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# EFFECT OF GLUTEN ADDITION TO RICE FLOUR IN DEVELOPING A NEW RICE FLOUR BREAD

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## Abstract

It was observed that the minimum quantity of vital wheat gluten required to mix with rice flour in bread making to be 20%. Studies on the chemical composition of this bread showed higher moisture and protein levels than wheat bread. Farinograph absorption curves of wheat gluten/rice flour mixes showed that stable doughs could be made with mixes having 20% and 25% w/w Gluten. It was observed that such doughs needed 70% water. Amylograph viscosity data showed the above mixture to behave like rice flour on heating, but on cooling it did not show a sharp increase in viscosity like rice flour. The extensibility of the above dough was lower and the resistence was higher than in a wheat flour dough. Gluten/rice flour dough tended to collapse and became porous after two hours. This dough gave a good loaf when developed by a combination of chemical and activated dough development methods. Lecithin when used at 0.5% (w/w) concentration in the form of a liquid crystaline lipid phase was found to improve the loaf volume further.

## Introduction

Gluten, the storage protein of wheat, possesses the ability to form an expandable elastic net work in the presence of water. This protein consists of two protein fractions namely glutenin and gliadin. It is the gluten-gel network that adheres starch grains and entraps the gas produced during early stages of the bread making process. As no other cereal posseses this property wheat has been imported to countries where wheat is not grown and the population wishes to have leavened products. Sri Lanka is one such country and the annual requirement of wheat flour is in the region of 356,509 metric tons.[1]

Several workers have reported on attempts of using rice/wheat composite flour systems in bread making([2-4]). The highest extent of incorporation of rice flour to wheat flour in bread making is reported to be 50%[5]. Relatively few attempts seem to have been made on the wheat gluten/rice flour systems. Earlier workers on wheat gluten/starch systems report that acceptable loaves could only be made by systems containing rye and barley starches[6]. The same workers report the wheat gluten/rice starch system to yield a poor loaf.

However, in this work using dry vital wheat gluten and rice flour from a type of rice grown in Sri Lanka, we were able to obtain a loaf of good quality from a mixture of 80% rice flour and 20% gluten. The results presented here also include investigations on the rheological properties of this dough. A comparison was also made with a conventional wheat flour dough.

## 2. Experimental

### 2.1 Materials

Raw partially polished rice flour (protein – 7.5% and ash – 1.0%) of the H 4 variety was used. Dry vital wheat gluten (protein – 75% and moisture—9%) was kindly supplied by the Bread Research Institute of Australia. Wheat flour (moisture – 13.5% and protein – 12%) used in the studies was a locally available wheat flour milled by Prima (Ceylon) Ltd. In all baking experiments 'Fermipan' instant yeast from Holland was used. Potassium Bromate and Ascorbic acid were of analar grade. The emulsifiers used were,

(*a*) A crude egg lecithin from BDH Chemicals Ltd. England.

(*b*) Sodium stearoyl 2 Lactylate (SSL) from Grindstead products, Brabrand, Denmark.

### 2.2 Methods

#### 2.2.1 Chemical composition of flours and bread

Moisture, protein and ash contents of the flours and bread were determined by AACC methods 44 – 19, 46 – 13 and 18 – 01 respectively. The conversion factor for protein is N × 5.7.

#### 2.2.2 Farinograph curves

A Brabender Farinograph was used. Dry vital wheat gluten (0 – 25%) was dry mixed with rice flour in the 300g. Farinograph mixing bowl for five minutes at a speed of sixty rev/min to ensure proper mixing of gluten and rice flour. After addition of water, mixing was continued at 60 rev/min until a stable dough was formed as indicated by the Farinograph.

#### 2.2.3 Amylograph curves

A Brabender Amylograph with a 750 cmg cartrige was used. 60 g each of pure rice flour and 20% gluten rice mixture were mixed separately in 450 ml of water and transferred to the Amylograph mixing bowl. It was rotated at 72 r.p.m. and the temperature was increased from 30°C to 95°C at a rate of 1.5°C/min. It was kept at 95°C for fifteen minutes and cooled to 50°C. The change in viscosity with temperature was recorded in the Amylograph.

### 2.2.4 Extensograph curves

A Brabender Extensograph was used. 300 g of wheat flour and 20% Gluten/rice mixture were separately dry mixed in the 300 g. Farinograph mixing bowl for five minutes. Six g of salt was dissolved in 45% of total water requirement and it was added to flour together with the remaining water and the dough was mixed at 60 rev/min. For wheat flour the standard mixing pattern was used. (ie. one minute mixing, resting for five minutes, and final mixing for two minutes). in the case of the Gluten/rice mixture, it was observed that the above mixing time was not appropriate and after several trails the following mixing pattern was established. Five minutes mixing, resting for five minutes and final mixing for ten minutes. The resulting doughs were then cut into 150 g pieces. These pieces were moulded using the moulder attached to the extensograph and the extensograms were obtained for each dough piece at time intervals of 45 min. 90 min. and 135 mins. respectively.

### 2.2.5 Measurement of dough raising power

100 g of wheat flour and 20% Gluten/rice flour were separately mixed with 1.00 g yeast and 1.00 g sugar in the Hobart Planetary mixer until a stable dough was formed. The doughs were transferred to a vessel having a measuring scale. The height of the dough was measured every five minutes over a period of two hours and a graph of height of dough vs time was plotted.

### 2.2.6 Baking

The formula adopted for test baking was : flour—100% (w/w) (wheat or mixture of rice and wheat Gluten), Yeast—1% (w/w), sugar—1% (w/w)/, salt—2% (w/w), Lecithin—0.5% (w/w), potassium bromate 100 ppm, ascorbic acid—100 ppm. The amount of water added was 55% (w/w) for wheat and 70% (w/w) for the rice/wheat Gluten mixtures. Rice flour and wheat gluten (different percentages) were dry mixed (slow speed) for five minutes in the Hobart Planetary mixture. The yeast was added to the sugar/salt solution and transferred to the mixing bowl. Potassium bromate and ascorbic acid were transferred to the mixing bowl, when lecithin was added it was shaken in water (1 : 10) until a homogeneous disperscon was obtained and was transferred together with the sugar/salt solution. The mixing was performed at low speed for two minutes, and high speed for five minutes. No fermentation was done. The dough was divided into the required size, each piece was moulded twenty five revolutions using laboratory type moulder, placed in greased aluminium pans and proofed for one hour at 37-C and 98% relative humidity. The bread was baked for twenty minutes at 240-C. The loaf volumes were measured using the rapeseed displacement method after cooling for two hours. Specific loaf volumes were calculated as loaf vol/bread wt. Quality of the bread crumb was judged by its texture, and examination of uniformity of its pores and pore size visually.

## 3. Results and Discussion

### 3.1 Chemical composition

The chemical composition of wheat flour, wheat bread, wheat gluten/rice composite flour mix and 20 % wheat gluten/rice bread is given, in Table I.

The moisture conterts of wheat bread and 20% wheat gluten/rice bread are 30% and 40% respectively. The reasons for this could be the difference in water absorption of wheat flour and wheat gluten/rice flour mix. The wheat flour had a water absorption of 55% and the wheat gluten/rice flour mix had

**Table 1**

**The Chemical Composition of Wheat Flour, Wheat Bread Composite Flour Mix and Gluten/Rice Bread (per 100g of Edible Portion)**

| | Moisture | Protein | Fat | Ash |
|---|---|---|---|---|
| 1. Wheat flour | 13.5 | 12 | 0.9 | 0.4 |
| 2. Wheat Bread | 30 | 7.8 | 1.0 | 0.8 |
| 3. Gluten/rice flour mix | 10.7 | 20.4 | 2.0 | 1.0 |
| 4. 20% Gluten/Rice Bread | 40.0 | 13.5 | 1.5 | 0.8 |

a water absorption of 70%. The protein contents (per 100 g edible portion) of wheat bread and wheat gluten/rice flour bread are 7.8 and 13.5 respectively. The reason for this is the difference in protein contents of the starting material ie. wheat flour and wheat gluten/rice flour mix has protein contents (per 100 edible portion) of 11 and 20.4 respectively.

### 3.2 Absorption curves

The Farinograph curves obtained for 0·25% Gluten/rice mixes are given in Fig. I and the results are given in Table II. It is clear from the figure that there are no proper dough forming characteristics shown in mixtures having 0.15% wheat Gluten/rice flour. Since it was difficult to obtain a proper absorption curve for these mixtures an arbitary water content of 70% was added. When 70% water was added to a mixture having 20% and 25% gluten the absorption curve indicated the formation of a stable dough and the Brabender curve was centred at 300 BU, and 450 BU respectively. Even these curves looked scratchy at the beginning and the dough development time was very long when compared with a farinograph curve of a wheat flour dough. This probably indicates a non uniform adjustment of ingredients in wheat gluten/rice flour dough at the initial stages of mixing but the developed dough

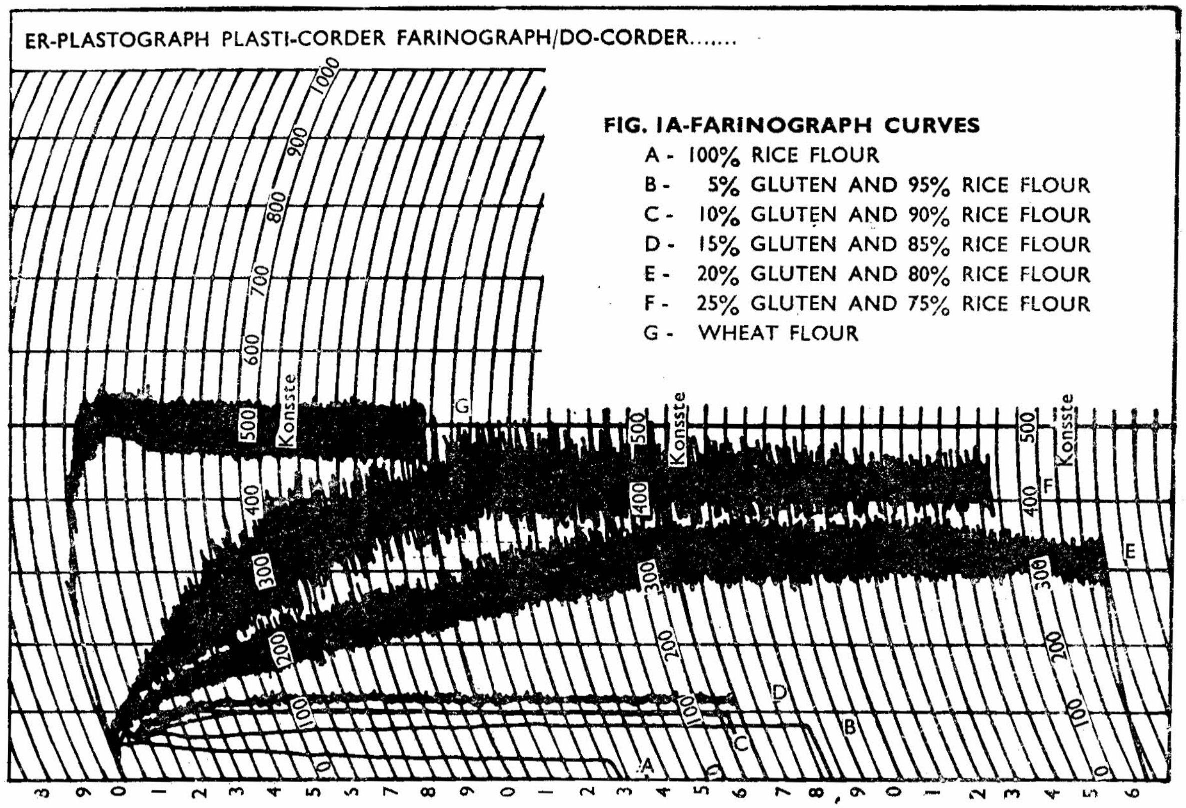


**Fig. 1** —1A—The Farinograph curves of A-100% rice flour, B-5% wheat Gluten/rice flour, C-10% wheat Gluten/rice flour, D-15% wheat Gluten/rice flour, E-20% wheat/rice flour, F-25% wheat Gluten/rice flour and G-wheat flour.

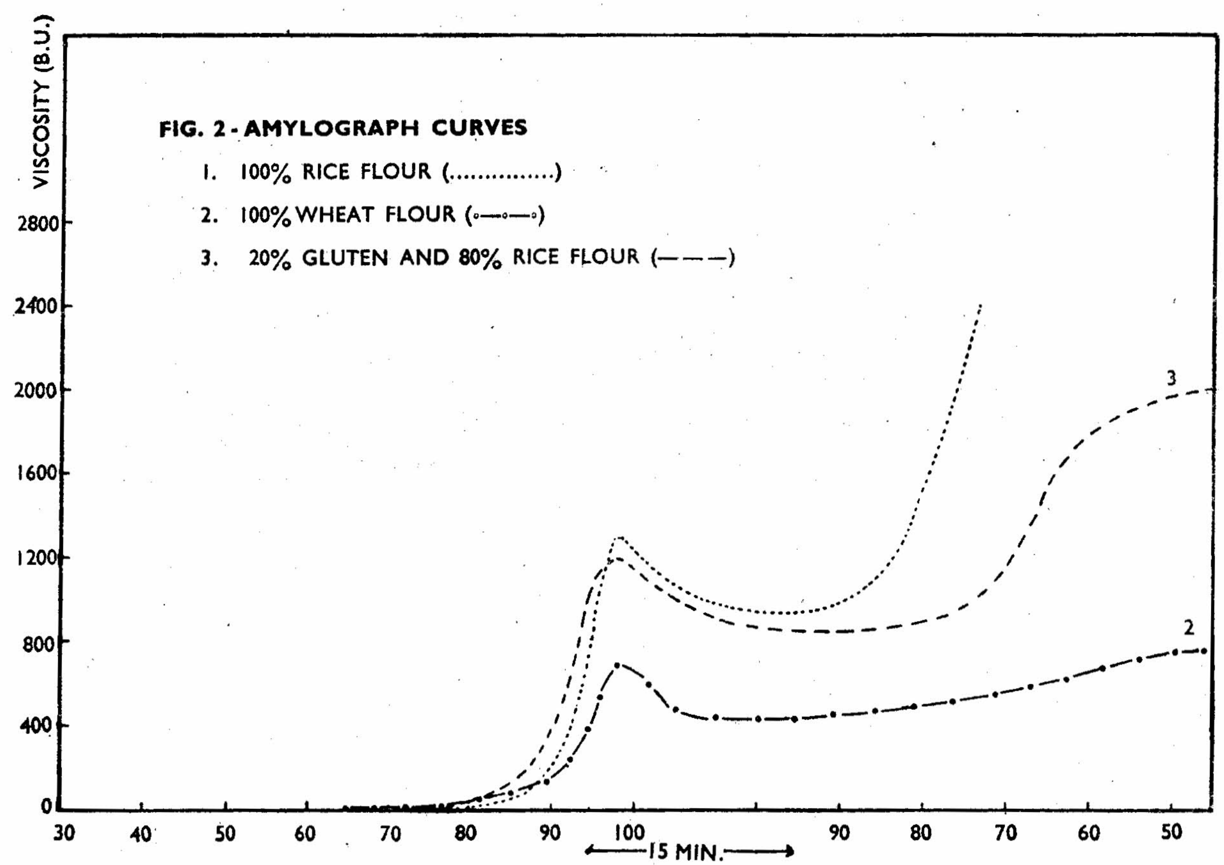


**Fig. 2**—The Amylograph curves of (1) %100 rice flour (...),(2)100% wheat flour(o—o—o)and(3) 20% wheat Gluten/rice flour.

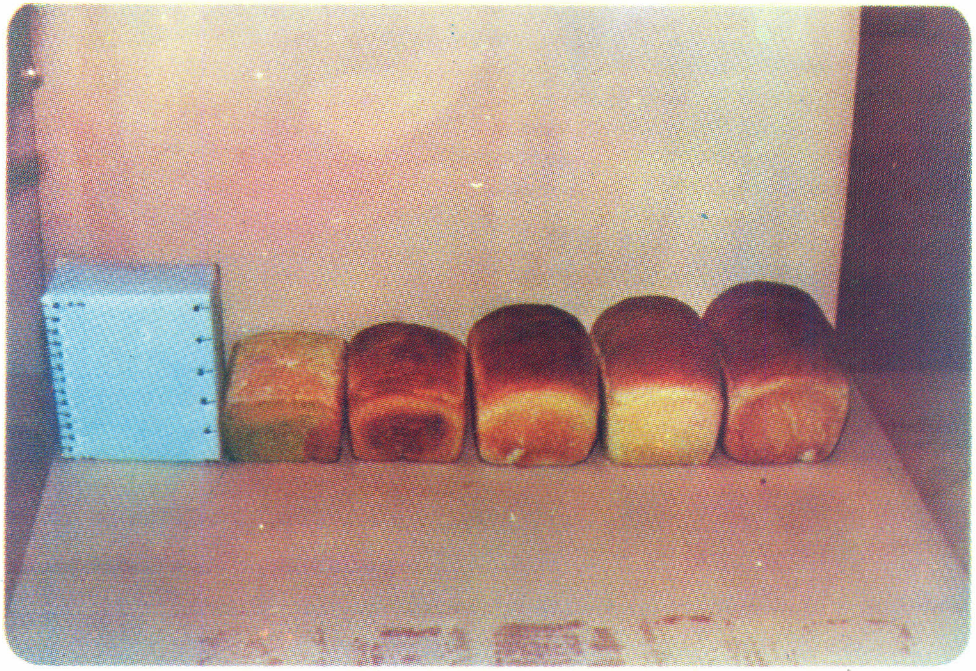

**Fig. 1B—The loaves of bread (starting from the left) baked from 5%, 10%, 15%, 20% and 25% wheat Gluten/rice flour mixes.**

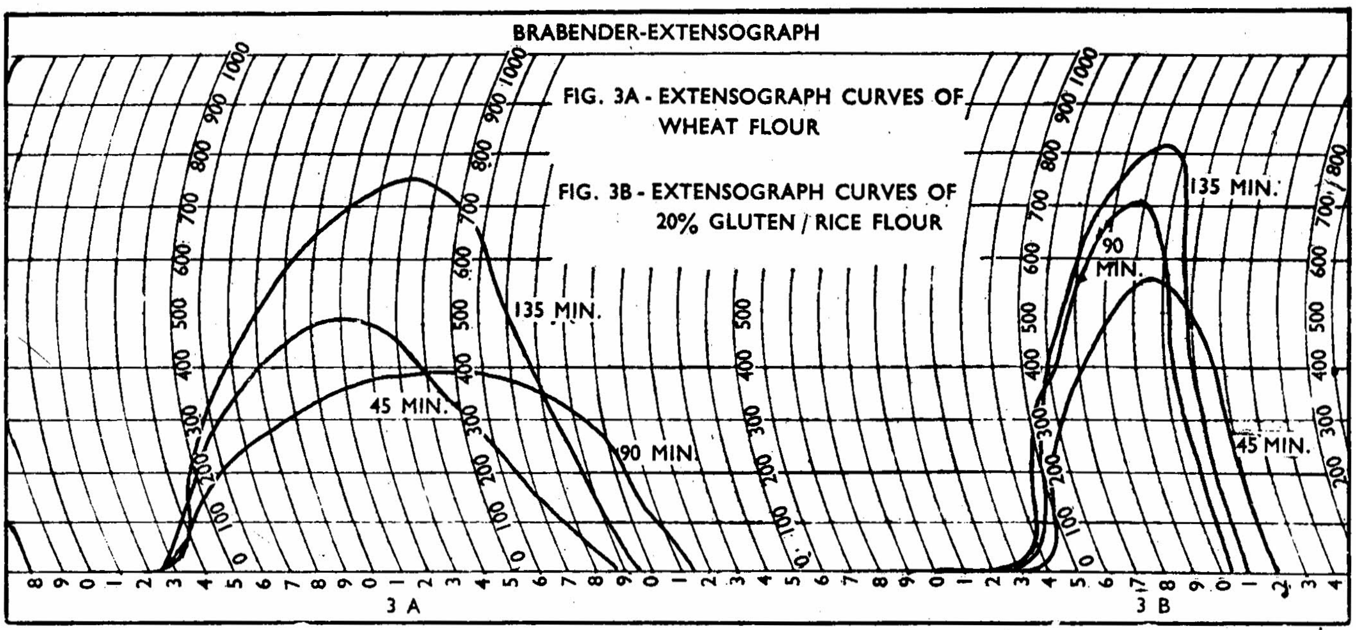


**Fig. 3** —3A—Extensograph curves of wheat flour.
3B—Extensograph curves of 20% wheat Gluten/rice flour.

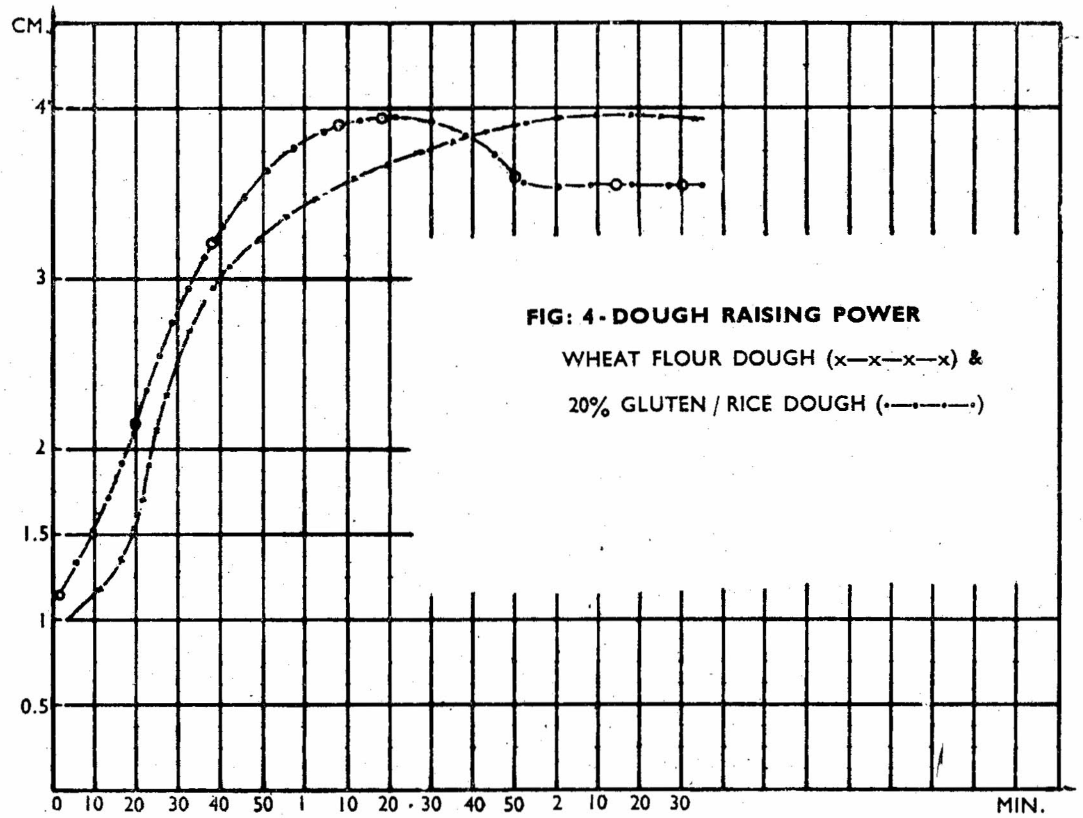


**Fig. 4** —The dough raising power of wheat flour dough (x—x—x) and 20% wheat Gluten/ rice flour dough. (o—o—o)

FIG. 5A - SPECIFIC LOAF VOL (cm3/g) VS %WHEAT GLUTEN

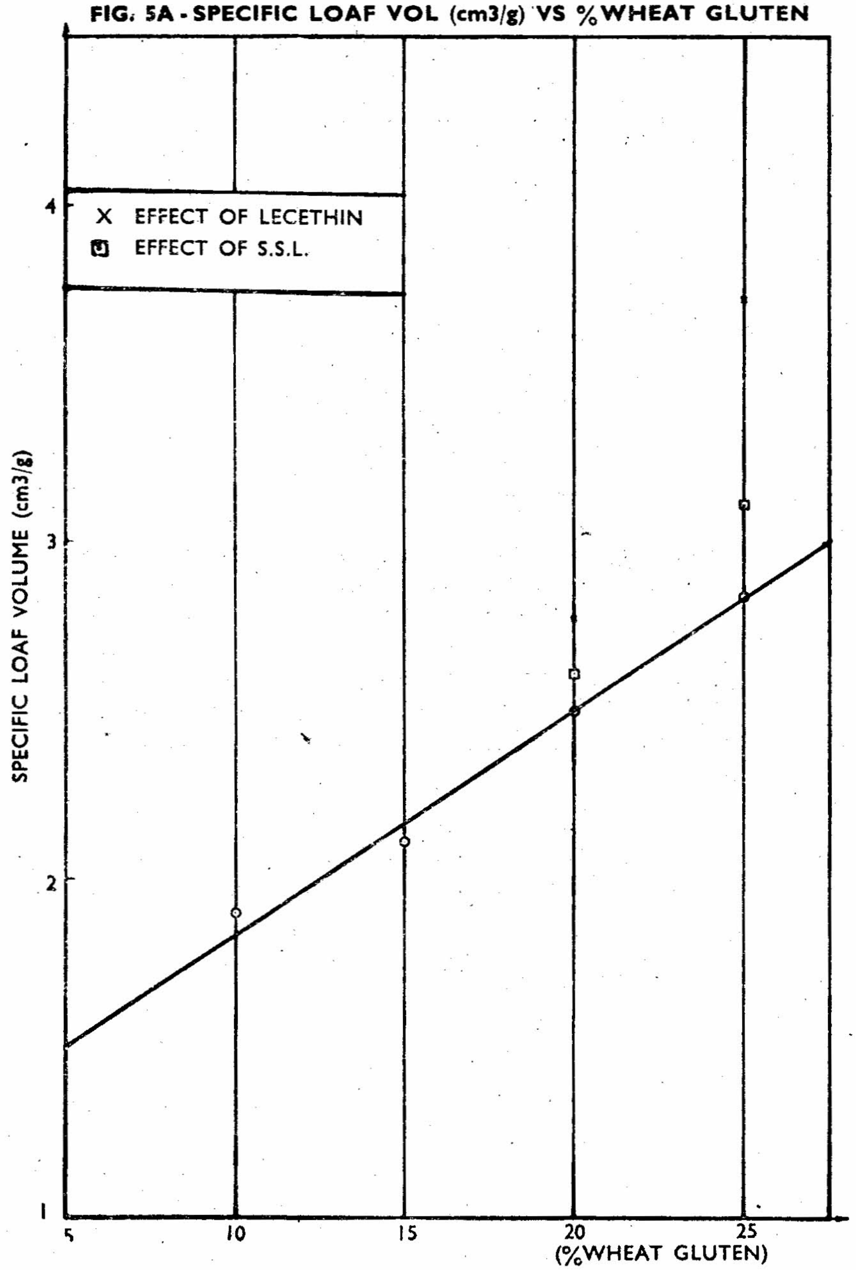


**Fig. 5A**—Specific loaf volume as a function of % wheat gluten (indicated by.) The effect of the addition of 0.5% (w/w) S.S.L. (indicated by.) and 0.5% lecithin (indicated by **x**).

**Table 2**

**Farinograph Absorption Values of Wheat Flour, 20% and 25% Wheat Gluten/Rice Flour Mixtures**

| | Dough Composition | Water Absorption (%) | Dough Development (mins) | Stability Time (mins) |
|---|---|---|---|---|
| 1. | Wheat Flour | 55 | 1.5 | 7.75 |
| 2. | 20% Gluten/Rice Flour | 65 | 11 | 6 |
| | | 70 | 15 | 11 |
| | | 75 | 19 | 11 |
| 3. | 25% Gluten/Rice Flour | 70 | 10 | 13 |

was seen to remain stable for a longer time. The effect of different added water percentages on 20% Gluten/rice farinograms is given in Table II. When 65% water was added to the 20% Gluten/rice mixture, it resulted in a less stable dough. The increase of water content to 75% in this mixture did not change the pattern of the curve very much but the dough handling properties became poor ie. the dough was sticky. Therefore for 20% Gluten/rice mixtures the suitable water absorption value was observed to be 70%.

**Amylograph studies**

Amylograph values and curves of wheat flour, rice flour and 20% Gluten/rice mixture are given in Table III and Fig. 2.

**Table 3**

**Amylograph Values for Wheat Flour, Rice Flour and Rice/Gluten Mixture**

| | Dough Composition | Maximum Viscosity (BU) | Pasting Temp. (°C) | Peak Temp. (°C) |
|---|---|---|---|---|
| 1. | Wheat Flour | 540 | 55.5 | 70.9 |
| 2. | Rice Flour | 1950 | 75.0 | 93.6 |
| 3. | 20% Gluten/Rice mixture | 1350 | 72.0 | 99.0 |

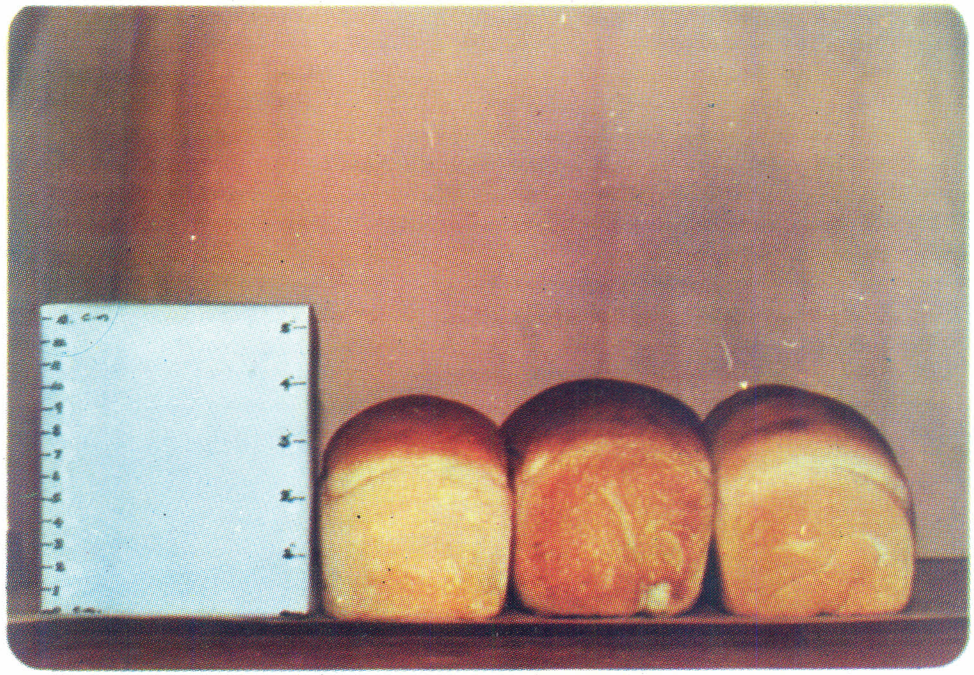

**Fig. 5B**—Bread baked from 20% wheat Gluten/rice flour (to the left), 25% wheat Gluten/rice flour (in the middle) and wheat flour. Both 20% and 25% wheat Gluten/rice flour doughs and 0.5% (w/w) lecithin.

Maximum viscosity value for pure rice flour (1950 BU) is very much higher than pure wheat flour (540 BU). This could be due to the low amylase activity in rice flour as compared to wheat flour. The pasting and peak temperature of pure rice flour are also much higher than wheat flour. The difference in these properties will give rise to difference in gelatinization properties in these two flours. The heating curve of 20% wheat Gluten/rice flour resemble that of rice flour. The addition of 20% gluten to rice flour slightly reduced the high viscosity of rice flour. On cooling, rice flour shows an unlimited increase in viscosity, while wheat Gluten/rice flour mix increases in viscosity and then levels off.

**Extensograph values**

The extensograph values and curves of wheat flour dough and 20% Gluten rice dough are given in Table IV and Fig. 3a and 3b).

**Table 4**

**Extensograph Values for Wheat Flour and Rice/Gluten Composite Flour Mixture**

| Dough | Resistance (BU) | | | Extensibility (cm) | | |
|---|---|---|---|---|---|---|
| Composition | 45 min | 90 min | 135 min | 45 min | 90 min | 135 min |
| 1 Wheat Flour | 260 | 365 | 460 | 19.0 | 16.5 | 17.0 |
| 2. Rice/Gluten Composite Flour | 480 | 660 | 740 | 9.0 | 8.0 | 8.0 |

The extensibility of the 20% Gluten/rice flour dough is very much lower (9 cm in 45 mins) than the wheat flour dough (19 cm in 45 mins) and the resistance of this dough (480 BU in 45 mins) is much higher than the wheat flour dough (260 BU in 45 mins). This shows that wheat Gluten/rice dough is a 'short' dough when compared to a wheat flour dough.

**Dough raising power**

The dough raising power of the 20% wheat Gluten/rice flour dough was compared with a wheat flour dough. The graph of dough height vs time is given in Fig. 4.

Both doughs rose at a steady rate for about one hour and the dough raising power of the wheat flour dough remains stable even after two hours but the wheat Gluten/rice flour dough collapses after two hours. After two hours the surface of the wheat Gluten/rice dough looks very porous and soft indicating the loss of gas retention power.

**Table 5**

**The Effect of Method of Mixing on the 20% and 25% Gluten/Rice Mixture**

**20% Wheat Gluten/Rice Mix**

| Method of Mixing | Hand Mixing | Mixing in Artofex Mixture | Mixing in Hobart Mixer |
|---|---|---|---|
| Loaf Volume (cc/g) | 1.5 | 1.8 | 2.5 |
| Crumb Characteristics | Not satisfactory | Not satisfactory | Satisfactory |
| **25% Wheat Gluten/Rice Mix** | | | |
| Loaf Volume (cc/g) | 1.7 | 2.0 | 2.8 |
| Crumb Characteristics | Not satisfactory | Not satisfaotory | Satisfaotory |

**Baking**

The effect of increasing levels of wheat gluten in increasing the specific loaf volumes of bread baked from a mixture of wheat Gluten and rice flour is given in Figure 5a and 5b. It is clear from these figures that the baking results of this wheat Gluten/rice flour mixture compares very well with the farinograph results. The loaf volumes and crumb characteristics of the bread made from 0-15% wheat Gluten and rice flour are not satisfactory at all. The dough having 20% wheat Gluten/rice mixture when mixed in the Hobart Planetary mixer (high speed) developed the elastic properties shown in a wheat flour dough. The conventional straight dough procedure when adopted for this mixture showed a deterioration of the structure of the dough and a simultaneous loss in gas retention power during the fermentation period. Therefore it was decided to use 100 ppm each of ascorbic acid and potassium bromate while omiting the fermentation step. These two chemicals being oxidizing agents strengthened the gluten structure. Table V gives the effect of method of mixing on the 20% and 25% Gluten/rice mix. The method of mixing was observed to be important in the development of the wheat Gluten/rice flour dough. Hand mixing did not give a properly developed dough with 20% or 25% wheat Gluten/rice mixture and the loaves were of inferior quality. The artofex mixing machine (a slow speed kneading machine) which is used for the mixing of a wheat flour dough did not give satisfactory results. Mixing in the high Hobart Planetary mixer gave a loaf with satisfactory loaf volume and crumb characteristics with mixtures having 20 and 25% wheat gluten and rice flour. The effect of polar lipids in two physical states on the quality of wheat gluten rice bread is presented in Table V I and Fig. 5. Lecithin in water gives a liquid crystalline lipid phase while sodium stearoyl-2-lactylate forms an aqueous gel phase n water. In both substitutions (20% and 25%wheat Gluten/rice) 0.5% lecithin had a better effect on loaf rolumes and crumb characteristics than 0.5% SSL. The effect of lecithin is more prominenton the 25% wheat Gluten/rice mixture (increase in loaf volume is 27.6%) than on the 20% wheat Gluten/rice mixture (increase in loaf volume is 12%). The figure 6 compares the 20% and 25% wheat Gluten/rice Flour loaves with a normal wheat loaf.

**Table 6**

**Effects of Polar Lipids in Two Physical States on the Quality of Wheat Gluten/Rice Bread**

| % Gluten | Additives | Phisical State of Additive | Specific Loaf Vol. | Crumb Characteristics |
|---|---|---|---|---|
| | No additive | — | 2.5 | Satisfactory |
| 20 | 0.5% SSL | Aqueous gel phase | 2.6 | Satisfactory |
| | 0.5% lecithin | Liposomal dispersion | 2.8 | Satisfactory |
| | No Additive | — | 2.8 | Satisfactory |
| 20 | 0.5% SSL | Aqueous gel phase | 3.1 | Satisfactory |
| | 0.5% lecithin | Liposomal dispersion | 3.7 | Satisfactory |

**Table 7**

**Effects of Polar Lipids in Two Physical States on the Quality of Wheat Gluten/Rice Bread**

| % Gluten | Additives | Physical State of Additive | Specific Loaf Vol. | Crumb Characteristics |
|---|---|---|---|---|
| | No additive | — | 2.5 | Satisfactory |
| 20 | 0.5% SSL | Aqueous gel phase | 2.6 | Satisfactory |
| | 0.5% lecithin | Liposomal dispersion | 2.8 | Satisfactory |
| | No Additive | — | 2.8 | Satisfactory |
| 20 | 0.5% SSL | Aqueous gel phase | 3.1 | Satisfactory |
| | 0.5% lecithin | Liposomal dispersion | 3.7 | Satisfactory |

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