

METHOD AND APPARATUS FOR THE CONTINUOUS PROCESSING
OF CEREAL GRAINS

The invention relates to a method and apparatus for the continuous processing of grains. The invention particularly relates to a method and apparatus for the continuous preparation of a puffed grain product, particularly an instant puffed rice flake product.

Any method or apparatus for processing foodstuffs must ensure that the final product is of uniform quality, is free from the risk of microbial contamination and other contaminants, and is easy and convenient to use by the consumer. At the same time, any method or apparatus must be capable of dealing with a large quantity of food.

The method and apparatus of the present invention provides a continuous process for producing a puffed cereal grain product which is suitable for instant use, such as an instant rice porridge. The end product is produced efficiently by the process of the invention, with relative speed and ease compared with processes conventionally used. The puffed grain product produced by the process of the invention is of consistently high quality, free from contaminants and is physically and chemically stable, as well as being microbiologically stable, over an acceptable shelf life period. The process of the invention is particularly preferred for



use with rice, however, it can also be used with other grains, such as, millet, barley etc, as well as with other foodstuffs, such as, dried beans, for example, split mung beans, green beans etc.

The present invention provides a method for the continuous preparation of a puffed grain product which comprises the steps of:

- soaking the grains in water;
- pre-cooking the grains with steam;
- exposing the grains to a first drying step;
- processing the grains into thin flakes; and
- puffing the grain flakes.

According to an embodiment of the invention, after the grains have been puffed, the puffed grain flakes are exposed to a second drying step.

According to an embodiment of the invention, after the grains have been soaked in water, the grains are removed from the water prior to the pre-cooking step, for example, by draining away the soaking water. The drained water may be re-cycled.

According to a further embodiment of the invention, the grains, in particular, rice grains, are coated, for example, with an emulsifier, after the soaking step and

before the pre-cooking step. The emulsifier coating acts to reduce clumping together of the grains during the continuous preparation of the puffed product. An example of a suitable emulsifier is a distilled monoglyceride emulsifier which is formed into a dispersion and mixed with the soaked rice grains to form a coating over the rice. The emulsifier is coated onto the rice grains at this stage in the method in order to reduce stickiness of the rice grains during the pre-cooking step. Furthermore, the emulsifier acts to reduce the occurrence of lumping of the grains so that the grains are more easily separated into individual grains in order to facilitate uniform drying and flaking later on in the process.

According to a further embodiment, the method of the invention includes delumping steps, for example, after the pre-cooking step and/or after the first drying step, in order to separate the rice grains prior to flaking. Delumping steps may also be conducted intermediately during the first drying step in order to obtain separated grains.

According to a further embodiment, the grains may be cooled after the first drying step, for example, by blowing filtered air through the rice grains, and optionally also after the second drying step. The filtered air may be blown over the rice grains at a temperature of approximately 40-50°C after the first

drying step and at ambient room temperature after the second drying step.

According to a further embodiment of the invention, the process includes a holding/conditioning step in order to allow moisture equilibrium within the grains to take place. The holding/conditioning step may take place after the first drying step, after the first cooling step or after a delumping step immediately prior to flaking. The partially dried grains may be conditioned for approximately 20-30 minutes on a holding/conditioning belt.

According to a further embodiment, the moisture of the grains after the first drying step is preferably reduced to approximately 25% from, for example, 35%. Preferably, the moisture content is further reduced during the puffing step to approximately 9 to 14%, preferably 10%. Preferably the moisture content of the puffed flakes is then reduced to approximately 5 to 6% during the second drying step. Alternatively, where there is no second drying step, the moisture content of the grains is reduced to these final levels during the puffing step.

Once the puffed flake product has been obtained, for example, puffed rice which has undergone the second drying step and then cooling and is referred to as alpha rice, the processed product may be temporarily stored, for

example, in bulk storage containers. Otherwise, the product is packaged into containers, for example, meal-size cups, optionally with the addition of further additives, flavourings, for example, chicken, beef, seafood, vegetarian, etc., garnish, colourings, antioxidants etc. being added to the dry mixture in the containers. Further additives, such as flavourings, may be added to the dried grain product in the containers in a separate sachet which is emptied onto the rice grains during use. The containers are then sealed so that they are airtight.

The instant puffed grain product, such as instant rice porridge, can then be stored over a period of time, for example, up to 12 months. The porridge is then eaten after mixing with an amount of boiling water, for example 250 ml for a single adult helping of porridge and being left for a short period of time, for example, approximately 3 minutes. Alternatively, the porridge may be used by adding water in a specified amount, heating to bring to the boil and cooling for a short time, for example, 3 minutes. The porridge is then ready to eat, without the need to drain away the added water.

The invention further provides an apparatus for carrying out the method as described hereinabove. The apparatus comprises:

- means for soaking said grains in water;
- grain feeder means for regulating the feeding rate of said grains into a pre-cooking means;
- pre-cooking means comprising a steaming tunnel having means for retaining the grains in the steaming tunnel for a pre-set time;
- a first drying means having means for retaining the grains in the dryer for a pre-set time;
- a roller means to flatten the grains into flakes;
- a puffer means for puffing said flakes;
- optionally, a second drying means having means for retaining the puffed flakes in the dryer for a pre-set time; and
- conveyor means for continuously transporting said grains to each component of the apparatus in sequence at a pre-set rate.

According to a further embodiment, the apparatus comprises means for delivering a dose of emulsifier to the grains on the conveyor means prior to them reaching the pre-cooking means, in order to coat the grains with the emulsifier to reduce their stickiness during steaming. Furthermore, the apparatus may comprise delumper equipment at one or more places on the conveyor means, in order to separate the grains into individual grains, in particular, prior to the processing of the grains into thin flakes.

According to a further embodiment, the apparatus may comprise a cooling chamber situated after the first drying means, optionally having a means of retaining the grains within the cooling chamber for a set period of time. Optionally, the apparatus may comprise a second cooling chamber situated immediately after the second drying means, which may also have a retaining means in order to retain the puffed flakes in the second dryer for a set period of time.

The apparatus may additionally comprise means for storing the puffed grain flakes, packaging the puffed flakes, together with the addition to the packaging of other additives, flavourings etc, and sealing the packaging.

Figure 1 is a flow diagram for a method of preparing soakable rice porridge in accordance with the present invention.

Figure 2 shows an example of a puffer means for puffing the flakes.

Figure 1 shows a method according to the invention which is suitable for use with rice to produce soakable rice porridge. A preferred rice is Taiwanese polished rice, which has chemical and physical properties as follows:

Moisture	13-14%
Protein	6-8%
Fat	0.5-0.7%
Fibre	≈2%
Ash	≈0.35%
Starch	76-78%
Amylose	11-12%
Amylopectin	88-89%
Length	4.6-4.9 mm
Width	3.0-3.3 mm
Length: width ratio	1.4-1.7

According to Figure 1, the rice is first soaked in water, for example, in a soaking tank. The time of soaking will depend on the type of rice used and may be up to 4 hours. In a preferred example according to the invention, raw polished whole short grain Taiwanese rice with a low amylose content is soaked in water in a soaking tank for 2½ hours, whole or broken long grain, high amylose type Philippine rice is soaked for approximately 1½ hours, and red or brown rice is soaked for 3 hours. Preferably, 50% by weight of rice and 50% by weight of water is used in the soaking step.

The water is drained off at the end of the soaking time.

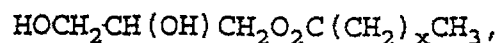
Meanwhile, an emulsifier dispersion is prepared. The preferred emulsifier is a distilled monoglyceride emulsifier. The emulsifier dispersion coats the rice

grains and reduces rice stickiness, in particular, during the steaming pre-cooking step.

In the preparation of the emulsifier, an alkaline solution is preferably added during preparation of distilled monoglyceride emulsifier in order to stabilise the system. Separation of the emulsifier into suspension occurs in acidic conditions. The addition of, for example, sodium hydroxide solution, ensures that alkaline conditions are maintained. The water and sodium hydroxide pellets are stirred with caution and left to cool before use.

The 1N sodium hydroxide solution can be mixed in a jacketed vessel with constant agitation with corresponding amount of water. The solution may be heated, for example, to approximately 70°C and the batch weight of distilled monoglyceride may be added with constant agitation also at a temperature of, for example, 70°C. After continuous agitation for approximately 5 minutes at approximately 70°C, the prepared emulsifier is stored in a tank. The emulsifier dosing into the soaked rice is regulated so that rice is coated with a controlled dose of emulsifier. This is preferably by means of a peristaltic pump or a volumetric screw feeder. A typical ratio of rice to emulsifier mix is 98.5% soaked rice (rice 73.0%; absorbed water 25.5%) to 1.5% of the emulsifier dispersion.

The preferred distilled monoglycerides have a formula:



wherein x is 14 or 16. The distilled monoglycerides go under the name of glycerolmonostearate and glycerolmonopalmitate. It should be understood, however, that any suitable emulsifier, optionally processed together with any suitable food grade alkaline solution, may be used in the process of the present invention.

Preferred formulation details of the emulsifier are as follows:

Formulation (% composition by food ingredient)

Table 1

1N Sodium Hydroxide

<i>Ingredient</i>	<i>% by weight</i>
Sodium hydroxide pellets	3.846
Water	96.154
Total	100.000

Emulsifier dispersion

<i>Ingredient</i>	<i>% by weight</i>
Water	94.90
1N sodium hydroxide solution	0.10
Distilled monoglyceride	5.00
Total	100.00

Rice and emulsifier mixing

Ingredient	% by weight
Soaked rice: Rice (73.0%)	98.50
Absorbed water (25.5%)	
Distilled monoglyceride	1.50
Total	100.00

Bulk Formulation for Soakable Rice Porridge

Table 2

Rice soaking

Raw material Name, Type	% by weight	Std batch Quantity
Rice	50	500 kg
Water	50	500 kg
Total and Yield:	100	1000 kg

1N Sodium Hydroxide Solution

Raw material Name, Type	% by weight	Std batch Quantity
Water	96.154	1.00 kg
Sodium hydroxide pellets	3.846	0.04 kg
Total and Yield:	100.000	1.04 kg

Emulsifier Dispersion

Raw material Name, Type	% by weight	Std batch Quantity
Water	94.9	9.49 kg
1N sodium hydroxide solution	0.1	0.01 kg
Distilled monoglyceride	5.0	0.50 kg
Total and Yield:	100.0	10.00 kg

Rice and emulsifier mixing (continuous operation)

Raw material Name, Type	% by weight
Soaked rice	98.5
Emulsifier dispersion	<u>1.5</u>
Total:	100.0

The coated rice grains then undergo pre-cooking, for example, by entering a steaming tunnel so that they are exposed to saturated steam at, for example, atmospheric pressure. The coated rice grains are pre-cooked for pre-set time, for example, approximately 9 minutes for rice, however, the exact time for the steaming process will depend on the type of cereal grain used. The steaming gelatinises the starch, eliminating the raw taste and powdery mouthfeel of uncooked rice. When pressed between two glass plates, white powdery specks should not appear if the grains are fully gelatinised.

The pre-cooked rice grains moved to the primary dryer. Drying can be conducted at 80°C for approximately 6 minutes, however, the drying time and temperature can be varied as required. The initial rice moisture is reduced for approximately 35% to 38% to approximately 25%. The rice grains may also be delumped intermediately during drying to obtain separated rice grains.

The partially dried rice grains then undergo cooling by having filtered air blown through the rice grains for cooling to approximately 40 to 50°C, or to room temperature. Cooling is preferred in order to avoid condensation during the optional holding/conditioning stage.

Partially dried and cooled rice grains then optionally undergo conditioning on a holding/conditioning belt for approximately 30 minutes. Whether conditioning is of benefit will depend the type of grain being used. This allows moisture equilibrium within the rice grains to occur. The conditioned rice grains are more elastic, yielding less brittle flaked rice.

The conditioned rice grains then undergo flaking, for example, the rice grains are rolled into thin flakes. The gap between the rollers is approximately 0.04 to 0.05 mm to achieve thin rice flakes of between approximately 5 to 8 mm in diameter.

After flaking, the rice flakes are conveyed into the puffer. The rice flakes are puffed by air at a temperature of between 190 and 210°C, preferably 200°C, further reducing moisture to approximately 10%. For example, a rotating paddle spreader located within the puffer uniformly distributes rice flakes on to the puffer conveyor belt to a depth of approximately 1-1.5 cm. In

the puffer, the rice flakes are exposed for approximately 10 to 40 seconds, preferably between 10 to 20 seconds to 200°C hot air with 12-15 m/s velocity. During this puffing stage, the rice flake moisture is reduced from approximately 25% to 10% and the flakes expand to their final volume and shape. The air velocity can be altered to reduce the moisture content to below 10%, if the second drying step is to be dispensed with.

The puffed rice flakes may then undergo a second drying step. The puffed rice may be dried with air at a temperature of approximately 80°C which allows for more gradual drying as compared to the puffing conditions. This reduces the risk of browning and formation of burnt rice particles. The second drying stage lasts approximately 6 minutes, however, the exact time will depend on the type of rice being used. The moisture in the rice flakes is reduced to approximately 5 to 6%.

After drying, the rice flakes are cooled with filtered air blown over the rice flakes at ambient room temperature to produce alpha rice. The thus formed puffed rice flakes are stored, for example, temporarily in bags or holding vessels such as bulk storage containers.

It is preferable in some cases to reduce the size of the puffed rice flakes, for example, by a rotary sifter. This is particularly preferred with long grain rice, such as Philippine rice.

The alpha rice is then packaged, for example, into polypropylene cups. Any conventional process can be used for this step, for example, the rice is tipped into a filler hopper for volumetric dosing of the containers. At this stage, other additives can be added to the rice, for example, flavourings, stabilisers, garnish etc. which have been separately prepared by dry mixing and are dosed directly into the storage containers. The storage containers are then sealed, for example, with an aluminium foil laminate lid. The final product is a soakable rice porridge which can be instantly used, for example, by adding boiling water or adding water and heating to bring to the boil for a short period of time such as 3 minutes, to result in an instant product. Any suitable packaging process and packaging means can be used.

The various temperatures, pressures and processing times will depend on the food product being processed. The following Tables 3 and 4 provide some further processing details, provided for illustrative purposes only.

Table 3

Rice processes

Unit operation	Taiwanese rice	Philippine rice	Red rice	Brown rice	Black glutinous rice
Soaking	2½ hrs	1½ hrs	3 hrs	3 hrs	3 hrs
Emul.addn	GMS	GMS	-	-	-
Steaming	9 mins	9 mins	9 mins	9 mins	9 mins
Delumping	on-line	on-line	on-line	on-line	on-line
Drying	6-8 mins	6 mins	6 mins	6 mins	6 mins
Delumping	on-line	on-line	on-line	on-line	on-line
Holding	30 mins	-	-	-	-
Flaking	0.04 mm	0.05 mm	0.04 mm	0.04 mm	0.05 mm
Drying	-	-	-	-	-
Puffing	200°C, 20 sec, 12 m/s	200°C, 20 sec, 12 m/s	200°C, 20 sec, 15 m/s	200°C, 20 sec, 15 m/s	200°C, 20 sec, 15 m/s
Drying	6-8 mins	6 mins	-	-	-
Crushing	-	-	rollers	rollers	rollers

Table 4

Grain processes

Unit operation	Millet	Barley	Terigu	Split mung beans	Green beans
Crushing	-	-	-	-	rollers
Soaking	3 hrs	3 hrs	3 hrs	3 hrs	4 hrs
Emul.addn	-	-	-	-	-
Steaming	11 mins	9 mins	9 mins	10 mins	10 mins
Delumping	-	on-line	on-line	on-line	-
Drying	7½ mins	6 mins	6 mins	6 mins	16 mins
Delumping	-	on-line	on-line	-	-
Holding	-	-	-	-	-
Flaking	0.07 mm	0.04 mm	0.04 mm	-	-
Drying	-	6 mins	6 mins	-	-
Puffing	200°C, 15 sec, 15 m/s	200°C, 20 sec, 15 m/s	200°C, 20 sec, 15 m/s	150°C, 60 sec, 15 m/s	150°C, 60 sec, 12 m/s
Drying	-	-	-	-	-
Crushing	-	rollers	rollers	-	-

A preferred apparatus consists of the following equipment:

- Several rice soaking tanks (number is variable depending on output, for example, three or four for a suitable batch).
- Jacketed stainless steel tank for emulsifier preparation.
- Stainless steel emulsifier holding tank for storing prepared emulsifier prior to usage.
- Peristaltic pump for accurate dosing rate of emulsifier into rice feeder equipment.
- Rice feeder equipment for mixing emulsifier with soaked rice and for regulating feeding rate onto steaming belt.
- A single pass steaming tunnel as the cooking means to give a retention time of approximately 9 minutes. Any conventionally available steam cooker may be used.
- Delumper equipment for separating the steamed rice into individual rice grains. The delumper equipment may be on-line and integral with the conveyor belt or other feeding means.
- Primary dryer, for example, any conventionally available dryer such as a rotary dryer, bed dryer, vertical dryer etc. with approximately 6-8 minutes retention time for reducing rice grain moisture to 25%.

- Cooling chamber with approximately 2 minute retention time, where filtered air is blown or withdrawn through the bed of partially dried rice grains for cooling to about 40-50°C.
- Holding/conditioning belt (optional) where rice grains are held for about 30 minutes prior to rolling.
- A roller equipment to flatten rice grains into flakes.
- A rice flake dispensing machine which evenly distributes the material on the puffer conveyor belt. Feed rate is adjusted to obtain a 3 cm max bed thickness of rice flakes on conveyor.
- Hot air puffer with 200°C ($\pm 10^\circ\text{C}$) air temperature, about 12-15 m/s air velocity and 10-20 seconds retention time. Puffing occurs and moisture is reduced to about 10%.
- Secondary dryer with approximately 6 minutes retention time to further reduce puffed rice flake moisture from 10% to 5%.
- A second cooling chamber with about 2 minutes retention time for reducing puffed rice flake (alpha rice) temperature to ambient room temperature.

Figure 2 shows a preferred puffer which can be used in accordance with the apparatus of the present invention.

The apparatus further comprises means for transporting the rice through the apparatus in the correct sequence, continuously and at a suitable, pre-calculated rate. Said means may be, for example, a conduit, a conveyor belt etc.

The skilled person will realise that variations will occur in the method and apparatus of the present invention depending on the foodstuff being processed, and the desired properties of the end product. The method and apparatus of the present invention results in a food product having a long shelf life, such as 12 months, over the shelf life period the product has acceptable organoleptic properties, good stability, only very minor insignificant increase in moisture content, but below a level which will encourage microbial growth and/or spoilage. It will be obvious to the skilled person that the temperatures, pressures and cooking conditions disclosed herein relate only to preferred embodiments of the invention for illustration purposes. Variations and adaptations of the method and apparatus can be applied. The following Examples are for illustrative purposes only.

Example 1

Philippine rice

Raw material

Both broken and whole grain rice were used. The chemical and physical properties are as follows:-

Table 5

Moisture	13-14%
Protein (N X 5.95)	7.6-8.0%
Fat	0.71-0.75%
Dietary Fibre	0.33-0.35%
Ash	0.36-0.38%
Starch	74-78%
Amylose	22-24%
Amylopectin	76-78%
Length	6.5-7.5 mm
Width	1.5-2.4 mm

The soaking time used for Philippine rice was based on previous findings for Thai, Malaysian and Indonesian rice, which are also of the long grain, high amylose rice varieties. This duration allowed hydration of the entire grain, which can be manifested by the absence of a white, crystalline centre of a split soaked grain. Insufficiently soaked grains retains a dry, white centre which contrasts to the translucent soaked exterior. The grains were processed according to the method of the invention, including optional crushing steps. The crushing steps result in size reduction of the flakes. Processing conditions are as follows:

Table 6

Unit operation	A	B	C (broken rice)	D
Soaking	1½ hours	1½ hours	1½ hours	1½ hours
Emulsifier addition	Glycerol monostearate	Glycerol monostearate	Glycerol monostearate	Glycerol monostearate
Steaming	9 mins	9 mins	9 mins	9 mins
Delumping	on-line	on-line	on-line	on-line
Drying	80°C, 6 mins	80°C, 6 mins	80°C, 6 mins	80°C, 6 mins
Delumping	on-line	on-line	on-line	on-line
Holding	30 mins	-	-	30 mins
Flaking	0.04 mm	0.04 mm	0.04 mm	0.07 mm
Puffing	200°C, 12 m/s, 20 sec	200°C, 12 m/s, 20 sec	200°C, 12 m/s, 20 sec	200°C, 12 m/s, 20 sec
Drying	80°C, 6 mins	80°C, 6 mins	80°C, 6 mins	80°C, 6 mins
Cooling	2 mins	2 mins	2 mins	2 mins
Crushing	rollers	-	-	rollers

For test B, the 30 minute holding period was eliminated, and the partially dried rice were flaked immediately after drying. Broken rice which have been pre-cleaned were used for test C, utilizing identical conditions as test B. For test D, the flaking gap was increased to obtain thicker flakes.

Test samples were evaluated after the following preparation method:

- 1) Weigh 30g sample in polypropylene cup.
- 2) Add 300 ml boiling water. Stir, cover cup with lid for 3 minutes.
- 3) Remove lid and stir again. Sample ready for evaluation.

The samples are evaluated for texture, appearance and texture holding characteristics during evaluation (i.e. product consumption).

Test A Sample were fully rehydrated after 3 minutes addition of boiling water. The puffed flakes integrity were retained during product consumption. Crushing of flakes required to 1-3 mm size for required product texture.

Test B Elimination of the 30 minute holding resulted in flake disintegration during product consumption. The puffed flakes do not require crushing.

Test C Porridge texture characteristics from broken grain rice is similar to whole grain products (Test B). However, as the raw material is slightly yellowish in colour, the appearance of a plain porridge (without flavourings) is inferior. With flavouring addition, the broken grain product cannot be visually differentiated from the whole grain product.

Test D Flakes were slightly too thick, resulting in incomplete rehydration. Crushed flakes were still 'sandy' in mouthfeel.

Example 2

Red rice and brown rice

The husk present in red and brown rice retards water penetration during soaking. As excessively extended soaking duration pose both microbiological hazard as well as processing constraints, a soaking study was conducted to determine a reasonably viable soaking duration which could be used for these rice types.

As for the Philippine rice in Example 1, the required soaking duration should enable the grain centre to be hydrated. For red and brown rice, this is achieved after 3 hours soaking, with the soaked grain moisture level at 30-31%.

Processing trials were conducted, initially using the process of the invention.

Emulsifier addition was not required as the grain coat (tegmen) present in red and brown rice did not allow the grains to stick together during steaming. Additionally, the grains were crushed after processing to obtain a mashed product texture. The holding stage, which serves to stabilize the grains prior to flaking, was eliminated as texture holding was not required for this product application.

In some of the tests, the puffer air velocity was increased to obtain a more puffed product which would facilitate rehydration. Identical processing conditions

were therefore used to produce puffed red and brown rice, as shown in Table 7. The increased puffer air velocity also dehydrated the puffed flakes sufficiently and a subsequent drying stage was not required. Additionally, as both rice types were pigmented, product browning was not observed.

Table 7

Unit Operation	Red rice		Brown rice	
	Test E	Test F	Test G	Test H
Soaking	3 hours	3 hours	3 hours	3 hours
Emulsifier addition	-	-	-	-
Steaming	9 mins	9 mins	9 mins	9 mins
Delumping	on-line	on-line	on-line	on-line
Drying	80°C, 6 mins	80°C, 6 mins	80°C, 6 mins	80°C, 6 mins
Delumping	on-line	on-line	on-line	on-line
Holding	-	-	-	-
Flaking	0.04 mm	0.04 mm	0.04 mm	0.04 mm
Puffing	200°C, 12 m/s, 20 sec	200°C, 15 m/s, 20 sec	200°C, 12 m/s, 20 sec	200°C, 15 m/s, 20 sec
Drying	6 mins	-	6 mins	-
Cooling	2 mins	2 mins	2 mins	2 mins
Crushing	rollers	rollers	rollers	rollers

The test products were analyzed as in Example 1. Improved results were observed for the rice porridge prepared in Tests F and H. Improved rehydration properties were noted.

Compared to a rice porridge prepared from polished rice, the texture is rough and slightly fibrous. However, this texture is also perceived in the freshly cooked product. The puffed product texture is therefore acceptable as it is typical of the raw material.

Both red rice and brown rice can be used in a multi-grain formulation, which may also contain Philippine rice, millet and barley.

Example 3

Black glutinous rice

The black glutinous rice grains were soaked for 3 hours as for red/brown rice, which allows the centre of the grain to be hydrated. The initial Test I utilized basic processing conditions according to the invention. However, the emulsifier addition and holding stages were not included, and the puffed material were crushed to obtain a mashed product texture. The rationale of the process adjustments are as for red/brown rice discussed in Example 2.

Processing conditions are shown in Table 8:

Table 8

Unit operation	Test I	Test J	Test K	Test L
Crushing	-	-	rollers	-
Soaking	3 hours	3 hours	3 hours	3 hours
Emulsifier addition	-	-	-	-
Steaming	9 mins	9 mins	9 mins	9 mins
Delumping	on-line	on-line	on-line	on-line
Drying	80°C, 6 mins	80°C, 3 mins	80°C, 3 mins	80°C, 6 mins
Delumping	on-line	on-line	on-line	on-line
Holding	-	-	-	-
Flaking	0.04 mm	0.04 mm	0.04 mm	0.05 mm
Puffing	200°C, 12 m/s, 20 sec	200°C, 15 m/s, 20 sec	200°C, 15 m/s, 20 sec	200°C, 15 m/s, 20 sec
Drying	6 mins	-	-	-
Cooling	2 mins	2 mins	2 mins	2 mins
Crushing	rollers	rollers	rollers	rollers

Increased puffer air speed was used for Test J so that subsequent drying is not required. Drying duration prior to flaking was also reduced to 3 minutes as the fibrous grain coat was sufficiently dry and do not stick to flaker rollers at slightly higher moisture levels.

For Test K, the black rice was pre-crushed prior to soaking. The purpose of breaking the grains was to facilitate water absorption during soaking, and more efficient cooking during steaming. However, the steamed material was slightly sticky and presented handling problems during subsequent delumping and drying operations.

The initial drying duration was extended back to 6 minutes for Test L. The flaking gap was increased to 0.05 mm to obtain a firmer texture with more 'bite'.

Tests I, J and K produced a soft and smooth porridge after 3 minute rehydration. There was no significant difference between pre-crushed grains (Test K) and non-crushed samples.

Example 4

Millet

The process of the invention was followed using conditions set out in Table 9.

Subsequent evaluation was in accordance with previous Examples.

Table 9

Unit operation	Test M	Test N
Soaking	3 hours	3 hours
Emulsifier addition	-	-
Steaming	9 mins	9 mins
Delumping	on-line	on-line
Drying	80°C, 6 mins	80°C, 6 mins
Delumping	on-line	on-line
Holding	-	-
Flaking	0.07 mm	0.07 mm
Puffing	200°C, 12 m/s, 20 sec	200°C, 15 m/s, 20 sec
Drying	-	-
Cooling	2 mins	2 mins

As the size of millet grains are significantly smaller than the other grains, the steaming and drying operations were conducted on trays with 1 mm mesh wiring. Original steamer and dryer belt mesh were too wide and millet grains would fall through.

Test M Grains intact but slightly too firm.

Test N Grains intact and soft. Slight disintegration
 during extended holding.

Test N sample is suitable for formulation usage as the rehydrated grain texture is soft. The grains are identifiable as they are still intact.

Example 5

Barley

Processing conditions were as shown in Table 10. The product of Test O was evaluated in accordance with the method used in previous Examples.

Table 10

Unit Operation	Test O
Soaking	3 hours
Emulsifier addition	-
Steaming	9 mins
Delumping	on-line
Drying	80°C, 6 mins
Delumping	on-line
Holding	-
Flaking	0.04 mm
Drying	9 mins
Puffing	200°C, 15 m/s, 20 sec
Drying	-
Cooling	2 mins
Crushing	rollers

Test O soft, slightly rough in texture, but acceptable.

Example 6

Split mung bean

The grain composition of split mung bean is different from the other grain described previously. The protein content of this raw material is much higher than other grains. Additionally, its starch content (~45%) is also in a different range.

Split mung bean grains behave differently from the grains of the previous Examples, due to composition differences. The objective of processing was to obtain a porous structure in the dehydrated product by modifying drying conditions. The conditions are shown in Table 11. Evaluation was as before.

Table 11

Unit operation	Test P	Test Q
Soaking	3 hours	3 hours
Emulsifier addition	-	-
Steaming	15 mins	10 mins
Delumping	on-line	on-line
Drying	80°C, 6 mins	80°C, 6 mins
Delumping	on-line	on-line
Holding	-	-
Flaking	-	-
Puffing	150°C, 15 m/s, 60 sec	150°C, 15 m/s, 60 sec
Drying	-	-
Cooling	2 mins	2 mins

Steaming duration was increased to 15 minutes in Test P to overcome a raw taste in the product. As a long exposure would significantly reduce line output, steaming time was reduced to 10 minutes (Test Q), which was sufficient to eliminate the raw taste.

Tests P and Q Cooked taste, good rehydration.

The process of the invention may be used with other grains, such as, oat, wheat, rye, buck-wheat, green beans, red beans etc.

CLAIMS:

1. -A method for the continuous preparation of a puffed grain product which comprises the steps of:

- soaking said grains in water;
- pre-cooking said grains;
- exposing said grains to a first drying step;
- processing said grains into flakes; and
- puffing said grain flakes.



2. A method according to claim 1 in which said grain is rice.

3. A method according to claim 1 or claim 2 which comprises exposing said puffed grain flakes to a second drying step after puffing the grain flakes.

4. A method according to any of claims 1 to 3 in which the water is drained away after the soaking step and before the pre-cooking step.

5. A method according to any of claims 1 to 4 in which prior to the pre-cooking step, said grains are mixed with an emulsifier coating to reduce lumping of said grains during processing.

6. A method according to any of claims 1 to 5 in which after the pre-cooking step the grains undergo delumping, and optionally also after the first drying step.



7. A method according to any of claims 1 to 6 in which the grains are cooled after the first drying step, and optionally also after the second drying step.

8. A method according to any of claims 1 to 7 in which before processing of the grains into flakes, the grains undergo a holding and conditioning step to enable moisture equilibrium within the grains to take place.

9. A method according to any of claims 3 to 8 in which the moisture content of the grains is reduced to 25% after the first drying step and to 5-6% during the second drying step.

10. An apparatus for carrying out the method according to any of claims 1 to 9 which comprises:

- means for soaking said grains in water;
- grain feeder means for regulating the feeding rate of said grains into a pre-cooking means;
- pre-cooking means comprising a steaming tunnel, having means for retaining the grains in the steaming tunnel for a preset time;
- a first drying means having means for retaining the grains in the dryer for a present time;
- a roller means to flatten the grains into flakes;
- a puffer means for puffing said flakes; and
- conveyor means for continuously transporting said grains to each component of the apparatus at a pre-set rate.



11. An apparatus according to claim 9 which further comprises a second drying means having means for retaining the puffed flakes in the dryer for a preset time, wherein in use grains are transported to said second dryer after puffing.

12. An apparatus according to claim 10 or claim 11 which further comprises means for delivering a dose of emulsifier to said grains on the conveyor means prior to them reaching the pre-cooking means, wherein the emulsifier coats said grains to reduce stickiness.

13. An apparatus according to any of claims 10 to 12 which comprises delumper equipment at one or more places on the conveyor means.

14. An apparatus according to any of claims 10 to 13 which comprises a cooling chamber situated after the first drying means, and optionally a second cooling chamber after the second drying means.