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Influence of particle size of rice flour in manufacturing rice incorporated wheat bread

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Abstract
Bread is an important food product across the whole cross profile of the Sri Lankan society. Incorporation of rice flour in bread manufacturing process is a viable option, as rice is the staple food crop in Sri Lanka. Rice flour, obtained from heat treated and raw rice grains were subjected to three grinding techniques; pin mill, turbo rotor mill and cyclone separator. Thereafter, leavening index of rice flour incorporated bread dough was determined along with cold and hot water treatment, as well as with different proportions of wheat flour. The best treatment in terms of leavening index was subjected for microbial fermentation and subjected for leavening index test again. All samples were replicated thrice. Bulk density, moisture content and pH of the bread prepared with the best treatment were determined, to measure the influence of post gelatinization process of rice flour. Results revealed that, best soaking method and best rice flour in manufacturing of rice bread were cold soaking and raw rice flour, due to rapid accomplishment of leavening index two. On the other hand, if the manufacturer is equipped with a pin mill (300 μm), turbo rotor mill (250 μm) or cyclone separator (75 μm) the desirable rice flour to wheat flour ratios are 30:70, 40:60 and 50:50 respectively. Because, all above levels with regard to grinding methods were failed to achieve leavening index two within the stipulated time of 2 ½ hours. Hence, productive treatment was cyclone separation, because it was capable to replace 50 % of wheat flour. Even though microbial treatment was capable to increase rice flour by 10 %, it was not suitable in bread manufacturing process due to poor organoleptic properties. pH, moisture content and bulk density of bread manufactured from the treatment of cyclone separation were 5.4, 40.9 % and 0.121 gcm^{-3} respectively and those values were within the range of regulatory requirements of bread. When considering the appearance, texture and mouth feel, there was no contrast between bread made with best treatment and 100 % wheat flour. Hence, 50 % of wheat flour can be replaced by adopting of cyclone separation process in manufacturing of bread, along with cold soaking process.

Keywords: bread, rice flour, wheat flour, leavening index, cyclone separator

Introduction

Rice is one of the oldest and most important food crops and it is the staple food of over half the world's population. In recent years there has been some shift from rice to flour based foods, mainly in urban areas due to the convenience (Bandyopadhyay and Roy, 1992). Bread is a very popular and important food product across the whole cross profile of the society. Over the last decades, a tendency to adapt bread as a regular food has become increasingly apparent in Sri Lanka. Due to escalation of price of wheat flour, purchasing of this product is beyond the reach of ordinary consumers. To satisfy the demand for bread, we have to import wheat and have to spend more foreign exchange (Cauvain and Young, 1999). Today, there is a trend of using wheat for making bio fuel. Therefore, we can not think about a price reduction of wheat flour. Hence, development of substitute food product while maintaining identical quality of wheat bread is an important aspect. Therefore, incorporation of rice flour into bread manufacturing process is a viable option, because rice is the staple food crop in Sri Lanka.

Rice carbohydrates are most digestible amongst all cereal grain carbohydrates. Other advantages of using rice flour include higher fiber content than wheat flour and more complete protein due to a better amino acid balance. The favorable balance of amino acids in the

rice flour and their good digestibility by the humans make it a valuable raw material (Manley, 1991).

Elastic property of gluten is the crucial factor in bread manufacturing process. Rice starch does not contain the substance called gluten. Hence, rice flour does not inherit with the elastic property. Therefore, rice flour can not be used to make bakery products such as bread, as wheat flour (Kent, 1975).

The use of rice flour for bakery products has high potential in Sri Lankan economy. Hence, identification of the techniques for using rice flour for bakery products is more important research study. Common ordinary rice flour particle size is 300 μm. But the particle size of wheat flour is 75 μm. When reduce the particle size, there is a possibility to increase the surface area of particles and will enhance the ability of trapping carbon dioxide during bread baking process.

General objective of the study is enhancing the elastic property of rice flour in manufacturing of rice incorporated wheat bread.

Specific Objectives are;

- To test different particle sizes of rice flour obtained from different kinds of grinding techniques in bread manufacturing process
- Determination of influence of hot and cold water treatment for pre-gelatinization process of rice flour
- To test different proportions of rice flour and wheat flour in bread manufacturing process
- To compare the normal and heat treated rice flour in bread manufacturing process
- To measure the influence of post and pre gelatinization of rice flour in manufacturing of rice incorporated wheat bread
- Further improvement of rice flour utilization with microbial activities

Material and Methods

The experiment was conducted at Harischandra Mills (pvt) Ltd in Matara during February to June in 2008.

Determination of leavening index

Determination of leavening index of rice flour obtained from different grinding techniques along with cold and hot water treatment, as well as with different proportions of wheat flour.

Well cleaned raw rice grains (about 1 kg) were taken and ground to get rice flour from a pin mill, a turbo rotor mill (universal type) and cyclone separator. Same quantity of rice grain was subjected for same grinding techniques as given above and roasted at 150 °C for 5 minutes.

Rice flour obtained from pin mill, turbo rotor mill and cyclone separator was subjected for pre-gelatinization process in order to prepare twelve types of dough by mixing with hot water at 60 °C and cold water at room temperature. Prepared dough with hot water and cold water were allowed for 30 minutes and 180 minutes respectively to facilitate pre-gelatinization process. Thereafter, the prepared dough from rice flour were incorporated with 1 % yeast, 1 % sugar and different proportions of wheat flour and mixed well. Different proportions of rice flour and wheat flour used for the leavening index test are shown in table 3.1.

A portion of prepared dough was taken and put into a measuring cylinder and the occupied volume (initial volume) in the measuring cylinder was recorded. The filling orifice of the measuring cylinder was covered with a piece of polythene and allowed for fermentation until 2 ½ hours as it is the optimum leavening time for bread manufacturing process (Navaratne, 2006).

The results obtained from the experiment were subsequently used to calculate leavening index (equation 1) by resorting under mention formula.

$$\text{Leavening Index} = \frac{\text{Increment volume}}{\text{Initial volume}} \quad (1)$$

Table 1. Different proportions of rice flour and wheat flour used for the leavening index trial.

Rice flour	Wheat flour	Total
30	70	100
40	60	100
50	50	100
60	40	100
70	30	100

Determination of leavening index of rice flour treated with microbes

The best treatment out of six previously tested was subjected for this study. There in, 300 g of rice flour from best flour combination was taken, was incorporated with 1 % yeast, 1 % sugar and adequate amount of cold water preferably to get the moisture content of the dough at 57-60 % (Navaratne, 2006). The mixture was well mixed in order to get dough of suitable consistency. The prepared dough was allowed for fermentation for 6 hours duration (Navaratne, 2006).

Well fermented dough was pulverized into small pieces and was dried in an oven at 70 °C to get moisture content at 12 %. Dried dough pieces were were ground using a laboratory scale pin mill and were subjected for

leavening index test with different proportions of wheat flour, preferably wheat flour level below the best flour combination.

Determination of influence of post gelatinization process on rice flour in manufacturing rice incorporated wheat bread

To measure the influence of post gelatinization process on rice flour, the bread sample obtained from best treatment was used to determine bulk density, moisture content, pH and organoleptic properties.

The bulk density of baked bread was determined using a slice of bread (2 cm thickness). It was weighed using the electronic balance and shrink wrapped with a polythene sheet. Thereafter, shrink-wrapped bread slice was dipped in water. Then, replacement of water due to volume of bread slice was recorded and bulk density of baked bread was calculated.

Moisture content of baked bread was determined using a slice of bread taken from the middle of a loaf. It was pulverized into small pieces and weighed more than 5 g using the electronic balance. Then, small pieces of bread were put in the moisture balance and switched on. The reading was given automatically after some time period.

pH of baked bread was determined using 20 g of bread crumb. It was weighed using the electronic balance. Thereafter, 200 ml of distilled water was boiled and allowed to cool. Then 20 g of bread crumb was added to 200 ml of distilled water and kept for 15 min. Thereafter, the mixture was blended and filtered using a funnel with a filter paper. Then pH value was measured using pH meter.

Table 4. Leavening index of rice flour obtained from each grinding technique along with cold and hot water treatment, as well as with different wheat flour proportions

Grinder	Rice :Wheat flour flour	Cold water treatment				Hot water treatment			
		R_1	R_2	R_3	Mean	R_1	R_2	R_3	Mean
Pin mill Raw rice flour	30:70	2	2	1.9	2	1.8	1.9	1.7	1.8
	40:60	1.8	1.7	1.7	1.7	1.7	1.6	1.7	1.7
	50:50	1.7	1.6	1.6	1.6	1.6	1.5	1.4	1.5
	60:40	1.5	1.6	1.5	1.5	1.4	1.4	1.5	1.4
	70:30	1.4	1.3	1.2	1.3	1.3	1.4	1.3	1.3
Pin mill Heat treated rice flour	30:70	1.8	1.7	1.6	1.7	1.7	1.6	1.6	1.6
	40:60	1.7	1.6	1.6	1.6	1.6	1.4	1.5	1.5
	50:50	1.5	1.4	1.4	1.4	1.3	1.4	1.3	1.3
	60:40	1.4	1.3	1.35	1.35	1.3	1.2	1.2	1.2
	70:30	1.3	1.3	1.4	1.3	1.2	1.3	1.2	1.2
Turbo rotor mill Raw rice flour	30:70	1.95	2	2	2	1.8	1.7	1.8	1.8
	40:60	2	1.9	2	2	1.8	1.7	1.7	1.7
	50:50	1.8	1.9	1.7	1.8	1.6	1.7	1.6	1.6
	60:40	1.7	1.6	1.65	1.65	1.6	1.4	1.5	1.5
	70:30	1.5	1.4	1.4	1.4	1.3	1.4	1.3	1.3
Turbo rotor mill Heat treated rice flour	30:70	1.8	1.9	1.7	1.8	1.8	1.7	1.7	1.7
	40:60	1.8	1.7	1.75	1.75	1.7	1.6	1.8	1.7
	50:50	1.6	1.7	1.6	1.6	1.6	1.5	1.55	1.55
	60:40	1.4	1.5	1.4	1.4	1.4	1.3	1.2	1.3
	70:30	1.35	1.4	1.3	1.35	1.2	1.3	1.2	1.2
Cyclone separator Raw rice flour	30:70	2	1.95	2	2	1.85	1.9	1.8	1.85
	40:60	2	2	1.9	2	1.8	1.6	1.7	1.7
	50:50	1.95	2	1.95	2	1.65	1.7	1.6	1.65
	60:40	1.9	1.7	1.8	1.8	1.6	1.7	1.6	1.6
	70:30	1.5	1.3	1.4	1.4	1.3	1.4	1.3	1.3
Cyclone separator Heat treated rice flour	30:70	1.8	1.9	1.7	1.8	1.8	1.7	1.7	1.7
	40:60	1.8	1.7	1.8	1.8	1.7	1.6	1.8	1.7
	50:50	1.8	1.7	1.7	1.7	1.6	1.7	1.6	1.6
	60:40	1.6	1.7	1.6	1.6	1.7	1.6	1.6	1.6
	70:30	1.4	1.5	1.4	1.4	1.6	1.4	1.5	1.5

Determination of leavening index of rice flour obtained from each grinding technique along with cold and hot water treatment, as well as with different proportions of wheat flour

Leavening index of rice flour obtained from each grinding technique along with cold and hot water treatment, as well as with different wheat flour proportions are mentioned in table 4.1.

If manufacturer was equipped with pin mill (300 µm), turbo rotor mill (250 µm) or cyclone separator (75 µm) and bread dough prepared with cold water, the desirable rice flour: wheat flour ratios were 30:70, 40:60 and 50:50 respectively. Because leavening index 2.0 is the optimum leavening parameter as far as bread manufacturing process is concerned and which has to be accomplished within a matter of 2 ½ hours (Navaratne, 2006). All above rice flour levels were failed to manufacture bread, because all above levels were failed to achieve leavening index 2.0, within the stipulated time of 2 ½ hours (Navaratne, 2006). Elastic property of gluten is the crucial factor in manufacturing of bread. Because gluten is capable to make an elastic network which stretched during fermentation process as a result of accumulation of carbon dioxide gas bubbles. Rice starch does not contain the substance called gluten. Hence, rice flour does not inherit with the elastic property. However if particle size of rice flour can be maintained as fine as possible, the elastic property of which can be improved into somewhat degree. Therefore, when particle size of rice flour becoming finer, sticky property of which is concurrently increase. When rice flour obtained from pin mill, particle size of which was somewhat course (around 300 µm). Therefore, the amount of rice flour to be incorporated into bread dough was less which was around 30 %.

When rice flour obtained from turbo rotor mill, particle size of which was somewhat finer (around 250 µm) than pin mill. Therefore, the amount of rice flour to be incorporated into bread dough was some what higher, which was 40 %. When rice flour obtained from cyclone separator, particle size of which was finer (around 75 µm). Therefore, more rice flour can be incorporated into bread dough which was around 50 %.

If same particle size subjected for bread dough making process with hot water at 60 °C for 30 minutes, the amount of rice flour incorporated into bread dough was less. Reason for this negative feature is the denaturing of water insoluble proteins in rice flour. Because water insoluble proteins in rice grain is also contributing to have somewhat elastic property. This negative factor is badly contributing to restrict the elastic nature of rice proteins.

Using of heat treated rice flour was not suitable in bread manufacturing process, because which was failed to achieve leavening index 2.0. Reason for this negative feature is the denaturing of proteins in rice flour. Even though the rice flour contain a little amount of protein which contributes to have a little elastic property, which denatured during heat treatment at 150 °C for 5 minutes.

Leavening index of fermented rice flour with different proportions of wheat flour

Rice flour obtained from cyclone separator (75 µm) was subjected for microbial fermentation and fermented rice flour in dry basis were incorporated with different proportions of wheat flour beginning from 50 % to 10 % with 10 % intervals. Five treatments evolving this trial were subjected for leavening index test and results were given in table 4.2. The data given in the table 4.2 clearly indicate that microbial treatment was capable to increase rice flour by 10 % into the bread dough. Reason for this 10 % increment is activities of microbes. They are capable to produce some byproducts (dextrin and simple sugars) that indirectly contribute to accelerate leavening index of fermented rice flour in bread fermentation process.

Table 2. Leavening index of fermented rice flour with different proportions of wheat flour

Rice flour	Wheat flour	Leavening index			
		R_1	R_2	R_3	Mean
50	50	2	2	2	2
60	40	2	1.9	2	2
70	30	1.8	1.9	1.7	1.8
80	20	1.7	1.6	1.6	1.6
90	10	1.5	1.6	1.4	1.5

Determination of influence of post gelatinization process on rice flour in bread manufacturing process

As pH value and moisture content, the most important regulatory requirements of baked bread, shall remain in between 5.3-6 and within the limit of 40 % respectively. Whereas, optimum bulk density of baked bread was 0.121 gcm^{-3} (Navaratne, 2006). Results cited that pH, moisture content and bulk density of bread obtained from best treatment were 5.4, 40.9 % and 0.121 gcm^{-3} respectively and those values were within the range of regulatory requirements of bread. When considering the appearance, texture and mouth feel of bread, there was no contrast between bread made with best treatment and 100 % wheat flour.

Conclusions

- Best soaking method and best rice flour in manufacturing of rice bread were cold soaking and raw rice flour, due to rapid accomplishment of leavening index two within 2 ½ hours.
- If manufacturer was equipped with either pin mill or turbo rotor mill, the desirable rice flour: wheat flour ratio in manufacturing of bread was 30:70 and 40:60 respectively. Because all above levels were failed to achieve leavening index two, within the stipulated time of 2 ½ hours.
- If manufacturer was equipped with cyclone separator, the desirable rice flour : wheat flour ratio in manufacturing of bread was 50:50 (best treatment).
- Even though microbial treatment was capable to increase rice flour by 10 % into the bread dough, it was not suitable in bread manufacturing process, due to poor organoleptic properties.
- pH, moisture content and bulk density of baked bread obtained from best treatment were 5.4, 40.9 % and 0.121 gcm^{-3} respectively and those values were within the range of regulatory requirements of bread
- When considering the appearance, texture and mouth feel of baked bread, there was no contrast between bread made with best treatment and 100 % wheat flour.
- 0 % of wheat flour can be replaced by adopting of cyclone separation process in bread manufacturing process.

Referances

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