables and Salmon” and “Poultry in White Sauce” according to the invention, and comparison with existing techniques.

5 The “Green Bean” food product is a Stage 1 food product, the “Green Vegetables and Salmon” is a Stage 2 food product and “Poultry in White Sauce” is a Stage 3 & 4 food product.

In a similar manner to Example 3, different food products were produced according to the invention using the equipment as described in Example 1
10 (“RotaTherm”) and for comparison, the same ingredients as the ones used to produce the food products according to the invention using three different conventional techniques (herein referred to as “Rotative Retort”, “Static Retort” and “Tubular”).

The food products were: (1) Green Bean, (2) Green Vegetables and Salmon, and (3) Poultry in White Sauce.

15 The cooking values of the food products and F0 of the processing techniques were measured and compared and the results are shown in Tables 1-3 below and also in Figure 2.

20 **Table 1:** Cooking value (Fc) (minutes) and F0 value (minutes) of the Green Bean food product processed under the four different techniques.

(1) Green Bean	F0	Fc
<u>Rotatherm</u>	<u>52.36</u>	<u>20.3</u>
<u>Tubular</u>	<u>45</u>	<u>52</u>
<u>Rotative Retort</u>	<u>27.2</u>	<u>185</u>
<u>Static Retort</u>	<u>27</u>	<u>216</u>

Table 2: Cooking value (Fc) (minutes) and F0 value (minutes) of the Green Vegetables and Salmon food product processed under the four different techniques.

(2) Green Vegetables and Salmon	F0	Fc
<u>Rotatherm</u>	<u>47.56</u>	<u>20.02</u>
<u>Tubular</u>	<u>47.82</u>	<u>55.61</u>
<u>Rotative Retort</u>	<u>25.74</u>	<u>171.1</u>
<u>Static Retort</u>	<u>26.66</u>	<u>223</u>

Table 3: Cooking value (Fc) (minutes) and F0 value (minutes) of the Poultry in White Sauce food product processed under the four different techniques.

(3) Poultry in White Sauce	F0	Fc
<u>Rotatherm</u>	<u>49.22</u>	<u>20.72</u>
<u>Tubular</u>	<u>44.84</u>	<u>51.52</u>
<u>Rotative Retort</u>	<u>25.42</u>	<u>180.3</u>
<u>Static Retort</u>	<u>24.59</u>	<u>208.7</u>

5 The results in Tables 1-3 are also plotted in the graph shown in Figure 2. In Figure 2, the cooking values (Fc) of the food products (in minutes) is plotted on the x-axis against the F0 value (in minutes) on the y-axis. The result for the Green Bean food product ('1') with each processing technique is illustrated with an open diamond, the results for the Green Vegetables and Salmon ('2') with each processing technique is indicated with an open triangle and the results for the Poultry in White Sauce ('3') with each processing technique is indicated with a cross.

As can be seen in Figure 2, the cooking values (Fc) for the "RotaTherm" processed food products were significantly lower while the F0 values were slightly higher compared to the food products processed by the other three techniques.

15 These results demonstrate that the technology of the present invention can be used to process different types of food products with an improved quality (e.g. perceived freshness) compared to conventional processing techniques.

It is also noted that similar successful results were obtained with the following food products:

- 20 - Stage 1 food products: "Carrot", "Vanilla Custard", "Cheese Spread";
- Stage 2 food product: "7 Mix Vegetable Soup"; and
- Stage 3 and 4 food products: "Meat Ball and Vegetable Soup", "Pistou Vegetable Soup", "Vegetarian Pasta", "Zucchini and Macaroni", and "Milky Rice".

CLAIMS

1. A continuous process for producing a packaged, sterile, viscous infant food product containing particles with a diameter in the range of from 3 to 25 mm, the process comprising the following steps:
- 5
- a) providing a mixture of two or more infant food ingredients, the mixture having a viscous continuous phase and particles with a diameter in the range of from 3 to 25 mm;
- b) sterilizing the mixture provided in step a) with an F0 value of at least 10 for the continuous phase of the mixture by:
- 10
- b1) continuously supplying the mixture to a vertically extending tubular cooking chamber having a lower end and an upper end, the cooking chamber having an inlet at its lower end, an outlet at its upper end, and being provided with at least three steam injectors, wherein the cooking chamber is equipped with an axially-extending rotatable
- 15
- agitator;
- b2) injecting steam having a temperature in the range of from 135°C to 200°C into the cooking chamber through the steam injectors and rotating the agitator at a speed in the range of from 50 to 700 rpm to obtain heated mixture;
- 20
- b3) continuously discharging heated mixture having a temperature in the range of from 128 to 145°C from the cooking chamber through its outlet into a holding tube having an inlet at a first end that is in fluid connection with the outlet of the cooking chamber and an outlet at its opposite end; and
- 25
- b4) continuously discharging the mixture from the holding tube through its outlet into an indirect cooling system,
- wherein the residence time of the mixture in the cooking chamber is in the range of from 10 to 120 seconds, the residence time of the heated mixture in the holding tube is in the range of from 30 to 240 seconds;
- 30
- c) cooling the mixture to a temperature in the range of from 10 to 60 °C in the indirect cooling system to obtain a sterile, cooled mixture; and

- d) aseptically packaging the sterile, cooled mixture to obtain sterile, packaged infant food product.
2. A process according to claim 1 wherein the F0 value is at least 30.
- 5 3. A process according to claim 2 wherein the F0 value is at least 40.
4. A process according to any one of the preceding claims, wherein the F0 value is at most 50.
- 10 5. A process according to any one of the preceding claims, wherein the agitator is rotated at a speed in the range of from 150 rpm to 400 rpm.
6. A process according to any one of the preceding claims wherein the steam injectors are for radially injecting steam into the cooking chamber.
- 15 7. A process according to any one of the preceding claims, wherein the rotatable agitator is a single shaft provided with radially extending arms with rounded edges.
8. A process according to any one of the preceding claims wherein the steam injected into the cooking chamber has a temperature in the range of from 140 °C to 175 °C.
- 20 9. A process according to any one of the preceding claims, wherein the cooking chamber has at least eight steam injectors.
- 25 10. A process according to any one of the preceding claims, wherein the residence time of the mixture in the cooking chamber is in the range of from 15 seconds to 90 seconds.
- 30 11. A process according to any one of the preceding claims, wherein the mixture discharged from the cooking chamber has a temperature in the range of from 138°C to 142°C.

12. A process according to any one of the preceding claims, wherein the residence time of the mixture in the holding tube is in the range of from 60 to 150 seconds.
13. An infant food product obtainable by a process according to any of the preceding
5 claims.
14. Use of the infant food product according to claim 13 for feeding an infant of an age
of between about 6 months and 36 months.

Fig. 1

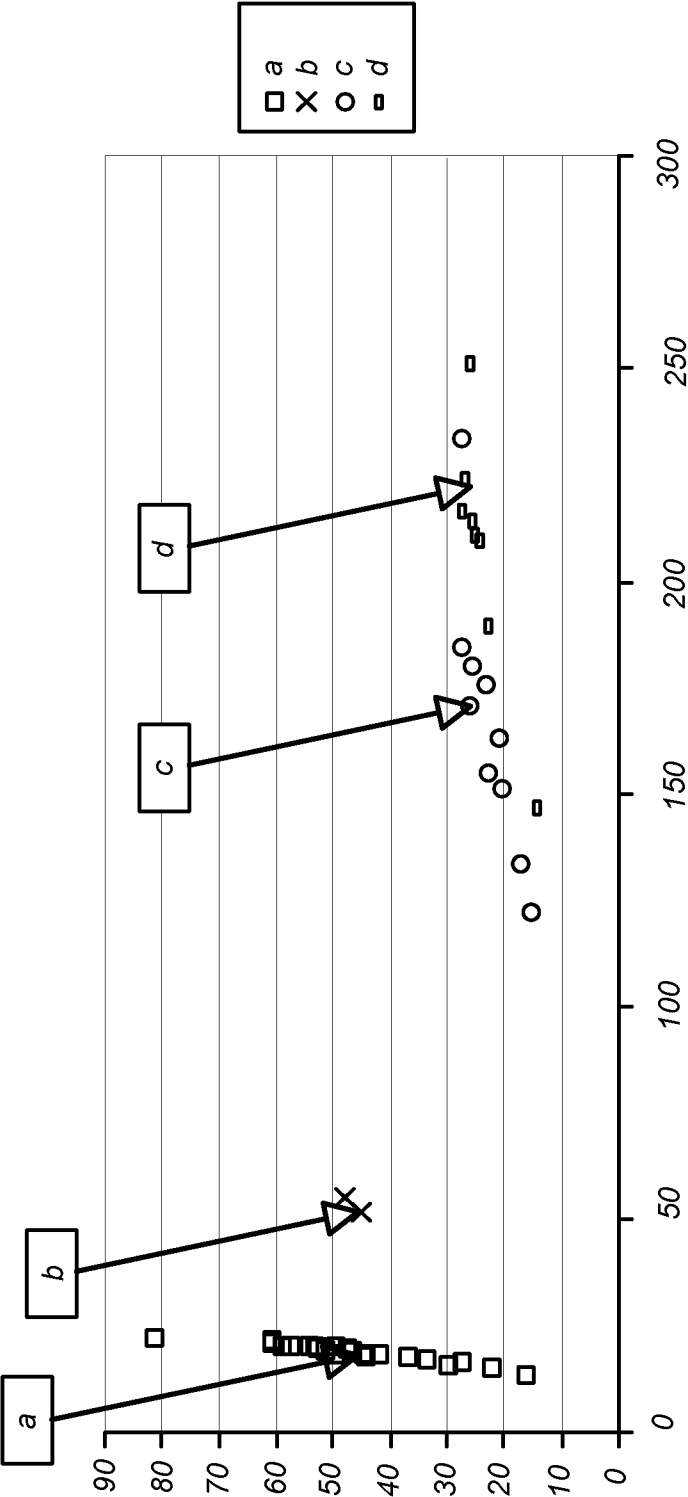


Fig. 2

