Cereal Chemistry

Vol. 53 July-August 1976 No. 4

BRABENDER FARINOGRAPH, RESEARCH EXTENSOMETER, AND HILLIFF CHAPATTI PRESS AS TOOLS FOR STANDARDIZATION AND OBJECTIVE ASSESSMENT OF CHAPATTI DOUGH

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ABSTRACT Cereal Chemistry 53(4): 457-469

The successful use of the Brabender Farinograph®, Henry Simon Research extensometer, and Hilliff chapatti press for standardization and objective evaluation of chapatti doughs based on 93–95% extraction wheat flour (*atta*) has been demonstrated. With a 50-g mixing bowl in lever position 1:3 of the farinograph, water absorption (%) and mixing time for any wheat flour could be determined by running a farinogram at the optimum dough consistency of 500 ± 20 BU. Optimum conditions for preparation of a chapatti dough were: 1 min of initial mixing, followed by a 5-min rest period, and final mixing until 1–2 min after the chapatti dough had attained the maximum consistency. The rolling characteristics of chapatti dough, as reflected by its stretching and spreading properties, could be objectively evaluated using the extensometer and the chapatti press, respectively. The farinograph-mixed dough could be rolled into chapatties immediately, thereby avoiding the conventional rest period of about 1 hr. Based on the standard doughs thus obtained, the chapatti-making quality of six varieties of Indian aestivum wheats was evaluated.

Like bread in the West, chapatti or *roti* is a traditional food item in the diets of nearly 700 million people of the Indian subcontinent. More than 80% of the total wheat production of about 25 million tons is milled in small disk grinders (locally known as *chakkis*) into whole wheat flour. For chapatti-making in the household, whole-wheat flour (locally known as *atta*) is first made into a dough of somewhat stiffer consistency than bread dough. This dough is rested for about 1 hr, rolled to the desired shape (circular or triangular), size, and thickness (about 2 to 3 mm), and baked on a hot iron plate or live coal fire.

Standardization of chapatti dough has assumed considerable importance on the Indian subcontinent, where a few thousand persons lunch every day in big hotels and industrial canteens. Further, Modern Bakeries (India), with an annual turnover of more than 100 million loaves of bread, is planning large-scale production of chapatties. Traditionally, the quantity of water required for the

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preparation of a chapatti dough is determined only by trial and error. Though Austin and Ram (1) have studied the chapatti-making quality of Indian wheat varieties, no published information is available on objective methods of standardization and evaluation of chapatti dough. Such information would be of great practical use in partly or fully mechanizing the chapatti-making process. The results of studies carried out on the standardization and evaluation of chapatti doughs, and the chapatti-making quality of Indian aestivum wheats, are reported here.

MATERIALS AND METHODS

Preparation of *Atta*

Six varieties of Indian wheats, Chhoti Lerma, Sharbati Sonora, Sonalika, Kalyan Sona, K-68, and Punjab (Commercial), procured from the Indian Agricultural Research Institute, New Delhi, were used in these studies. Wheat samples were ground in a Kamas laboratory hammer mill (SLAGY, Sweden) using an 0.8-mm sieve. The whole-wheat flour obtained was then passed through a 40-mesh sieve to remove coarse bran particles. The resulting *atta* was of 93–95% extraction.

Chemical Analysis

Moisture, protein, total ash, diastatic activity, starch damage, and total sugars in different *atta* samples were estimated according to AACC methods (2).

Effect of Salt on Chapatti Dough

Before initiating studies on objective evaluation of chapatti dough, it was necessary to determine the optimum level of salt, traditionally added in home-scale preparation for taste as well as desirable handling and rolling characteristics. Doughs containing 0.0, 0.5, 1.0, 1.5, and 2.0% salt were prepared in a laboratory Hobart mixer (Model N-50) and evaluated for their consistency by hand-feel and rolling behavior. Chapatties baked from these doughs were tested for acceptability.

Adjustment of Brabender Farinograph

To assess the consistency of bread doughs, a farinograph (model SEW) with a 50-g mixing bowl is generally used in lever position 1:1. Shurpalekar and Venkatesh (3) used the farinograph in lever position 1:3 for objective evaluation of *papad* doughs based on blackgram (*Phaseolus mungo*). As chapatti doughs are somewhat stiffer than bread doughs but softer than papad doughs, it was necessary to determine the consistency of chapatti doughs in lever positions 1:1 and 1:3.

The aim of these experiments was to have the consistency variations of doughs recorded in the range of 400–600 BU to facilitate comparative studies on different wheat varieties.

Kneading Trials on the Farinograph

Several preliminary trials were carried out on the farinograph in lever position 1:3 (better suited than lever position 1:1) to arrive at the optimum levels of water addition and mixing time for the preparation of chapatti dough of desired

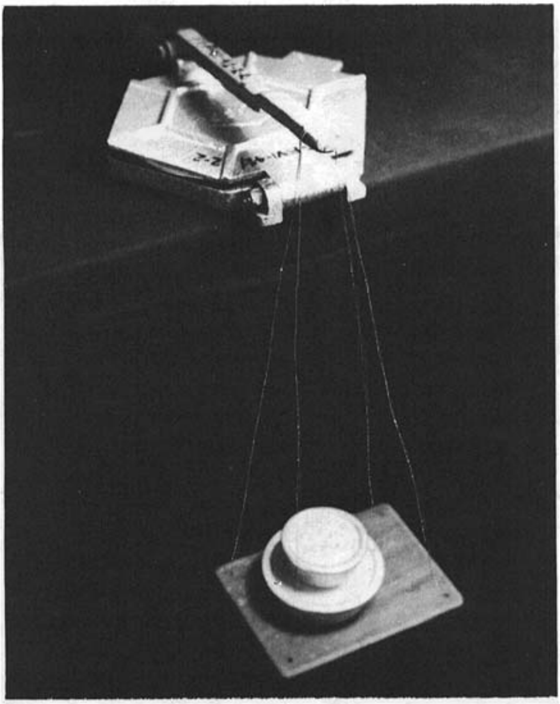

Fig. 1. Hilliff chapatti press with hanging weights (dough ball being pressed is not visible).

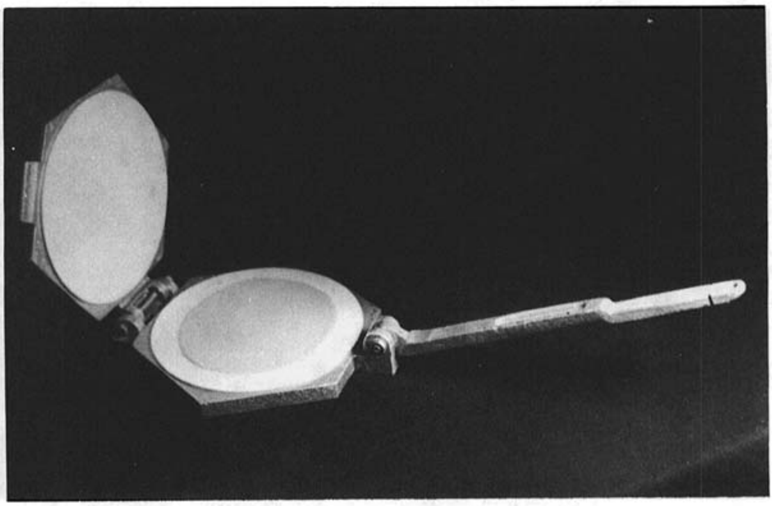

Fig. 2. Hilliff chapatti press after removing weights and opening the lid. (Pressed, circular chapatti sheet is seen.)

characteristics. Criteria like hand-feel (stiff or soft), stickiness, and ease of rolling into a sheet formed the basis for evaluation of the dough characteristics. In all the following experiments, a 50-g sample of *atta*, 0.75 g of common salt, and the same quantity of water were used for preparation of the dough.

Continuous Mixing

Continuous mixing was tried for periods ranging from 1 to 10 min.

Mixing with Rest Period

Bread doughs evaluated on the Brabender Extensograph were generally rested for 5 min (after initial mixing) for proper hydration of gluten. Similarly, chapatti doughs were given rest periods of 5, 10, or 15 min after initial mixing for 1, 2, or 3 min. This was followed by final mixing periods of 1–10 min for optimum gluten development, as indicated by maximum consistency. The optimum mixing time for different *atta* samples was calculated from the farinograph curve. This included initial and final mixing periods so as to obtain doughs of desirable characteristics.

Optimum Consistency of Chapatti Dough

Atta samples from six varieties of wheats were included in this study. Chapatti doughs with consistencies of 400, 450, 500, 550, and 600 BU were prepared by adding required quantities of water and using mixing conditions standardized from the above trials. Based on the evaluation of different doughs, and using the criteria of hand-feel and rolling characteristics, the optimum consistency (BU)

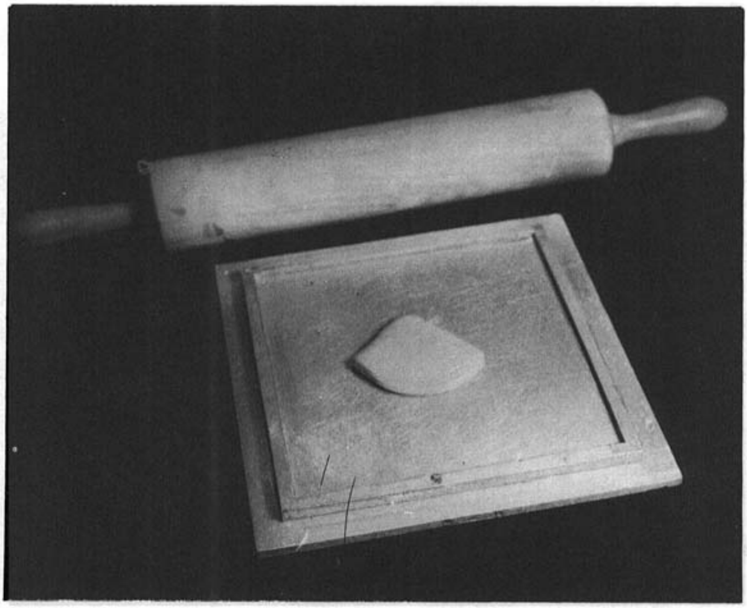

Fig. 3. Wooden rolling pin and aluminum platform fitted with detachable square aluminum frame for maintaining uniform thickness of chapatti.

for chapatti dough was determined. The quantity of water required for obtaining doughs of optimum consistency was determined for different wheat varieties.

Effect of Mixing Method

Generally, Hobart-type mixers are used for large-scale preparation of chapatti doughs. For objective comparison of the effect of mixing methods, doughs were prepared both in farinograph and laboratory-Hobart mixers, using the same quantity of water and the same mixing time. The rolling characteristics, which mainly depend on the stretching and spreading properties, were determined for these doughs.

A Henry Simon Research extensometer was used for comparing the stretching property of the doughs. The extensibility, resistance, and overall strength of the doughs as expressed by the area under different extensometer curves were determined according to standard procedure.

A Hilliff chapatti press (Figs. 1 and 2) was used for evaluating spreading quality. A 20-g spherical ball of chapatti dough was placed in the center of the Teflon-coated platform of the chapatti press. The lid portion with handle was then brought down and pressure was applied by attaching a known weight of 9 lb as indicated in Fig. 1. The dough (Fig. 2) was pressed for a 5-min period, and its spread was traced on a graph sheet so the area could be calculated.

Water Requirement for Hobart-Mixed Doughs

Hobart-mixed doughs containing the same quantity of water as farinograph-mixed doughs were comparatively stiff and difficult to roll. Therefore, it was necessary to add extra water to obtain a Hobart-mixed dough with a consistency comparable to that of farinograph-mixed doughs. The same mixing time was used, plus 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0% extra water, when chapatti doughs were prepared from different *atta* samples. A weighed quantity of Hobart-mixed dough, equivalent to that of farinograph-mixed dough based on a 50-g *atta* sample, was immediately transferred to the farinograph mixer and its consistency recorded on the farinograph. The level of extra water required for Hobart-mixed dough to attain optimum consistency was determined.

Preparation and Evaluation of Chapatti

To evaluate the chapatti-making quality of different wheat varieties, doughs were prepared in the 50-g mixing bowl of the farinograph. The desired quantity

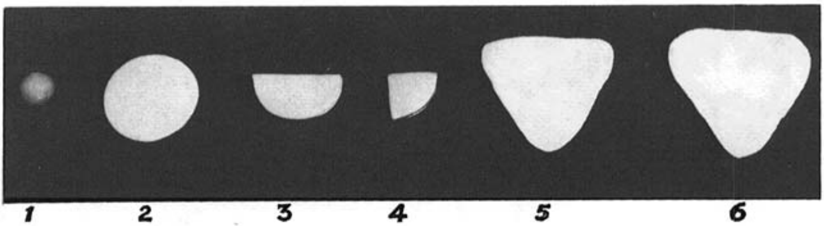

Fig. 4. Different stages of chapatti preparation. 1) Dough ball, 2) circular sheet, 3) first folding, into a semi-circle, 4) second folding, into a quadrant, 5) unbaked triangular chapatti, and 6) baked chapatti.

of water was added so as to obtain doughs of optimum consistency. From this dough, 35 g was rounded and placed in the center of an aluminum platform specially fabricated to maintain uniform thickness of the chapatti (Fig. 3). This dough was rolled with a wooden rolling pin into a circular sheet of 10–12 cm diameter and 1.5 mm thickness. The sheet was folded into a semi-circle, and then into a quadrant which on rolling gave a triangular-shaped chapatti with sides of about 18 cm. Refined vegetable oil was used for greasing the surface during each folding to facilitate formation of discrete laminations during baking. The chapatti was then baked for 3–4 min at 350° F on a thermostatically controlled hot plate. The baked chapatti was kept in a stainless-steel container with the lid slightly open. This facilitated cooling of chapatti without excessive loss or condensation of moisture inside the container. The different stages of operation in the preparation of chapatties are shown in Fig. 4.

Based on the quality criteria of texture (pliability, stiffness or softness, surface smoothness), number of discrete laminations (Fig. 5), and eating quality (soft or leathery chewing quality and flat or sweetish taste), the chapatties from different wheat varieties were evaluated by a panel of six judges. For determining the overall acceptability, texture and eating quality were given preference over number of laminations. Different chapatties were thereby graded as excellent, good, satisfactory, fair, and poor.

RESULTS AND DISCUSSION

Chemical Composition of *Atta*

The data on some of the important chemical characteristics are given in Table I. The protein content of different *atta* samples ranged between 8.8 and 11.5% as against the desirable range of 10–13% for chapatties, as reported by Austin and Ram (1). Total sugars, which reflect the sweetish taste characteristics of chapatties, were within the normal range of 2–5% (1) and were comparatively higher for varieties *Kalyan Sona, K-68,* and *Punjab*.

Values of diastatic activity were considerably lower than those reported by Sinha *et al.* (4). This may be attributed to the difference in the severity of

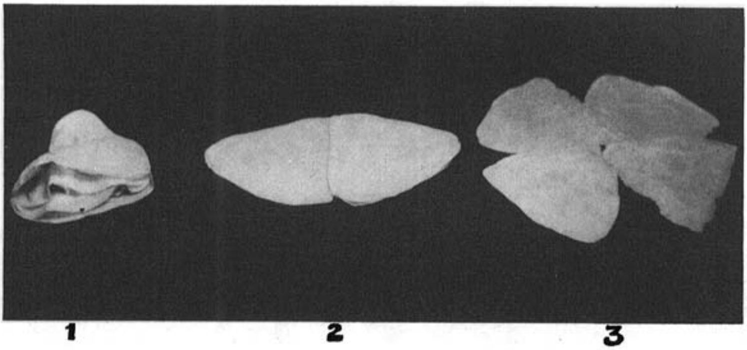

Fig. 5. Discrete laminations of chapatti. 1) Four laminations of a chapatti (made visible by inserting paper balls), 2) chapatti opened like a book (showing two laminations on the right), and 3) chapatti fully opened out (showing four separated laminations).

grinding, which results in varying degrees of starch damage, which in turn influences diastatic activity considerably. On the Indian subcontinent, wheat is mostly ground in small disk mills where as much as 10% starch damage has been observed.[2] The varieties of wheat used in the present studies were ground in a hammer mill, and for all the *atta* samples, starch damage of less than 7% was observed.

Effect of Salt

Increase in salt level was found to increase the water absorption and stiffness of the dough. Use of 2.0% salt resulted in a chapatti dough which was somewhat difficult to roll, and yielded chapatties with a salty taste. On the other hand, dough containing no salt or 0.5% salt was short and weak, with poor rolling characteristics and flat taste. Eating quality of the chapatti was optimum at the 1.0 or 1.5% level of salt addition. However, the dough containing 1.5% salt was relatively softer to hand-feel and had better rolling characteristics.

[2]Unpublished data, Shurpalekar *et al.*

TABLE I
Chemical Composition[a] of *Atta* from Six Varieties of Indian Wheats

Variety	Moisture %	Protein (N × 5.7) %	Total Ash %	Diastatic Activity mg/10 g	Total Sugars mg/10 g	Damaged Starch %
Chhoti Lerma	7.8	8.8	1.41	126	188	2.8
Sharbati Sonora	8.6	11.1	1.41	156	282	4.9
Sonalika	7.8	11.5	1.30	170	254	4.8
Kalyan Sona	7.6	8.9	1.30	234	342	6.6
K-68	8.8	10.7	1.29	166	346	6.8
Punjab (Commercial)	8.6	9.6	1.33	171	344	5.0

[a]On a 14% moisture basis.

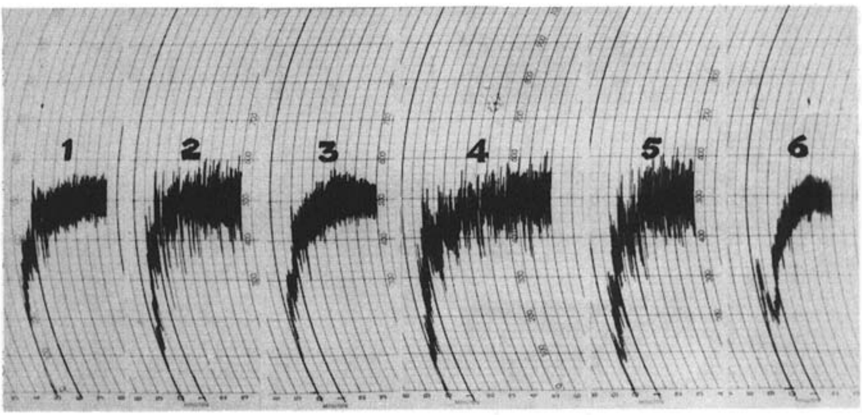

Fig. 6. Farinograph curves for chapatti doughs from different wheats. 1) Chhoti Lerma, 2) Sharbati Sonora, 3) Sonalika, 4) Kalyan Sona, 5) K-68, and 6) Punjab (Commercial).

TABLE II
Spread Characteristics of Chapatti Doughs from Farinograph and Hobart Mixers

Wheat Variety	Water Absorption		Mixing Time[b] min	Thickness of Chapatti		Area Spread of Chapatti		Difference in Area Spread %
	Farinograph dough %	Hobart dough[a] %		Farinograph mixer mm	Hobart mixer mm	Farinograph mixer sq cm	Hobart mixer sq cm	
Chhoti Lerma	50.0	51.6	3.0	1.58	2.18	113	93.0	21.5
Sharbati Sonora	53.0	55.4	5.0	1.75	1.92	119	95.8	24.1
Sonalika	53.0	55.8	3.0	1.00	1.84	139	113.0	22.4
Kalyan Sona	51.0	54.0	3.5	1.55	2.05	123	95.8	28.2
K-68	53.0	56.0	5.0	2.26	2.23	112	86.6	29.7
Punjab (Commercial)	57.0	59.0	2.0	0.80	1.00	155	126.3	22.7

[a]Required 1.5–3.0% more water than farinograph doughs to attain the desired consistency of 500 BU.
[b]Mixing time was the same for both farinograph- and Hobart-mixed doughs, with the exception of 5-min mixing for Kalyan Sona dough from Hobart mixer.

Adjustment of Farinograph

In lever position 1:1, the chapatti doughs of desired characteristics, as judged by hand-feel, showed consistency ranging from 750 to more than 1000 BU for different wheat varieties. The farinograms were not smooth and exhibited too many oscillations, especially in the case of strong flours. In contrast, curves obtained in lever position 1:3 were smoother and nearer the center of the recording chart. It was concluded that lever position 1:3 was suitable for comparative evaluation of chapatti doughs which were somewhat softer than papad doughs (3).

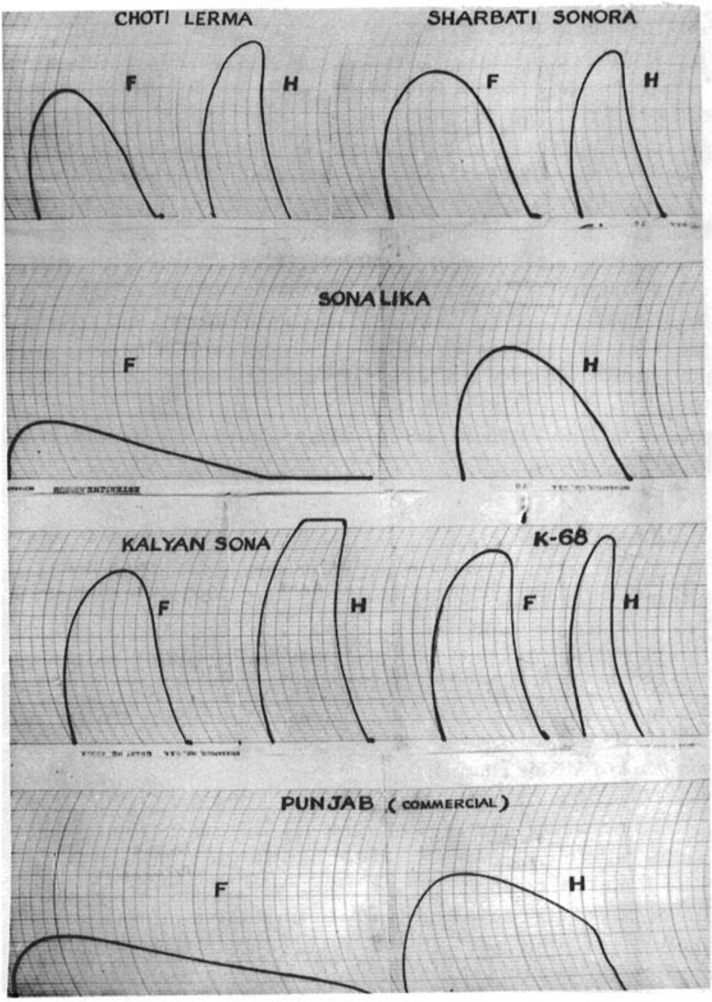

Fig. 7. Extensometer curves for different chapatti doughs mixed in farinograph (F) and Hobart (H) mixers.

Continuous Mixing Trials

Depending on the variety of wheat, continuous mixing for shorter periods (1–3 min) resulted in an underdeveloped dough. Such a dough had not attained its maximum consistency and did not have desirable handling and rolling characteristics. This was probably because of improper hydration of gluten. For varieties requiring longer development time, doughs mixed so as to obtain maximum consistency were somewhat sticky and difficult to handle. When mixed further, these doughs had a tendency to become runny as they lost their elasticity, and they then became highly sticky and extensible.

Mixing Trials With Rest

Minimum mixing and rest periods are likely to be advantageous for large-scale continuous production of chapatties. Based on these considerations, initial mixing for 1 min was found adequate for proper mixing of dough ingredients. During the 5-min rest period and subsequent mixing, optimum hydration of gluten and proper dough development had taken place. This was evident from the elastic and somewhat rubbery nature of the dough as judged by hand-feel. Such a dough also possessed the desired rolling characteristics. Longer rest periods of 10–15 min had no additional beneficial effect on the dough characteristics.

It was considered desirable to continue mixing until 1–2 min after the dough had reached maximum consistency. For some wheat varieties, any further mixing weakened the dough. This affected its handling and rolling properties adversely. A similar adverse effect was observed even in varieties where dough consistency showed comparatively longer stability. From the different kneading trials, the optimum conditions arrived at were 1 min initial mixing followed by a 5-min rest period and further mixing until 1–2 min after maximum consistency of the dough was attained.

Optimum Consistency of Chapatti Dough

Among chapatti doughs of different consistencies (400–600 BU) obtained in lever position 1:3 for six varieties of wheat, 500 ± 20 BU was found to be the optimum, as judged by hand-feel and rolling characteristics. Therefore, for a given *atta* sample, the quantity of water required to obtain a dough of 500-BU consistency could be termed the farinograph water absorption. Farinograph curves for chapatti doughs from different wheat varieties are given in Fig. 6.

Water Absorption and Mixing Time

The water absorption for chapatti doughs, based on *attas* from different wheats, ranged between 50 and 57% (Table II). This variation may be attributed to the varietal differences with respect to quality and quantity of gluten, and to the extent of starch damage during milling. The range of 50–57% water absorption is, however, considerably lower than the minimum of 68% reported by Austin and Ram (1). It is desirable to avoid excessive starch damage because it increases water absorption (5) of *atta* and is likely to result in a sticky dough.

The mixing time as indicated by farinograph curves (Fig. 6) ranged between 2 min for a soft wheat like Chhoti Lerma and 5 min for the medium hard wheats Sharbaṭi Sonora and K-68.

Discoloration in Chapatti Dough

In larger-scale preparation, chapatti doughs are generally rested for about 1 hr before rolling. This has been reported to improve the rolling characteristics and to facilitate activity of diastatic, proteolytic, and other enzymes (1). On the other hand, discoloration of chapatti dough has been observed by Abrol (6) during the rest period. Such discoloration has been attributed to the oxidation of phenolic compounds by the polyphenol oxidase present in the branny layers.

The chapatti doughs prepared in a farinograph mixer can be rolled immediately without any rest period, so the problem of discoloration does not arise. Also, the avoidance of a rest period can be used advantageously in

TABLE III
Extensometer Characteristics of Chapatti Doughs from Farinograph and Hobart Mixers

Wheat Variety	Farinograph-Mixer Dough			Hobart-Mixer Dough		
	Extensibility (E) mm	Resistance (R) mm	Ratio figure (R/E)	Extensibility (E) mm	Resistance (R) mm	Ratio figure (R/E)
Chhoti Lerma	50	60	1.20	30	82	2.73
Sharbati Sonora	60	68	1.13	33	76	2.30
Sonalika	110	27	0.24	70	60	0.85
Kalyan Sona	50	80	1.60	40	100	2.50
K-68	50	88	1.76	25	94	3.76
Punjab (Commercial)	160	32	0.20	92	58	0.63

TABLE IV
Chapatti-Making Quality of Six Varieties of Indian Wheats[a]

Variety	No. of Discrete Laminations[b]	Texture	Eating Quality	Overall Acceptability
Chhoti Lerma	3	Somewhat stiff and less smooth	Somewhat leathery and flat taste	Fair
Sharbati Sonora	4	Pliable and smooth	Soft and sweetish	Good
Sonalika	3	Pliable and smooth	Soft and sweetish	Good
Kalyan Sona	4	Pliable and silky smooth	Very soft and sweeter	Excellent
K-68	4	Pliable and silky smooth	Very soft and sweeter	Excellent
Punjab (Commercial)	3	Pliable but less smooth	Soft and sweetish	Satisfactory

[a]Chapatties from all varieties of wheats had acceptable creamy color.
[b]Of baked chapatti.

developing machinery for continuous large-scale production of chapatties.

Farinograph- *vs.* Hobart-Mixed Doughs

Extensometer curves for Hobart- and farinograph-mixed doughs based on different wheat varieties are shown in Fig. 7. The data on the stretching property of doughs, presented in Table III, show that for a given variety of wheat, farinograph-mixed dough had higher extensibility and lower resistance to extension compared to Hobart-mixed dough. Farinograph-mixed doughs based on varieties Sonalika and Punjab (Commercial) had excessive extensibility and poor resistance to extension, but the dough based on Kalyan Sona had exceptionally high resistance. The ratio figures R/E (Resistance/Extensibility) for Hobart-mixed doughs were more than double those for the farinograph-mixed doughs, indicating the relatively stiff nature of Hobart-mixed doughs. It may therefore be inferred that the Research extensometer can be used for objective comparison of the stretching property of chapatti doughs. However, no correlation was observed between the data obtained from extensometer curves and the suitability of wheat varieties for chapatti making.

The data on spreading quality of chapatti doughs are given in Table II. Farinograph-mixed doughs had a 20 to 30% greater area for chapatti sheets than those mixed with the Hobart mixer. This indicated that farinograph-mixed doughs were comparatively easier to roll. In the majority of cases, the area-spread was directly proportional to extensibility and inversely proportional to resistance. The criterion of area-spread, using the simple Hilliff chapatti press, can thus be used with advantage to objectively evaluate the dough attributes related to rolling characteristics.

Water Requirement of Hobart-Mixed Doughs

Unlike farinograph-mixed doughs, a standardized consistency of Hobart-mixed doughs cannot be arrived at objectively. Also, it is not possible to determine the requirements of water and mixing time for preparing a chapatti dough of desired consistency from a given *atta* sample. Therefore, Hobart-mixed doughs had to be evaluated for their consistency on the farinograph.

Data in Table II indicate that 1.5 to 3.0% extra water was required to obtain Hobart-mixed doughs with the same consistency and rolling characteristics as those of farinograph-mixed doughs. Similarly, the farinograph could be used to determine the water requirement for the preparation of a standard chapatti dough in different types of mixers.

Quality Evaluation of Chapatti

Generally, a circular, ideally baked chapatti will have only two discrete laminations and has to be eaten hot. If stored for a few hours, it has a tendency to become somewhat hard and dry, and its eating quality is adversely affected. In contrast, a triangular-shaped chapatti with three to four laminations has superior texture and better eating quality, and these attributes are retained even when the chapatti is kept for several hours.

The quality characteristics of chapatties based on different wheat varieties are described in Table IV. Chapatties from varieties Kalyan Sona and K-68 were graded excellent, while those from the soft variety, Chhoti Lerma, were only fairly acceptable. Both Sharbati Sonora and Sonalika gave good chapatties.

Acknowledgment

The authors are grateful to Shri P. Haridas Rao for critically reading the manuscript.

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[Received February 25, 1975. Accepted July 11, 1975]