A NOTE ON THE RELATION OF SAMPLE SIZE TO HAGBERG FALLING NUMBER VALUES

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The Hagberg falling number test (1,2) is a widely accepted, rapid test for determining the α-amylase activity of wheats. The method has been incorporated in the official methods of the American Association of Cereal Chemists (3) and the International Association for Cereal Chemistry (4). Factors affecting the test have been studied by several workers (5–10). Reduced sample weights for the test have been preferred for those wheats showing high falling number values (5,8,9). Since precise information is lacking on the relation between sample weight and falling number values, the authors studied implications of this approach using Indian wheats. In this paper, results show that the method is rendered less sensitive as the sample weight for the test is reduced below 7 g.

MATERIALS AND METHODS

Sixty-three samples of wheat, comprising 39 varieties from the 1969–70 and 1970–71 crop years, five samples of commercial wheats from roller flour mills, and four samples from the local market, were used.

Each wheat sample (200 g) was ground in a laboratory hammer mill (Kamas Slago-200 A) fitted with a 0.8 mm sieve. Straight-grade flours were obtained after appropriate conditioning (11).

Wheat and flour moistures were determined according to the AACC method (3).

Only those falling number tubes with the least variation in weight and size were used in the test (9). Falling numbers in seconds were determined on 7-, 6-, and 5-g samples (14% moisture basis) of ground wheats and flours in 25 ml of water using the automatic falling number apparatus (Falling Number AB, Sweden). The effect of 60° L malt syrup (0.5% on flour basis, Fleishmann's USA) on the falling number values was determined on 7-, 6-, 5-, 4.5-, and 4.0-g samples of selected flours.

Correlation coefficients were determined for the falling number (FN) of ground wheats and milled flours. The falling numbers were also converted into liquefaction numbers (LN) using the expression:

$$LN = \frac{6000}{FN-50}$$

This was done to study the interrelation in view of the reported linear relation of liquefaction number with the α-amylase content of flours.

RESULTS AND DISCUSSION

Compared with falling numbers of European wheats (2), those of Indian

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wheats (Table I) were very high, whether ground wheat or flour was used in the test. As sample size was reduced from 7 to 5 g (25 ml water), all falling numbers decreased. Forty-nine samples of ground wheats had falling number values below 100 sec when 5 g was used. When sample size was increased to 6 g, 59 samples had falling numbers of 301 to 600 sec. The number of samples in that range was reduced to 44 when 7-g samples were used. The data show that 5-g samples of ground wheat were grossly inadequate; however, the flours behaved somewhat differently. Twenty-eight 5-g samples of flour had falling numbers below 300 sec and 35 had values of 300 to 600 sec. With 6-g flour samples, 57 flours had falling numbers of 300 to 600 sec. Six-gram samples of ground wheat and flour gave a similar distribution of values. In the higher falling number range of 601 to 900 sec, there were only 14 samples of ground wheat compared to 23 of flours (7 g + 25 ml water). The high falling number values for 7-g samples of Indian wheats reflect either low α-amylase activity or high pastiness of the starches of those wheats. According to Perten[3], falling numbers exceeding 350 sec do not measure the α-amylase activity of flours.

Mean falling numbers of Indian wheats and of flours were comparable (Table II). However, reducing the sample size from 7 to 6 g reduced the falling number by 27.1 to 28.8%. There was great variation in the falling numbers of ground wheat and flours when 7 g was used (coefficients of variation, Table II). The liquefaction numbers, based on falling numbers of 7-g samples of ground wheat, were highly correlated with those of 6-g samples (+0.83, Table III). A similarly high correlation (+0.84) was obtained for 7-g samples of ground wheat and straight-grade flours. Among flours, the highest correlation (+0.79) was between

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TABLE I
Distribution of Samples According to Falling Numbers Determined on Ground Wheat and Corresponding Straight-Grade Flours

Falling Number Range sec	Ground Wheat 5 g	Ground Wheat 6 g	Ground Wheat 7 g	Straight-Grade Flours 5 g	Straight-Grade Flours 6 g	Straight-Grade Flours 7 g
I. Below 100	49[a]	0	0	0	0	0
101–200	0	1	0	2	0	0
201–300	12	3	2	26	5	0
300 and below	61	4	2	28	5	0
II. 301–400	2	24	4	34	13	4
401–500	0	34	15	1	42	11
501–600	0	1	25	0	2	24
301–600	2	59	44	35	57	39
III. 601–700	0	0	6	0	1	19
701–800	0	0	6	0	0	2
801–900	0	0	2	0	0	2
601–900	0	0	14	0	1	23
IV. 901 and above	0	0	3	0	0	1

[a]Values are the number of samples yielding a falling number in the designated range.

the liquefaction numbers using 6 and 5 g. The corresponding values for the falling numbers coefficients of correlation were 0.71 and 0.61.

There was a significant decrease in the falling number values determined on 7 g of flour following supplementation with 0.5% of 60° L malt extract (Table IV). Maximum decrease (54.8%) was shown by PV18 flour compared with 44.0 and 42.0% for Kalyan and the regional baking standard flour (RBS-70A, USA), respectively. Reducing the sample size to 5 g flour reduced the falling numbers by 18 to 21%. The decrease (%) in the falling numbers was less in the series of samples supplemented with the malt extract compared with the control.

TABLE II
Mean and Range of Falling Numbers of Indian Wheats

Sample Weight g	Mean sec	Range sec	Standard Deviation	Coefficient of Variation %
Ground wheat				
7	562	275–1048	152.8	27.2
6	400	197–541	61.1	15.3
5[a]	...	...	...	...
Flour				
7	571	334–939	118.5	20.8
6	416	218–600	67.7	16.3
5	302	185–412	50.9	16.9

[a]Majority of samples had low falling numbers.

TABLE III
Correlation Coefficients for Falling Numbers and Liquefaction Numbers of Ground Wheat and Straight-Grade Flours for 5-, 6- and 7-g Samples

Sample Weight g	Falling Number	't'[a]	Liquefaction Number	't'[a]
Ground wheat				
7 *vs.* 6	0.71	7.88	0.83	11.7
Flours				
7 *vs.* 6	0.61	6.02	0.58	5.59
7 *vs.* 5	0.55	5.14	0.66	6.87
6 *vs.* 5	0.75	8.87	0.79	10.00
Ground wheats *vs.* flours				
7 *vs.* 7	0.66	6.86	0.84	12.10
7 *vs.* 6	0.57	5.41	0.56	5.31
7 *vs.* 5	0.38	3.21	0.44	3.85
6 *vs.* 7	0.71	7.88	0.62	6.21
6 *vs.* 6	0.61	6.02	0.48	4.31
6 *vs.* 5	0.61	6.02	0.29	2.36

[a]Fishers 't' for significance at P 0.01 level value is 2.66.

TABLE IV
Effect of Enzymatic (60°L) Malt Extract on Falling Numbers

Flour	Sample Weight g	Sample Weight Decrease %	Falling Number Control[a] (A) sec	Falling Number Control[a] (A) Decrease %	Falling Number +0.5% Malt extract (B) sec	Falling Number +0.5% Malt extract (B) Decrease %	Decrease ($\frac{A-B}{A} \times 100$) %
PV-18	7.0	...	854	...	386	...	54.8
	6.0	14.3	538	37.0	347	10.1	35.5
	5.0	28.6	404	52.7	320	17.1	20.8
	4.5	35.7	317	62.9	256	33.7	19.2
	4.0	42.9	66	92.3	69	82.1	...
Kalyan	7.0	...	670	...	375	...	44.0
	6.0	14.3	483	27.9	313	16.5	35.0
	5.0	28.6	336	49.9	266	29.1	21.0
	4.5	35.7	281	58.1	220	41.3	21.7
	4.0	42.9	69	89.7	67	82.1	...
RBS	7.0	...	534	...	308	...	42.0
	6.0	14.3	404	24.3	283	8.1	30.0
	5.0	28.6	271	49.3	222	27.9	18.1
	4.5	35.7	228	57.3	177	42.5	22.4
	4.0	42.9	65	87.8	67	78.2	...

[a]Equivalent boiled extract in the aqueous phase.

The results clearly emphasize the desirability of using a 7-g sample of ground wheat or flour. A sample weight less than 7 g renders the falling number technique less effective as an index of α-amylase activity. Medcalf *et al.* (7) determined falling numbers on 5-g samples (dry basis) of sound wheats. Greenaway and Neustadt (5) reviewed collaborative data on falling numbers as influenced by a number of factors, among which was essentially a linear relation between sample size and falling number. By implication, Medcalf *et al.* (7) concluded that the values obtained with 5-g samples would all be relatively proportionate. That inference seems an oversimplication of the observations of Greenaway and Neustadt (5) using flours with falling numbers less than 100 to 200 sec even after increasing sample size from 5 to 9 g. Interpolation of those observations to flours or meals with very high falling numbers has to be carefully justified. Meredith (9) preferred 5 g plus 25 ml water for the falling number test in view of the AACC subcommittee suggestion that precision can be improved by using smaller samples of sound flours. It appears that the views of the subcommittee on sample size and a linear relation between sample size and falling number should be reviewed. The primary objective of the falling number test is to determine α-amylase activity of wheat or flour milled from it. Evidence presented here shows that the test becomes less sensitive as sample size is reduced below 7 g.

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