A FARINOGRAPH TECHNIQUE FOR MACARONI DOUGHS[1]

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ABSTRACT

A technique is described for studying the farinogram characteristics of macaroni doughs in the absorption range of 26.5 to 36.0%; this is the general range used in processing macaroni. With the 50-g. bowl attached to the farinograph, the balance linkage is set in the rear position (normal for 300-g. bowl), the instrument is zeroed, and the dampening is set to 0.8 seconds.

Macaroni doughs prepared from various types of wheat may be distinguished from one another by the farinograph. Variation of durum wheat grade has a distinct effect on farinograms. Farinogram characteristics of semolinas produced from durum wheats grown in different years are quite similar for a given variety, provided that protein content does not change significantly. Variation of protein content, temperature, absorption, or particle size produces a distinct change in farinogram characteristics.

Although the farinograph has been used extensively to determine characteristics of bread doughs at or near baking absorption (52 to 65%), and Brabender has studied semolina doughs at absorptions greater than 53%[2], no report on the use of the farinograph to determine macaroni dough characteristics, at normal absorptions of 26.5 to 36.0%, has come to the authors' attention. This paper describes adjustments to the farinograph required for study of macaroni doughs, and illustrates the effect of wheat type, variety, grade, protein content, absorption, temperature, and particle size on the farinogram characteristics. The results for each series are discussed in separate sections.

Materials, Equipment, and Method

The semolinas and farinas used in the study of wheat type, grade, and protein content were milled in the laboratory on an Allis-Chalmers Experimental Mill. The milling procedure has been described by Fisher and Meredith (3). This method produces a semolina of relatively uniform particle size. The semolina used in the study of absorption, temperature, and particle size was commercially milled to 55% extraction from a No. 2 Canada Western Amber Durum.

The 50-g. stainless-steel bowl was attached to the farinograph. The linkage was moved to the rear position (the 300-g. bowl setting) and the damper was screwed down to the bottom position. The farino-

[1]Manuscript received July 14, 1960. Paper No. 193 of the Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg 2, Canada.

[2] Brabender, C. W. Application of rheological measuring techniques in the alimentary paste industry. C. W. Brabender Instruments, Inc., South Hackensack, N.J. Mimeo., pp. 1–4 (1955).

graph was then zeroed and the damper was set to give 0.8 seconds from 1,000 to 100 Brabender units. With these settings it is possible to obtain farinograph curves with semolina in the absorption range 26.5 to 36.0%. The farinograph used for this study has a speed of 59.3 r.p.m. and a side clearance of 0.030 in. between the blade edge and the bowl sides. A sample of 50.00 ± 0.01 g. (14.0% moisture basis) was placed in the bowl which was maintained at 30°C., except in the temperature study. The farinograph containing the sample was started and the desired amount of water, at the same temperature as the bowl, was introduced at the corner of the bowl. The farinograph was run 4 minutes after the peak had been reached.

Three terms are used throughout this paper to describe farinograms. Dough development time (DDT) is used as defined in *Cereal Laboratory Methods* (1). The term maximum consistency (MC) is used to designate the height in Brabender units of the center of the curve at the point of maximum consistency. Tolerance index (TI) is also used as defined in *Cereal Laboratory Methods* (1), except that the difference of curve height is measured 4 minutes rather than 5 minutes after maximum consistency.

For assessing gluten quality, glutens were washed out from semolina doughs using a Theby Gluten Washer. The washing solution is a sodium chloride-phosphate buffer of pH 6.5. Glutens are washed by machine for 12 minutes and finished off with 2 minutes' hand washing.

Results and Discussion

Effect of Grade. The various grades of Canada Western (CW) Amber Durum have different farinogram characteristics. Figure 1 shows the farinograms of four grades of Amber Durum wheat at their

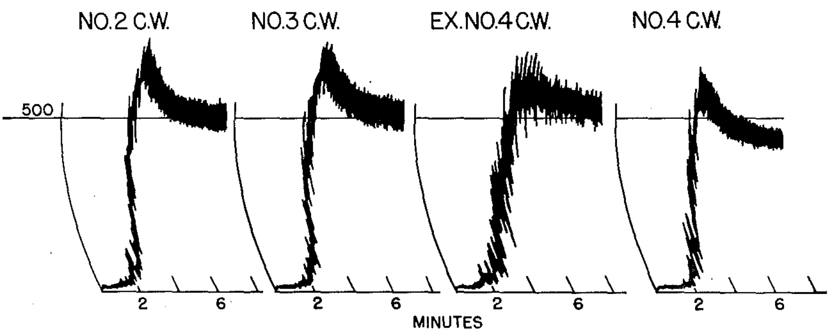

Fig. 1. Farinograms representing semolinas milled from various grades of Canada Western Amber Durum.

TABLE I

DATA FOR ABSORPTION AND DERIVED FARINOGRAM INDICES FOR SEMOLINAS MILLED FROM FOUR GRADES OF CANADA WESTERN AMBER DURUM

GRADE	ABSORPTION	DOUGH DEVELOPMENT TIME	MAXIMUM CONSISTENCY	TOLERANCE INDEX
	%	*minutes*	*B u*	*B u*
No. 2 CW	31.5	4.00	665	165
No. 3 CW	31.5	4.25	650	140
No. 4 CW	33.5	4.25	570	130
Extra No. 4 CW	32.5	5.25	580	55

processing absorption as determined by the micro procedure for macaroni processing (4). As grade decreases (Table I), dough development time increases and tolerance index decreases slightly. Maximum consistency also appears to decrease but this is largely due to increased absorption. The small tolerance index for Extra No. 4 CW will later be shown to be a varietal characteristic of Pelissier. This variety is excluded from the top grades of Amber Durum wheat (Nos. 1, 2 and 3 CW) and thus enters the next grade, Extra No. 4 CW.

Effect of Variety. Semolinas milled from the standard varieties Mindum, Stewart, Carleton, Golden Ball, and Ramsey produce similar farinograms. Pelissier is the only licensed durum variety grown in Canada that produces a different farinogram. Figure 2 shows the typical curve of this variety compared with Mindum at the same absorption of 33.0%. The dough development time for Mindum was 3.25 minutes as compared with 10.0 minutes for Pelissier. The maximum

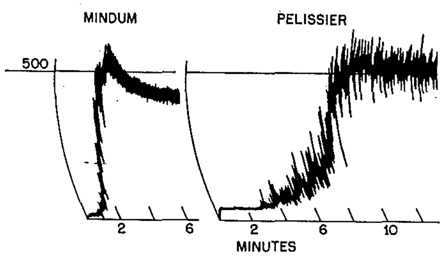

Fig. 2. Farinograms representing Mindum and Pelissier at 33.0% absorption.

consistency and tolerance index for Mindum were 545 B.u. and 125 B.u.; for Pelissier 530 B.u. and 20 B.u. The low tolerance index of Pelissier changes very slightly with varying absorption. This characteristic is related to gluten properties, not grade or absorption.

A low tolerance index, of 75 B.u. or less, is shown by certain durum varieties and other wheat types which have the following semolina gluten properties as determined from the washed-out gluten. The gluten is elastic to very elastic, extensible, and forms a strong, fairly thin membrane on sheeting. These glutens would be classed as bread wheat types. Durum glutens from the standard Canadian varieties are less elastic, more extensible, and form a fairly weak, very thin membrane.

Figure 3 shows the farinograms of macaroni doughs of four foreign durums, made at processing absorption. These durums were exported

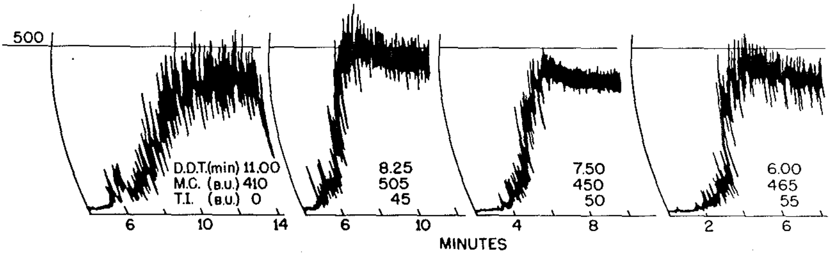

Fig. 3. Farinograms representing foreign durum macaroni doughs at 35.0% absorption.

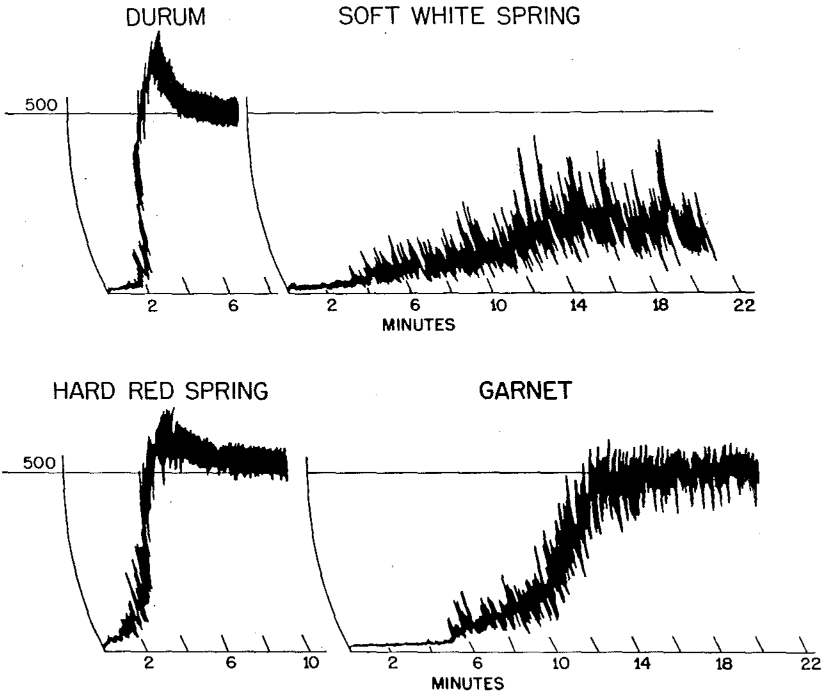

Fig. 4. Farinograms representing various types of wheat.

from four countries and are representative only of individual cargoes. The first and last farinograms represent the same variety grown in two different countries. The varieties of the other two samples are unknown. The grade of these wheats as determined by the Board of Grain Commissioners Inspection Branch ranged from No. 2 to No. 3. This series illustrates further the wide variation in farinogram characteristics which may occur with durums grown in widely differing environments.

Effect of Wheat Type. Farinas, milled from various types of wheat, produce farinograms which are considerably different from farinograms of durum semolinas. Figure 4 shows the farinograms for Soft White Spring, Garnet, and Hard Red Spring compared with a No. 2 CW Amber Durum curve at constant absorption of 31.5%. Samples which graded either No. 2 or No. 3 were used to reduce possible effects of differences in grade. The absorption used is not a macaroni-processing absorption, but was selected to show differences that exist at constant absorption.

Effect of Protein. The farinograms shown previously represent samples which vary in protein content. To study the effect of protein

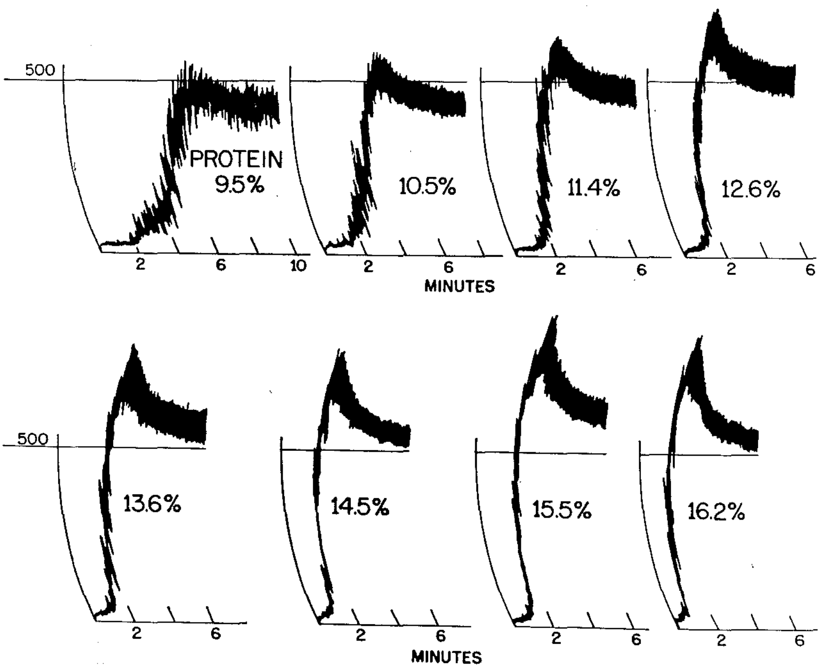

Fig. 5. Effect of protein content on farinogram characteristics.

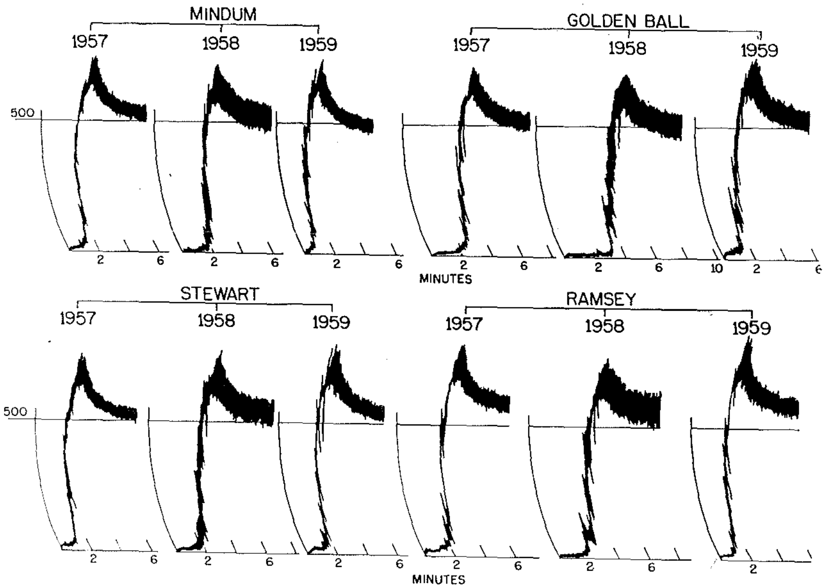

Fig. 6. Farinograms of four varieties grown in three different years.

content independent of the influence of wheat type, variety, and grade, two samples of Stewart durum were obtained which graded No. 2 CW. One sample had a protein content of 10.5% and the other 17.5%. Eight samples of wheat were blended from these two samples, so that on milling to 50% extraction, eight samples of semolina were obtained which ranged from 9.5 to 16.2% protein in approximately 1% protein increments.

Figure 5 illustrates the effect of protein content on the farinograms of macaroni doughs at 31.5%. Table II contains the farinogram

TABLE II
EFFECT OF PROTEIN CONTENT ON FARINOGRAM CHARACTERISTICS OF MACARONI DOUGHS

Protein Content	Dough Development Time	Maximum Consistency	Tolerance Index
%	minutes	*B u*	*B u*
9.5	6.25	460	30
10.5	4.50	520	80
11.4	4.00	570	100
12.6	3.25	645	135
13.6	3.00	710	140
14.5	2.25	710	155
15.5	2.50	800	185
16.2	2.25	760	220

measurements for this series. As protein content increases, dough development time decreases, maximum consistency increases, and tolerance index increases. The farinogram of a very low protein sample has the same characteristics as the farinogram of a poor variety or a nondurum wheat.

Effect of Environment. Macaroni doughs of four standard varieties (Mindum, Golden Ball, Stewart, and Ramsey) have been studied in the farinograph for the years 1957, 1958, and 1959. Each variety sample represented a composite from a number of experimental stations in Western Canada. Figure 6 shows the farinograms of these varieties at 31.5% absorption. Table III contains the farinogram data, and shows the protein and wet gluten contents of the samples.

TABLE III
THE PROTEIN CONTENT, WET GLUTEN CONTENT, AND FARINOGRAM CHARACTERISTICS OF SEMOLINAS FROM FOUR VARIETIES OF CANADIAN AMBER DURUM GROWN IN DIFFERENT YEARS

VARIETY	YEAR GROWN	PROTEIN CONTENT	WET GLUTEN CONTENT	DOUGH DEVELOPMENT TIME	MAXIMUM CONSISTENCY	TOLERANCE INDEX
		%	%	*minutes*	*B u*	*B u*
Mindum	1957	13.8	40.4	3.00	685	160
	1958	12.1	35.6	4.00	640	125
	1959	13.7	41.6	2.50	670	170
Golden Ball	1957	12.6	36.1	4.25	660	140
	1958	11.6	33.9	5.50	630	130
	1959	12.7	37.7	3.50	675	145
Stewart	1957	13.7	39.7	2.75	680	170
	1958	12.1	36.2	4.25	670	130
	1959	13.8	42.6	3.00	710	170
Ramsey	1957	14.0	40.8	3.50	730	150
	1958	12.3	37.7	4.50	670	115
	1959	13.8	42.7	3.00	740	160

The farinogram characteristics of each variety are quite similar for 1957 and 1959, but are slightly different for 1958. In 1958 dough development time increased, maximum consistency decreased, and tolerance index decreased slightly. In the 1958 samples, protein content was lower than in the samples grown in 1957 and 1959. Because of the effect of protein content discussed previously, it was concluded that the variation in farinogram characteristics from year to year was due largely to a variation in protein content. Minor differences between farinograms for years of equal protein (1957 and 1959) are probably due to differences in gluten quality as shown by a change in wet gluten content. Year-to-year variations in farinogram characteristics for a given variety are small compared to variations due to wheat type, variety, and grade.

Effect of Absorption. Farinograms in Fig 7 show the effect of varying absorption on a top-grade commercial semolina. As absorption increases, dough development time decreases, maximum consistency decreases, and tolerance index does not change significantly.

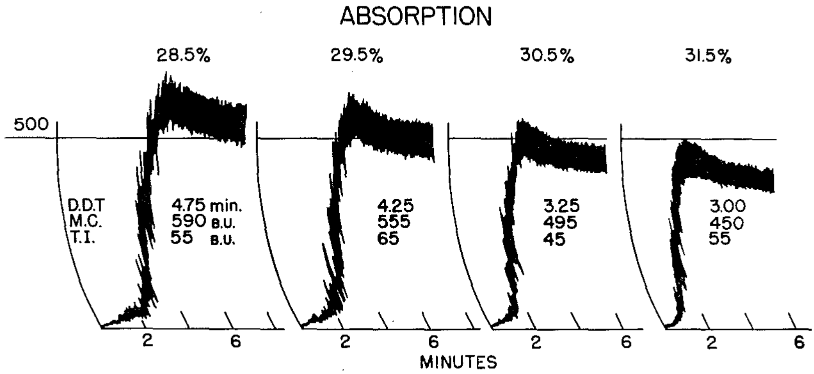

Fig. 7. Effect of varying absorption on farinograms of commercial semolina at 30°C.

The low tolerance index is not due to variety, type, protein, or grade, as the semolina used was milled from a No. 2 Canada Western Amber Durum. It will be shown later that the low tolerance index is caused by the presence of large particles in the semolina.

Effect of Temperature. Farinograms of commercial semolina were obtained using a constant absorption of 28.5% while controlling the mixing bowl temperature at 30°, 35°, and 40°C. The farinograms are shown in Fig. 8. As temperature increases, dough development time decreases, maximum consistency decreases, and tolerance index increases. It is therefore necessary to control the temperature of the bowl to evaluate farinograms.

Effect of Particle Size. The farinogram (extreme left, Fig. 9) of the

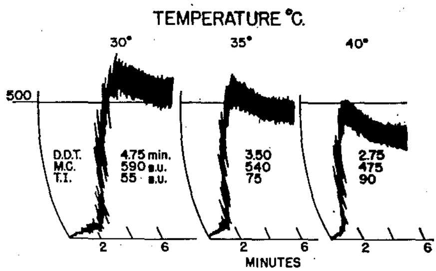

Fig. 8. Effect of varying temperature on farinograms of commercial semolina at 28.5% absorption.

commercial semolina milled from a No. 2 CW Amber Durum does not look like the farinogram of a macaroni dough produced from semolina milled in the laboratory. The dough development time of 3 minutes is normal, but the low maximum consistency of 450 B.u. and the low tolerance index of 55 B.u. are not consistent with the characteristics of a No. 2 CW Amber Durum semolina.

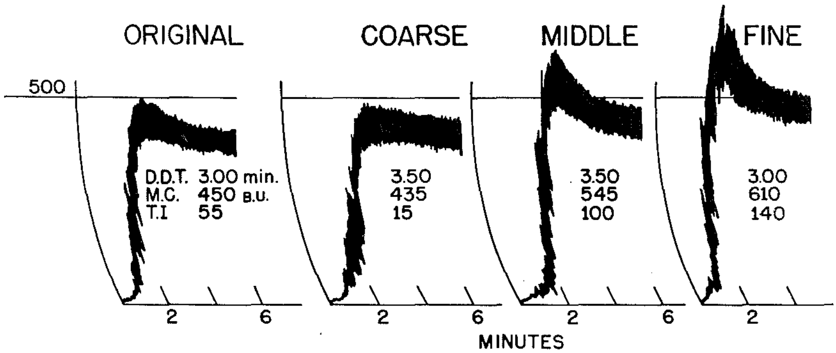

Fig. 9. Effect of varying particle size on farinograms of commercial semolina at 31.5% absorption.

Table IV shows the relative proportions of various-sized particles in a commercial semolina as compared to the laboratory-milled semolina. A sample of this commercial semolina was separated into three fractions by sieving. The fraction retained by a 40-mesh†[3] was designated as the coarse fraction; the fraction which passed through the 40-mesh† and was retained by the 80-mesh† was designated as the middle fraction; and the fraction which passed through an 80-mesh† was designated as the fine fraction. Figure 9 shows the farinograms of the original semolina and the three fractions, all run at a constant absorption of 31.5%.

TABLE IV

RANGE OF PARTICLE SIZE IN SEMOLINAS USED

Sample	Held on 40-Mesh [a]	Held on 80-Mesh [a]	Passed Through 80-Mesh [a]
	%	%	%
Laboratory milled	0	92	8
Commercial	28	66	6

[a] U.S. Standard Sieve series.

As particle size decreases, maximum consistency increases and

[3] † Designates U.S. Standard Sieve series.

tolerance index increases. Dough development time does not change significantly. These results seem to show that the low maximum consistency and low tolerance index of the original sample are due to the presence of large particles in the semolina.

The interrupted farinograph technique for bread doughs (2) has been described by Brabender. This technique has been used in this laboratory to study semolinas at lower absorptions. The curve produced after the rest period is identical to the original curve, independent of variety, grade, and protein content for a homogeneous semolina. However, the heterogeneous semolina which contains large particles will, with a 15-minute rest period, change its farinogram characteristics to resemble a homogeneous semolina. The major effects of rest period (Fig. 10) on the heterogeneous semolina are to increase the maximum consistency (from 470 to 545 B.u. in the example) and to increase the tolerance index (from 30 to 120 B.u. in the example). It was concluded that the rest period enabled water to penetrate the large particles. This redistribution of water produces a farinogram which is similar to the curve shown for the homogeneous semolina. It may be that this interrupted technique, despite the greater time required, will prove a useful modification for general studies of commercial semolinas.

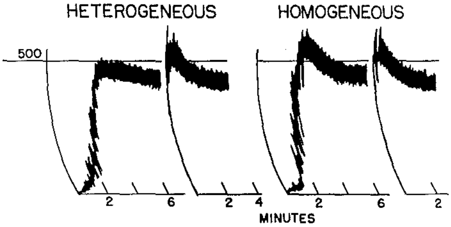

Fig. 10. Interrupted farinograms on commercial semolina.

The Combined Effect of Absorption, Temperature, and Particle Size. It has been shown that increasing absorption and increasing temperature have the same effect on dough development time and maximum consistency. Figure 11 shows that farinograms can be reproduced at various absorptions by adjusting the temperature to give the same dough development time of 4.75 minutes and maximum consistency of 590 B.u. However, the tolerance index shows the same increase from 55 to 90 B.u. as that obtained at a constant absorption with the same temperature changes (Fig. 8). It therefore appears that tolerance index is independent of absorption. This finding agrees closely with the results of the absorption study (Fig. 7).

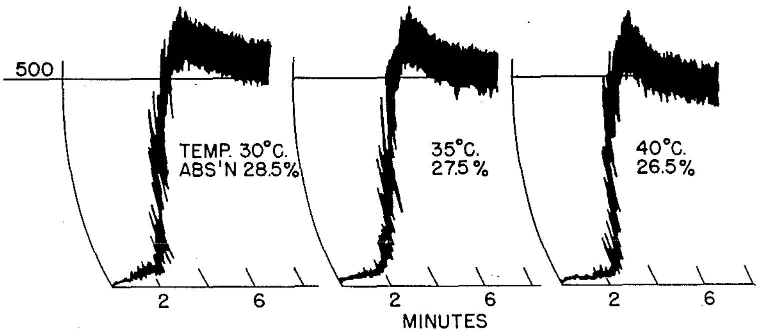

Fig. 11. Combined effect of temperature and absorption on farinograms.

A farinogram that resembles the curve of a homogeneous semolina dough can be produced from a heterogeneous semolina by varying absorption and temperature. Figure 12 shows a No. 2 commercial semolina curve produced at normal temperature (30°C.) and absorption (31.5%) compared to a curve produced at 40°C. and 26.5% absorption.

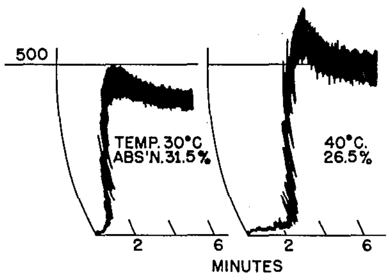

Fig. 12. Farinograms showing how curve characteristics may be controlled by absorption and temperature.

General Discussion

Farinograms of macaroni doughs were obtained using macaroni processing absorptions and appropriate settings for the farinograph. The curve characteristics were influenced to a greater extent by wheat type and durum variety than by grade and protein content.

The two principal types of farinograms were those with a high tolerance index and those with a low tolerance index. High tolerance index values are associated with good durum varieties, reasonably high protein content, and homogeneous particle size; low values are obtained from wheats other than durums, from low-protein samples, from poor durum varieties, and from heterogeneous semolina.

Maximum consistency is influenced mainly by absorption and temperature. Dough development time is influenced most markedly by wheat type and variety but also varies with absorption and temperature; low protein and low grade may lengthen dough development time.

It seems probable that the farinograph may prove useful as a control instrument for commercial macaroni processing. Semolina of uniform quality has always been advantageous, and uniformity is even more necessary now that continuous processing is so widely used. In essence the problem relates to the degree of correlation that exists between the processing properties of semolina and the characteristics of the farinograms. This correlation is not readily examined in a laboratory equipped only for processing semolina on a microscale. Nevertheless, the results presented in this paper do suggest that changes in various semolina qualities are reflected by typical changes in farinograms and suggest that this technique could be developed to provide a means of controlling paste properties in continuous macaroni processing plants. Further work along these lines is being done in this laboratory.

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