THE EFFECT OF STARTING TEMPERATURE ON AMYLOGRAMS[1]

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ABSTRACT

Higher starting temperatures reduce the time required for the amylogram to reach a peak. The quantity of flour must be reduced to obtain the same relative amylogram values as that for the lower starting temperatures. The enzymes convert less starch at the higher starting temperatures. A procedure is described for operating the amylograph which cuts the usual test time in half.

The amylograph has become one of the most popular means that the cereal chemist uses today for controlling the addition of malt supplement to flour. However, one drawback of the instrument is the time required to make a determination. The average time required is approximately 31 minutes, and unless a battery of instruments is employed, the number of samples which can be tested in a day is limited.

Marnett *et al.* (3) in 1948 described a modified procedure which took approximately 15 minutes per determination. However, they used a temperature rise of 4°C. per minute, which is unsatisfactory since the amylograph is geared to operate at a temperature rise of 1.5°C. per minute. Experiments were, therefore, designed to see the effects of starting temperature and flour concentration on the amylogram.

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Materials and Methods

Four different amylographs were selected for this study. Three of the amylographs were the older style with the center pins in the feelers and ranging in age from 10 to 20 years. These amylographs had three bottom heating coils. One amylograph was the new style with a suspended feeler and had only two bottom heating coils.

Flours selected for the test ranged from patent to first clear. Flours were milled on both commercial and Buhler experimental mills. Some flours were treated with varying amounts of barley malt supplement. Other flours were commercial flours with wheat malt supplement added.

Dibasic sodium phosphate-citric acid buffer solution (470 ml.), with a pH of 5.35, was used. Varying weights of flour (14% m.b.) were slurried with the buffer solution. The solution and the flour were not brought to the starting temperature prior to running each test.

The regular procedure used 100 g. of flour with the thermoregulator set at 30°C. In the other tests performed, the thermoregulator was set at the desired starting temperature.

The modified or accelerated procedure for which data are given was 85 g. of flour (14% m.b.) with the thermoregulator set at 55°C. as the starting temperature.

Results and Discussion

In 1944 Anker and Geddes (1) stated that with increased concentration of the slurry there was an increase in the viscosity. A similar investigation, as shown in Fig. 1, concurred with their findings. As is

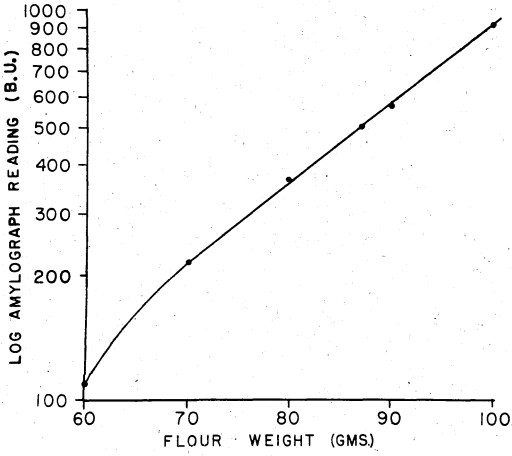

Fig. 1. Effect of flour weight on amylograms (constant starting temperature).

shown here, there is a semilogarithmic relationship between the amount of flour added and the maximum peak viscosity at a constant starting temperature. It can be seen by this illustration that even though there is an increase in the amount of enzymes present with the increase in flour weight, and an increase in the amount of starch converted, there is also a proportionate increase in viscosity. Therefore, it is possible to adjust the height or peak of the amylogram by changing the concentration of the slurry.

Anker and Geddes as well as Marnett *et al.* also showed that with increased starting temperature there is an increase in the peak viscosity. This is illustrated in Fig. 2, which shows the effect of starting temperature on the peak viscosity when the concentration of the slurry is held constant. At the lower starting temperatures the enzymes have

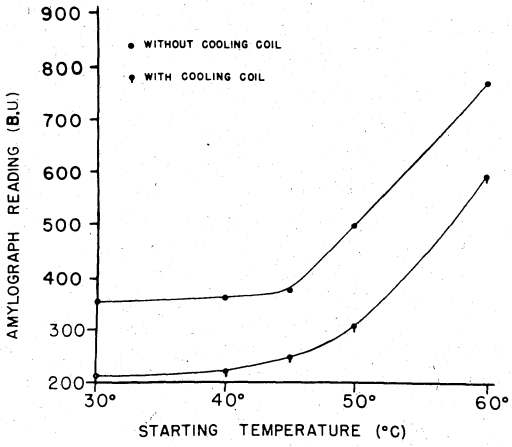

Fig. 2. Effect of starting temperature on amylograms (constant flour weight).

a longer time to convert the starch before they are inactivated by the heat; therefore, peak viscosity is lower. At the higher starting temperatures the reverse is true; the enzymes are inactivated sooner and a higher viscosity is realized. Also shown is the effect of the cooling coil on the viscosity. Although this gives a very similar curve, the peak viscosities are proportionately lower at any given starting temperature. The use of the cooling coil appears to protect the enzymes. This protection is probably brought about by better distribution of the heat in the bowl and elimination of "hot spots." Therefore, the enzyme is not deactivated as soon by the heat and will reduce more of the starch to sugar.

To verify the effect of increased starting temperature on enzyme

inactivations, the amount of reducing sugars was determined on each of the slurries as soon as the peak viscosity was reached. Data in Fig. 3 show that a semilogarithmic relationship appears to exist between peak viscosity and percent reducing sugar. The data indicate

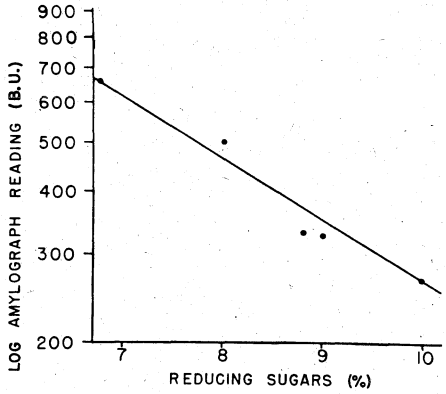

Fig. 3. Relationship of amylogram values and percent reducing sugar.

that the longer it takes to inactivate enzymes, the longer the time enzymes work, the more starch is converted to sugar. These results concur with the previous work of Hollenbeck and Blish (2).

These illustrations demonstate the effects of starting temperatures and flour concentrations on amylograms and portray the major factor which influences the amylogram, all other things being held constant.

Figure 4 illustrates the results of 56 samples which were determined by three different operators on four different amylographs. Table I

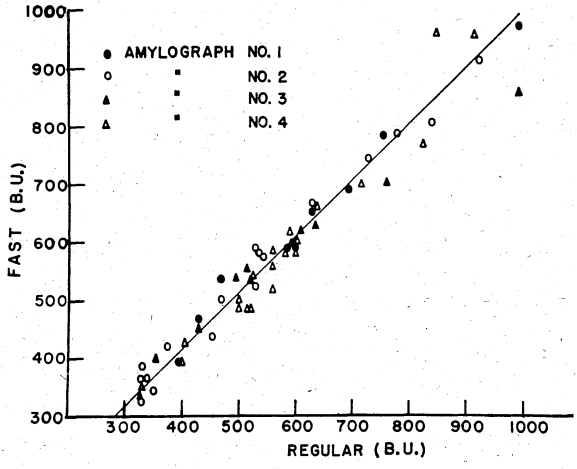

Fig. 4. Accelerated versus regular amylogram values.

TABLE I

COMPARISON OF REGULAR AND ACCELERATED AMYLOGRAM VALUES

Flour Grade[a]	Amylograph No.	Amylograph Units		Flour Grade[a]	Amylograph No.	Amylograph Units	
		Regular	Accelerated			Regular	Accelerated
		x	y			x	y
C	3	325	335	S	4	580	580
C	2	330	335	P	4	580	585
C	4	330	350	S	1	585	590
P	2	330	365	P	4	590	620
P[b]	2	330	385	P	4	600	585
P[b]	2	335	365	C	1	600	605
S	2	350	340	P	3	610	620
P	3	355	400	C	1	630	650
P	2	375	415	P	2	630	670
C	1	395	395	S	4	635	630
C	4	400	395	P	4	635	665
P	4	405	425	P	1	695	690
S	3	430	450	S	4	715	700
P	1	430	465	S	2	730	745
S	2	455	430	P	1	755	785
S	2	470	500	S	3	760	705
C	2	470	535	P	2	780	790
C	3	495	540	S	4	825	770
S	4	500	485	P[b]	2	840	805
P	4	500	500	P[b]	4	845	965
S	4	515	485	S	4	910	960
P	3	515	555	C	2	920	915
S	4	520	485	C	3	990	860
S	4	520	535	S	1	990	970
P	4	525	540		Av.	568.75	578.66
P	2	530	520				
P	2	530	590				
P[b]	2	535	585	C	1	1000+	1000+
P[b]	2	540	575	C	4	1000+	970
S	4	560	520	P[b]	2	1000+	950
P	3	560	560	P[b]	2	1000+	1000+
S	4	560	585	P	2	1000+	1000+

[a] P, patent; S, straight-grade; C, clear flours.
[b] Buhler experimentally milled flours.

gives the data for 61 samples tested. The correlation coefficient between the modified or accelerated procedure and the regular procedure was a positive 0.978. The accelerated procedure results are directly proportional to the regular procedure and are of the same order and magnitude. The results of the higher starting temperature procedure average 10 amylograph units (B.U.) higher than the results of the regular procedure. The regression equation from these results is:

$$X = 1.024\,Y - 23.8$$

where X = the amylograph reading for the regular procedure, starting temperature of 30°C.

Y = the amylograph reading from the fast or accelerated procedure, starting temperature of 55°C.

However, since the accelerated values averaged 9.91 B.U. higher, the corrected equation would be:

X = 1.024 Y − 13.9 to compensate for this difference.

Not only was there good agreement between the two procedures, but also the modified or accelerated procedure required, on the average, 17.5 minutes per determination as compared with 31 minutes by the regular method. Flours having low diastatic activity require approximately 20 minutes per determination; flours with high diastatic activity require approximately 15 minutes. The accelerated procedure should be very well adapted to flours having amylogram values between 300 and 700 B.U. range.

(NOTE: Since the amylograph is not standardized, different results are obtained on different instruments using the regular procedure. Some of this difference is due to the rate of heating because of the placement of the coils, the number of coils, the residual heat, etc. Therefore, it has been found necessary for a few instruments to change the starting temperature to compensate for these differences. The amount of flour used (14.0% m.b.) is still 85 g. However, the starting temperature may be 45°, 50°C., or some other temperature. It is advisable to run some flours by the regular procedure and then run the same flours by the accelerated procedure at the elevated starting temperature. If the results are higher than the regular procedure, it is necessary to lower the starting temperature. If the results are lower, then the starting temperature must be raised. By using this approach, compensation is made for internal differences in the construction of the individual amylograph.)

Literature Cited

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3. MARNETT, L. F., SELMAN, R. W., and SUMNER, R. J. A modified amylograph method for the rapid determination of flour amylase activity. Cereal Chem. **25:** 127–132 (1948).