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# QUALITY OF INDIAN WHEATS[1]

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**Summary**

Analytical, physical, chemical, and baking studies were performed on 43 samples, representing 30 spring wheat varieties harvested in India. Some high-yielding wheats and wheats recently introduced from Mexico were excellent bread wheats compared with a typical composite bread flour (RBS-70A) from wheats grown in the U.S. Water absorptions of India's wheats averaged materially above those of U.S.-grown varieties. Water absorptions of some of the semidwarf Mexican varieties were as high as 75 to 78%, and many indigenous Indian varieties had water absorptions above those of average U.S. wheats. Bread-baking quality of both Mexican and Indian varieties varied from excellent to poor; however, the Mexican varieties generally were better bread wheats.

THE INTRODUCTION IN 1966 of high-yielding spring wheats in India from the Centro Internacional de Mejoramiento de Maiz Y Trigo (CIMMYT) greatly changed the quantity and quality of Indian wheats. In 1971 one of those varieties, Kalyan Sona (known as Siete Cerros in Mexico) was planted on 75% of the Punjab, an important wheat-growing region of India. That variety has contributed most to India's increase in total wheat production, from about 12 to nearly 25 million metric tons between 1966 and 1971 (Fig. 1). During the last three years Modern Bakeries of India, Ltd., a government organization producing white pan bread, expanded at an estimated rate of 15% each year. The Indian milling industries are expanding and attempting to meet the quality needs of the breadmaking and biscuit (cookie) industries, while also satisfying traditional food needs.

With more than 550 million people to feed, India's national commitments to food production remain paramount. Thus production of wheat—second only to rice—is a primary commitment. Secondary wheat quality commitments are concerned with producing wheats that: a) have higher protein content, b) satisfy traditional food requirements (e.g., chapatties, puris, and paratas), c) satisfy the expanding breadmaking industry, and d) satisfy the expanding biscuit (cookie) industry.

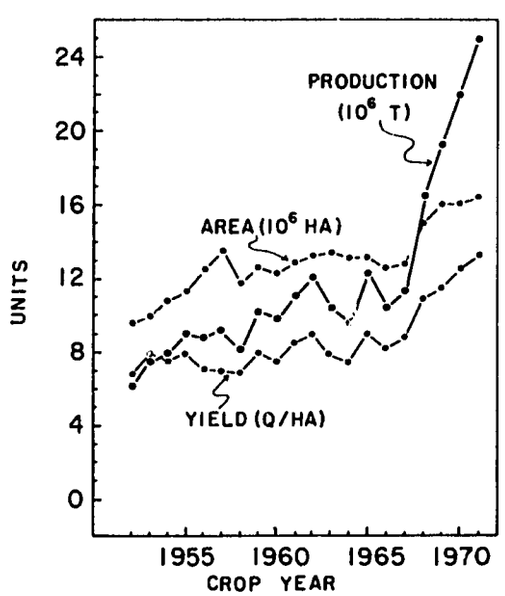


**Fig. 1. Production (million tons, -e-e-), area sown (million hectares, upper -o-o-), and yield (quintals per hectare, lower -o-o-) of wheat in India from 1952 through 1971.**

India's dependence on the quality characteristics introduced by those high-yielding, semidwarf, spring wheats was studied, using samples from two crop years and three breeding stations, at the Central Food Technological Research Institute, Mysore, India.

In the first detailed study of Indian wheat quality in 1940, Singh and Bailey (1) found high bushel and

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1,000-kernel weights, compared with spring and winter wheats grown in Minnesota. Average protein content of flours milled from the 1940 Indian wheats was only 9.6% (13.5% m.b.); but water absorptions were high, average of 31 samples, 72.6%.

From 1942 to 1947 studies on the quality of Indian wheats were conducted at the Punjab Agricultural College, Lyallpur, now in Pakistan. Those studies mainly involved assessing milling and baking quality and surveying protein contents. Many of the varieties had water absorptions of 75.0 to 82.0%, although average flour protein was comparatively low (2).

Bains and Irvine (3), more recently, reported that several Indian varieties yielded high percentages of straight-grade flour. However, their farinograph water absorptions were not exceptionally high.

Tara and Bains (4), studying the relation of starch damage and protein content to water absorption, found that starch damage contributed to high water absorptions of commercial Indian samples.

Sadisivan et al. (5), in taste panel tests, found no significant difference between chapatties made from wheats of Mexican (Sherbati Sonora and Sonalika) or Indian (K65 and C-306) parentage.

## Materials and Methods

Forty-three samples, representing 30 wheat varieties, were harvested in India at three breeding stations (Ludhiana, Karnal, and Niphad). A composite flour used as a standard, RBS-70A, represented several hard winter wheat varieties harvested at many locations throughout the Great Plains of the U.S. in 1969. That standard flour had a protein content of 12.3% (14% m.b.), a good loaf volume potential, and a medium-long mixing time of 4.25 min. Wheats were tempered to 13.5 to 15% moisture, depending on pearling value (hardness) and protein content, for 48 hr. before milling on a Buhler mill.

Hectoliter and 1,000-kernel weights were determined by standard methods (6). Protein, moisture, and ash contents were determined as described in AACC Methods (6). A straight-dough experimental baking procedure described by Finney and Barmore (7-10) was used. The method employed optimum mixing time and water absorption, and a formula that included: flour, 100 g.; sugar, 6 g.; salt, 1.5 g.; shortening, 3 g.; fresh baker's yeast, 2.25 g.; dry buffalo milk (whole), 4 g.; 60°L. malt syrup (Fleischmann's, U.S.A.), 0.5 g.; and $KBrO_3$, 4 mg.

The response of Indian varieties to potassium bromate was determined by a baking test using the AACC lean-baking formula (6) with and without 1 mg. potassium bromate.

Sedimentation tests were determined by the standard procedure (6). Mixograms were determined on 35 g. flour using farinograph water absorptions. Farinograms were obtained on 50 g. of flour and sufficient distilled water to be centered on the 500 B.U. line.

*Hectoliter and 1,000-Kernel Weights.* The 43 samples were conveniently divided into two groups, traditional Indian varieties or newly developed Mexican varieties.

TABLE I. MILLING, PHYSICAL, CHEMICAL, AND RHEOLOGICAL DATA FOR INDIAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

| | | Wheat | | | | Flour | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variety | Location[b] | 1000-Kernel Wt. g. | Hectoliter Wt. kg. | Protein % | Ash % | Yield % | Protein % | Ash % | Sedimentation | Farinograph Absorp. % |
| NI-917 | N | 47.1 | 81.8 | 11.9 | 1.33 | 60.7 | 11.1 | 0.51 | 29.0 | 66.4 |
| NI-917 | N | 44.3 | 81.3 | 13.9 | 1.44 | 65.2 | 12.7 | 0.48 | 29.0 | 68.5 |
| NI-5643 | N | 38.7 | 80.8 | 12.1 | 1.31 | 65.4 | 11.1 | 0.41 | 33.5 | 64.1 |
| NI-5643 | N | 36.6 | 83.5 | 14.5 | 1.25 | 68.6 | 13.1 | 0.39 | 32.5 | 66.9 |
| NI-5644 | N | 28.0 | 78.0 | 12.8 | 1.98 | 63.7 | 12.4 | 0.57 | 30.5 | 66.1 |
| NI-5644 | N | 39.0 | 82.0 | 13.8 | 1.35 | 74.0 | 12.6 | 0.47 | 31.0 | 67.6 |
| NI-5439 | N | 38.8 | 79.5 | 11.1 | 1.34 | 71.4 | 10.3 | 0.48 | 35.5 | 60.8 |
| NI-5439 | N | 39.3 | 81.8 | 12.9 | 1.26 | 73.9 | 12.8 | 0.45 | 34.5 | 60.9 |
| NI-747-19 | N | 37.8 | 79.3 | 11.3 | 1.36 | 69.0 | 10.4 | 0.51 | 36.5 | 62.0 |
| NI-747-19 | N | 33.0 | 78.3 | 13.1 | 1.37 | 73.6 | 12.1 | 0.48 | 36.5 | 59.5 |
| NI-7010 | N | 41.5 | 79.5 | 13.4 | 1.34 | 71.7 | 12.7 | ... | 31.0 | 67.6 |
| NI-7176 | N | 44.4 | 84.0 | 9.7 | 1.21 | 66.6 | 9.2 | ... | 29.0 | 69.7 |
| NI-7008 | N | 52.3 | 81.7 | 12.6 | 1.32 | 74.6 | 11.1 | ... | 24.0 | 61.9 |
| NI-5645 | N | 36.1 | 82.0 | 13.3 | 1.16 | 70.7 | 12.1 | 0.59 | 31.0 | 67.6 |
| NI-5642 | N | 38.0 | 83.7 | 13.4 | 1.24 | 66.4 | 12.6 | ... | 31.0 | 68.5 |
| NI-5641 | N | 40.3 | 81.7 | 13.5 | 1.28 | 74.2 | 12.9 | 0.47 | 31.0 | 69.7 |
| C-273 | L | 42.9 | 82.1 | 12.5 | 1.68 | 65.7 | 11.3 | 0.47 | 24.0 | 60.3 |
| C-306 | L | 42.2 | 80.9 | 10.9 | 1.45 | 66.4 | 9.8 | 0.45 | 25.0 | 65.1 |
| C-306 | L | 43.7 | 78.7 | 8.8 | 1.47 | 68.4 | 8.0 | ... | 20.0 | 61.1 |
| HD-1734 | K | 44.2 | 81.7 | 9.0 | 1.50 | 71.3 | 8.0 | 0.63 | 20.0 | 62.6 |
| NP-824 | K | 40.9 | 74.7 | 10.2 | 1.93 | 76.0 | 9.4 | 0.72 | 23.5 | 58.4 |
| NP-830 | K | 43.7 | 74.7 | 12.0 | 1.44 | 74.5 | 11.0 | 0.61 | 29.0 | 59.1 |
| NP-880 | K | 44.6 | 76.3 | 9.6 | 1.59 | 71.7 | 8.7 | 0.74 | 20.0 | 59.1 |
| NP-890 | K | 48.7 | 81.0 | 9.5 | 1.46 | 74.6 | 8.7 | 0.58 | 24.0 | 60.2 |
| RBS-70A | | | | | | | 12.3 | 0.39 | 46.0 | 60.1 |

[a]All data expressed on a 14% m.b.

[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.

TABLE II. MILLING, PHYSICAL, CHEMICAL, AND RHEOLOGICAL DATA FOR MEXICAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

| | | Wheat | | | | Flour | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variety | Location[b] | 1000-Kernel Wt. g. | Hectoliter Wt. kg. | Protein % | Ash % | Yield % | Protein % | Ash % | Sedimentation | Farinograph Absorp. % |
| S-308 | N | 36.8 | 81.0 | 11.2 | 1.45 | 70.6 | 9.8 | ... | 26.5 | 54.3 |
| S-308 | K | 40.6 | 71.7 | 12.4 | 1.72 | 74.8 | 11.2 | 0.68 | 31.5 | 59.0 |
| S-308 | L | 44.5 | 78.7 | 11.3 | 1.56 | 71.6 | 9.4 | 0.40 | 21.0 | 59.6 |
| PV-18 | L | 36.6 | 80.1 | 10.4 | 1.45 | 70.7 | 9.2 | 0.39 | 24.5 | 61.9 |
| S-307 | N | 38.4 | 77.5 | 10.4 | 1.27 | 70.0 | 9.3 | 0.39 | 20.5 | 49.0 |
| S-307 | N | 38.1 | 80.0 | 12.1 | 1.34 | 69.0 | 10.3 | 0.36 | 24.0 | 53.6 |
| S-331 | N | 36.2 | 80.5 | 12.5 | 1.34 | 66.9 | 11.1 | 0.42 | 26.0 | 54.8 |
| S-331 | N | 33.4 | 82.0 | 12.8 | 1.45 | 68.2 | 11.1 | 0.34 | 24.0 | 55.1 |
| HD-1941 | L | 38.6 | 77.2 | 11.7 | 1.62 | 68.6 | 10.3 | 0.49 | 28.0 | 59.8 |
| HD-1941 | K | 31.9 | 71.0 | 11.8 | 1.72 | 74.1 | 10.8 | ... | 28.5 | 56.9 |
| WL-212 | L | 33.3 | 74.7 | 12.2 | 1.70 | 67.4 | 10.6 | 0.44 | 32.0 | 61.0 |
| UP-301 | L | 40.8 | 76.6 | 11.7 | 1.52 | 68.2 | 10.2 | 0.50 | 25.0 | 57.9 |
| WG-377 | L | 35.6 | 77.7 | 11.2 | 1.47 | 67.8 | 10.1 | 0.50 | 25.0 | 63.5 |
| WG-357 | L | 40.5 | 79.1 | 12.2 | 1.52 | 69.2 | 11.0 | 0.46 | 26.5 | 61.0 |
| Pusa Lerma | K | 33.6 | 75.3 | 9.5 | 1.72 | 70.7 | 8.3 | ... | 23.0 | 48.0 |
| Sharbati Sonora | K | 29.0 | 75.0 | 11.1 | 1.77 | 75.1 | 10.2 | ... | 27.5 | 54.2 |
| Kalyan Sona | L | 29.5 | 73.6 | 12.3 | 1.75 | 68.7 | 11.1 | 0.47 | 31.0 | 63.8 |
| Kalyan Sona | N | 37.8 | 82.0 | 11.5 | 1.23 | 68.1 | 10.4 | 0.35 | 30.0 | 68.6 |
| Kalyan Sona | K | 36.1 | 77.7 | 9.4 | 1.69 | 74.7 | 8.3 | 0.70 | 24.5 | 63.3 |
| RBS-70A | | | | | | | 12.3 | 0.39 | 46.0 | 60.1 |

[a]All data expressed on a 14% m.b.
[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.

Hectoliter weights of the Indian wheats were approximately the same as average hard winter and spring wheat varieties grown in the U.S. (Tables I and II). The Indian wheats averaged 79.0 kg. per hectoliter (63.2 lb. per bu.) and ranged from 73.6 to 83.3 kg. per hectoliter (59.0 to 67.5 lb. per bu.). Their 1,000-kernel weights ranged from 28.0 to 52.3 g. and averaged 39.3 g., considerably higher than the average of hard winter and spring wheats grown in the U.S.

*Wheat and Flour Protein.* Flour protein ranged from 8.0 to 13.3%; average for the 43 samples was 10.7% (Tables I and II). Average flour protein content was 1.03% less than the average of the corresponding wheats (Tables I and II).

*Buhler-Milling Properties.* Despite large differences in hardness and milling characteristics, reasonable flour yields were obtained from most of the wheats (Tables I and II). Certain samples from Niphad were extremely hard and tended to stay in the form of "semolina" during milling. With the limited reduction capacity of the mill, the flow was altered to reduce those varieties to traditional flour size of 10XX. That was accomplished by removing the 46SS and 72SS fine bran and shorts sieves on the reduction side, thereby increasing the number of reductions to which the granular material was subjected. As flour yield increased, however, so did flour ash content.

*Sedimentation Values.* Sedimentation values for the Indian wheats varied from 20.5 to 36.5 cc., and averaged a relatively low 27.5 cc. (Tables I and II). Despite the good-to-excellent loaf-volume potential of certain Indian wheat flours, sedimentation values failed to reflect that potential. Average bread wheat flours in U.S. would be expected to have sedimentation values comparable to the 46.0 cc. of the RBS-70A. The correlation coefficients for sedimentation value versus loaf volume and for sedimentation value versus flour protein were $r=0.568$ and $r=0.548$ ($p<0.001$), respectively.

*Wheat and Flour Ash.* Wheat ash content varied from 1.16 to 1.93%, and averaged 1.46% for the 43 samples tested. Flour ash varied greatly, as might be expected, because the study included soft, medium, and hard wheat varieties (Tables I and II).

*Rheological Properties.* Selected mixograms from both the Indian and the Mexican varieties are reproduced in Figs. 2 and 3, respectively (except that S-331 in Fig. 2 is Mexican). Kalyan Sona, the most important commerical variety in India, is pictured with the other varieties of Mexican background. Note the low mixing tolerance of all the Indian varieties, except for NP-830 (Fig. 2). In contrast, most the Mexican varieties (Fig. 3) have mixing tolerances comparable to that of the standard flour RBS-70A.

Particularly noteworthy are the water absorption and flour protein data for all 43 samples (Fig. 4). The regression line for RBS-70A represents the breadmaking absorption level of hard winter wheat varieties grown in the U.S. Seventy-four percent of the Mexican varieties (●) and 96% of the Indian varieties (o) had absorptions above the RBS-70A regression line. Water absorptions of the Mexican Kalyan Sona samples (x) exceed water absorptions of most of the varieties tested, especially when considered on a constant protein basis. Mean water absorption values were in decreasing order: Kalyan Sona (73.2%), Indian varieties (70.3%, Table III), Mexican varieties (62.5%, Table IV). On

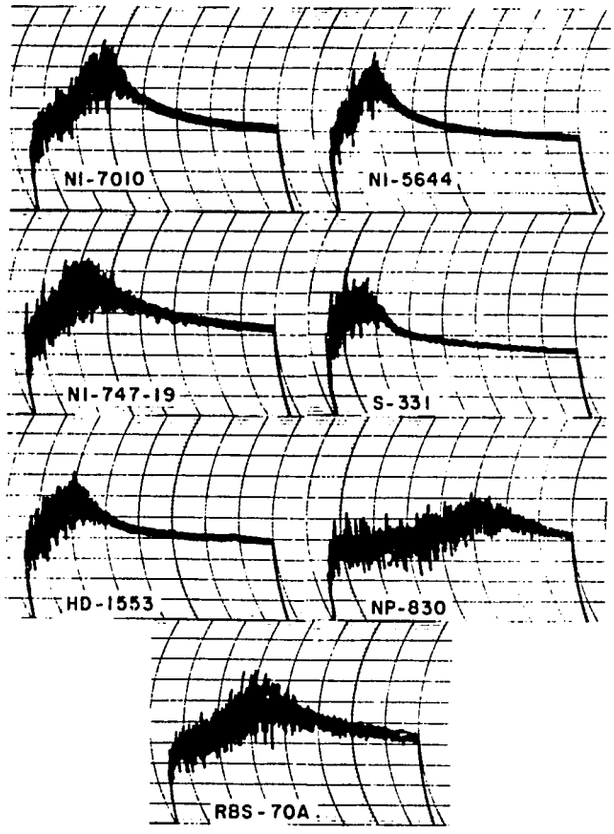


Fig.2. Mixograms of Indian wheat varieties.

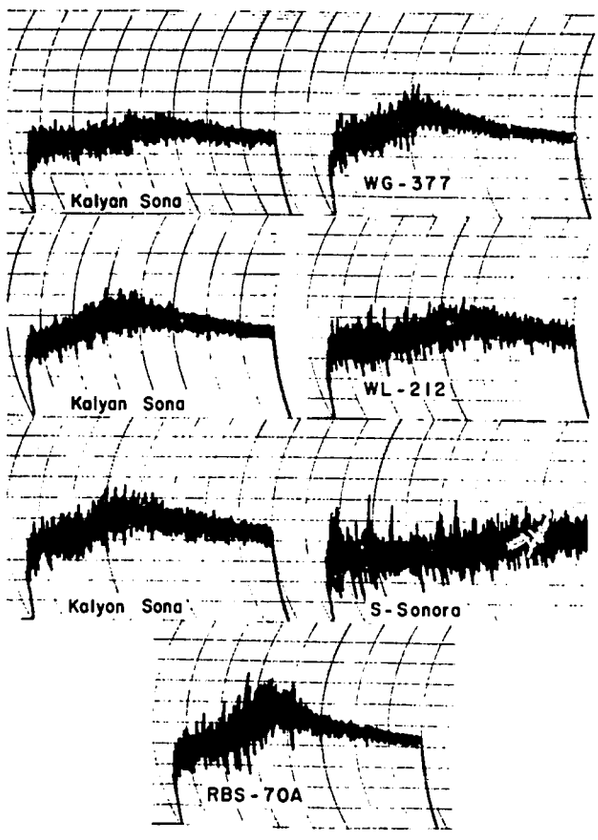


Fig. 3. Mixograms of Mexican wheat varieties grown in India. The three mixograms for Kalyan Sona are for samples grown in three different locations.

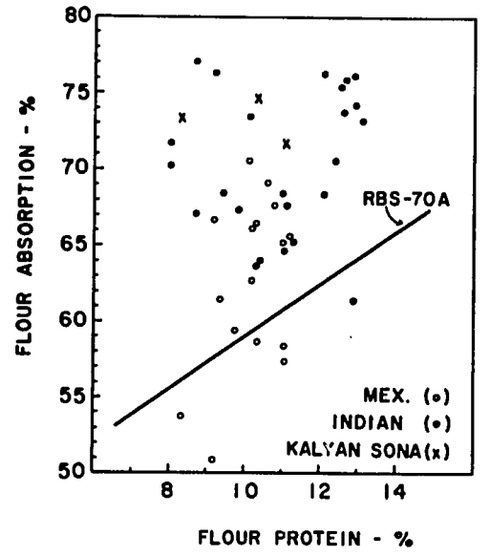


Fig. 4. Flour protein versus baking absorption. The line for RBS-70A represents the flour protein versus baking absorption regression line for an average of U.S.-grown bread wheats.

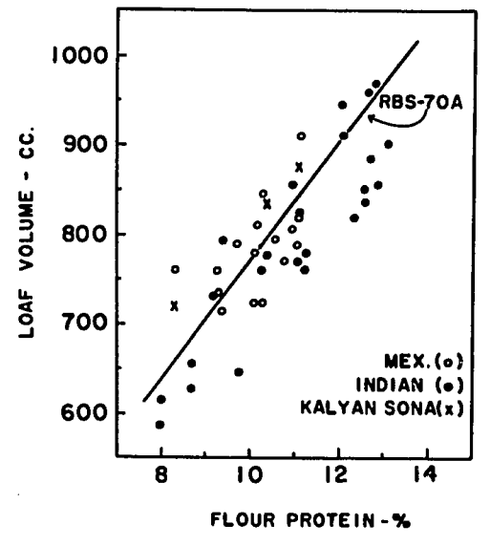


Fig. 5. Flour protein versus loaf volume. The line for RBS-70A represents the flour protein versus loaf volume (regression line) for an average of U.S.-grown bread wheats.

a constant protein basis, however, even the mean absorption of the Mexican varieties would appreciably exceed that of RBS-70A. Although Kalyan Sona had the highest average water absorption, it also had the lowest average protein content, 9.9%.

Those high water absorptions of most varieties deserve further investigation. It may be that the varieties are genetically so constituted, or it may be that Indian growing conditions contribute to producing kernel endosperms that are more susceptible to starch damage during milling. The relation of starch damage and protein content to water absorption of those samples has been published elsewhere (11). Most of the varieties tested were exceptionally hard. Earlier work by Tara and Bains (4) indicated that starch damage contributed to high water absorptions of the Indian commercial samples tested.

TABLE III. BREADMAKING DATA FOR INDIAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

| Variety | Location[b] | Flour Protein % | Breadmaking Absorption % | Mixing Time min. | Loaf Volume cc. | Regr. Coeff.[c] |
|---|---|---|---|---|---|---|
| NI-917 | N | 11.1 | 73.4 | 4.375 | 770 | 58.0 |
| NI-917 | N | 12.7 | 74.9 | 2.500 | 885 | 60.5 |
| NI-5643 | N | 11.1 | 67.6 | 5.375 | 770 | 58.0 |
| NI-5643 | N | 13.1 | 73.1 | 3.375 | 900 | 59.5 |
| NI-5644 | N | 12.4 | 70.6 | 4.000 | 820 | 55.0 |
| NI-5644 | N | 12.6 | 72.7 | 2.375 | 835 | 55.5 |
| NI-5439 | N | 10.3 | 63.7 | 6.000 | 760 | 63.0 |
| NI-5439 | N | 12.8 | 61.3 | 3.875 | 970 | 68.0 |
| NI-747-19 | N | 10.4 | 64.0 | 4.875 | 775 | 64.0 |
| NI-747-19 | N | 12.1 | 68.3 | 4.250 | 945 | 71.0 |
| NI-7010 | N | 12.7 | 75.7 | 3.875 | 960 | 68.0 |
| NI-7176 | N | 9.2 | 76.3 | 5.500 | 730 | 68.0 |
| NI-7008 | N | 11.1 | 64.7 | 1.500 | 825 | 65.0 |
| NI-5645 | N | 12.1 | 76.2 | 4.750 | 910 | 67.0 |
| NI-5642 | N | 12.6 | 74.7 | 3.000 | 850 | 57.0 |
| NI-5641 | N | 12.9 | 74.1 | 2.125 | 855 | 56.0 |
| C-273 | L | 11.3 | 65.3 | 4.000 | 760 | 55.0 |
| C-306 | L | 9.8 | 67.3 | 3.500 | 645 | 49.5 |
| C-306 | L | 8.0 | 70.1 | 5.875 | 585 | 53.0 |
| HD-1734 | K | 8.0 | 71.6 | 4.750 | 615 | 59.0 |
| NP-824 | K | 9.4 | 68.4 | 14.250 | 790 | 74.0 |
| NP-830 | K | 11.0 | 68.3 | 9.000 | 855 | 69.5 |
| NP-880 | K | 8.7 | 67.1 | 7.000 | 625 | 56.0 |
| NP-890 | K | 8.7 | 77.0 | 26.500 | 655 | 61.5 |
| Mean (All Indian Samples) | | 11.0 | 70.3 | | | 61.3 |
| RBS-70A | | 12.3 | 63.2 | 4.250 | 925 | 67.5 |

[a]Data expressed on a 14% m.b.
[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.
[c]Loaf volume vs. flour protein content.

TABLE IV. BREADMAKING DATA FOR MEXICAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

| Variety | Location[b] | Flour Protein % | Breadmaking Absorption % | Mixing Time min. | Loaf Volume cc. | Regr. Coeff.[c] |
|---|---|---|---|---|---|---|
| S-308 | N | 9.8 | 59.4 | 3.500 | 790 | 71.0 |
| S-308 | K | 11.2 | 65.6 | 4.750 | 910 | 74.0 |
| S-308 | L | 9.4 | 61.4 | 2.000 | 715 | 63.0 |
| PV-18 | L | 9.2 | 66.7 | 4.250 | 730 | 68.0 |
| S-307 | N | 9.3 | 50.2 | 2.625 | 760 | 71.0 |
| S-307 | N | 10.3 | 58.7 | 1.875 | 845 | 74.0 |
| S-331 | N | 11.1 | 57.4 | 2.125 | 820 | 64.0 |
| S-331 | N | 11.1 | 58.3 | 1.750 | 790 | 60.5 |
| HD-1941 | L | 10.3 | 66.4 | 4.875 | 725 | 58.0 |
| HD-1941 | K | 10.8 | 67.7 | 11.500 | 770 | 60.0 |
| WL-212 | L | 10.6 | 69.0 | 5.875 | 759 | 65.0 |
| UP-301 | L | 10.2 | 62.7 | 4.250 | 725 | 59.0 |
| WG-377 | L | 10.1 | 70.5 | 4.875 | 780 | 68.0 |
| WG-357 | L | 11.0 | 65.2 | 4.500 | 805 | 63.0 |
| Pusa Lerma | K | 8.3 | 53.9 | 4.125 | 760 | 83.0 |
| Sharbati Sonora | K | 10.2 | 66.2 | 20.000 | 810 | 70.5 |
| Kalyan Sona | L | 11.1 | 71.6 | 4.750 | 875 | 71.0 |
| Kalyan Sona | N | 10.4 | 74.6 | 3.125 | 835 | 72.0 |
| Kalyan Sona | K | 8.3 | 73.3 | 7.000 | 725 | 76.0 |
| Mean (Kalyan Sona only) | | 9.9 | 73.2 | | | 73.0 |
| Mean (All Mexican Samples) | | 10.1 | 62.5 | | | 67.9 |
| RBS-70A | | 12.3 | 63.2 | 4.250 | 925 | 67.5 |

[a]All data expressed on a 14% m.b.
[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.
[c]Loaf volume vs. flour protein content.

*Breadmaking Quality.* Loaf volume potential (protein quality) of wheat varieties can be evaluated after plotting their protein contents and bread loaf volumes. When using an optimized bake test, the relation between flour protein content and loaf volume is essentially linear within a variety. Because the slopes of their loaf volume-protein content regression lines represent differences in loaf volume per unit of protein, quality differences between wheat varieties can be assessed simply by referring to the regression coefficients.

*Experimental Baking.* The mean regression coefficient for loaf volume and flour protein content of the Mexican varieties grown in India equals that of RBS-70A (Table IV). It is most significant that the samples of Kalyan Sona (r=73.0), presently grown on more than 75% of an important wheat-growing region, significantly outperformed RBS-70A (r=67.5). Kalyan Sona is equally desirable from the point of view of milling characteristics, dough-handling properties, and machinability.

The RBS-70A regression line for loaf volume and flour protein (Fig. 5) divides the Mexican varieties into two groups, with eight varieties above the line and eight below. All three samples of Kalyan Sona (x) lie above the RBS-70A line; while 18 of 24 Indian varieties lie below the RBS-70A regression line.

*New High-Yielding Varieties Not Yet Released.* Among the new, unreleased, high-yielding, spring wheat varieties tested, WG-377, WL-212, and WG-357 were the most promising bread varieties. Their loaf volume-protein content regression coefficients were 68.0, 65.0, and 63.0, respectively. Two of those varieties (WG-377 and WL-212) had above-average water absorptions of 70.5 and 69.0%. All three varieties had excellent dough-handling properties and were easily machined.

Those varieties have been released to Indian farmers for cultivation. It is, of course, highly important that high-yielding varieties other than Kalyan Sona be commercially planted. If the rust resistance of Kalyan Sona should fail sometime in the future, before other desirable varieties were introduced, the annual production of wheat could be drastically reduced.

*Potassium Bromate Response.* Earlier work in India indicated that some Indian varieties did not respond to potassium bromate[4]. Potassium bromate responses varied from negligible to extremely high among the 43 samples.

In 1971, varieties C-273 and Kalyan Sona (S-227) from Ludhiana, and Kalyan Sona (S-227) from Niphad, responded moderately to potassium bromate-approximately

[4]Personal communication from G. S. Bains, CFTRI, Mysore, India.

35 cc. per loaf. The same year NI-5644, S-308, and NI-5642 from Niphad, and Kalyan Sona (HD-1593) from Karnal, had medium responses of 50, 60, 40, and 45 cc., respectively. Varieties NI-5645 and NI-5641 from Niphad, and WG-377 from Ludhiana, had high-bromate responses of 90, 115, and 80 cc., respectively. In all cases the response to potassium bromate was measured by the AACC (6) lean-baking formula with and without 1 mg. potassium bromate.

*Future of Bread Wheats in India.* It appears that the primary commitment to produce more wheat and the secondary commitment to produce wheats of desirable quality characteristics (functional properties) that satisfy traditional as well as more recent food requirements are being met by concerned Indians. Studies in New Delhi indicate that the recently introduced Mexican varieties are suitable for traditional food products such as chapatties, puris, and paratas (5). Thus, with wheat production in India approaching self-sufficiency and with bread and cookie wheat flours more available, it appears that the commitment to increase the percentage of protein in the major commercial wheat varieties is now as important as continuing to meet total wheat production needs. Even a modest increase of 0.5 to 1% in protein (raising the average from about 10 to 10.5 or 11%) would make available an additional 125 to 250 thousand metric tons of that body-building material so vital to physical and mental health.


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