A STUDY OF WHEAT FLOUR DOUGH STICKINESS

by

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INTRODUCTION

Wheat breeding programs in many countries are using material derived from rye (1B/1R or 1A/1R translocations) to achieve improvement of yield and disease resistance. However, many of these cultivars have been found to exhibit a serious quality defect. Dough from their flour has shown an intense stickiness.

The negative properties of these wheat varieties predominantly appear in a modified dough rheological behavior. The doughs surfaces are moist and sticky (Bolling, 1974. Rietzel, 1975).

These new wheat varieties generally have good milling quality, reasonable analytical values and overall good quality. However, the doughs are extremely sticky, which hinders processing, particularly in large factories where the dough is handled rapidly by machines. The handling problems lead to baked goods with reduced yield and relatively small volume. These wheats are designated in the literature as non-bakable wheats or problem wheats (Suckow et al 1983).

Neither current standard analytical methods used to determine flour quality characteristics nor the so-called rapid methods give any indication as to the source of the undesirable dough behavior.

This study was undertaken to understand the sticky dough phenomenon and hopefully identify techniques to eliminate

the stickiness. We also hoped to establish a procedure to predict the presence or absence of the sticky characteristic of new wheat varieties.

LITERATURE REVIEW

Although the reason for stickiness of problem wheat flour doughs is still unclear, researchers have made great efforts analyzing the differences in dough behavior of normal and so-called non-bakable wheats. Both physical and chemical methods have been used to find the factors causing sticky dough. Several researchers have tried to design test instruments to determine the degree of dough stickiness (Bolling, 1975).

Research on Finding Sources of Flour Dough Stickiness

Rohrlich et al (1973) detected sticky quality in air-classified fractions which were high in protein but low in pentosans. However, the sticky quality did not appear in fractions which were high in starch and pentosans. Based on those results he concluded that the protein components participate in stickiness. To analyze the function of each individual component and their combination in sticky dough, Suckow and his co-workers (1983) isolated the most important components from various wheat varieties, fractionated them, and characterized them by physical and chemical methods. The characterizations were carried out with physical and chemical research procedures commonly used in flour chemistry, and with newly-developed isolation and fractionation techniques to separate flour components, such

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as pentosans and glycoprotein. In addition to determining the flour component causing the negative dough properties, the normal and problem wheat flours were also separated into their components. From these, reconstituted flours were produced to determine the quality changing effect of the individual fractions (Suckow et al 1983). Unfortunately, after analyzing the relationship between dough stickiness and each individual flour components, they concluded that no one fraction was responsible for dough stickiness (Suckow et al 1983).

It is possible that stickiness is produced not by an individual component, but rather through the interaction between different flour substances. Rather than cereal components themselves, the environmental conditions under which vegetation phase was grown also seems to be involved in the formation of wet and sticky doughs (Suckow et al 1983). This statement can be illustrated by the samples they tested from 1980 in cultivation zone Schleswing-Holstein of Germany. In that year, unfavorable weather conditions dominated, after a cool and wet period lasting until August, warm weather appeared shortly before the harvest, that led to heavy enzyme activation in the kernel. As a result, the wheat harvested generally had a high amylolytic activity, which was expressed in extremely low falling numbers. The dough produced from these samples were moist and sticky (Bolling and Gerstenkorn 1980). In

addition to the increased amylolytic activity, it was also found that the problem wheat varieties have higher content of soluble materials, especially the content of soluble glucose polymers (Suckow et al 1983).

Instrumental Studies of Dough Stickiness

One approach aimed at distinguishing between breadmaking wheat and feed quality wheat was the use of a stickiness test suggested by Bolling (1975). The Bolling method relied on subjective hand determination of the degree of stickiness.

To study this method, the technical representatives within the National Milling Association of the European countries, known as the "Groupement", discussed the Bolling test. They rejected the Bolling test, owing to its lack of reproducibility, and decided to develop an EC baking test. The first baking test was based on the work of the ICC Baking Test Study Group. The test involved mixing flour to a predetermined energy level with salt, sugar, reconstituted dried yeast, and no fat. In performing the test, laboratories were asked to comment on physical characteristics of the dough at various stages. Good agreement was found on the physical state of the dough up to the molding stage and on its machinability. It was, therefore, recommended, and accepted. But wide variations in results on individual samples were found between laboratories (Ford et al 1981). A modified test using

standardized equipment was also adopted, namely, a Stephan high-speed mixer and a Brabender ball homogenizer. As there has been no further agreement or improved process, this standard test still holds (Ford et al 1981).

INACTIVATION OF ALPHA-AMYLASE IN WHEAT AND FLOUR WITH ACID

The use of problem wheat for bread flour is often limited by its frequently excessive alpha-amylase activity. This adversely affects the quality of the bread obtained, and it also causes difficulties at the bakery up to and including the slicing stage. The wet harvest conditions produced high levels of alpha-amylase activity in many samples. There is a recurring but unsolved need to greatly reduce the alpha-amylase of these wheats, or flours, without otherwise damaging their baking quality.

The inactivation of alpha-amylase in flour and wheat by hydrochloric acid treatment, followed by neutralization with ammonia gas, has been suggested (Fuller et al 1970). Visco metric measurements were made using the Brabender amylograph. In studies on the effect of pH on the peak viscosity of flour-water slurries, flour (60g) was stirred mechanically for 1 hr. at room temperature in 0.1N HCL. After pH measurement (adjust to 2.5), the flour-acid slurry was neutralized by the addition of 0.1N NaOH and water necessary to give a weight of 510g to equal 60g of flour + 450 ml of water. This (neutralized) slurry was then transferred to the amylograph to determine its peak

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viscosity in the usual manner. In other studies, peak values were obtained for a mixture of flour (80g) or heat-inactivated flour (70g) with water (450 ml), using in all measurement, the standard 700 cm-g torsion head and a final temperature of 95oC.

After such a treatment, they concluded that a considerable degree of irreversible inactivation of alpha--amylase could be achieved by gaseous hydrochloric acid treatment of "dry" flour, or the aqueous hydrochloric acid conditioning of wheat. Careful control of the experimental conditions was necessary to minimize deleterious effects on the other flour constituents.

The destruction of alpha-amylase activity by acidification has also been examined by Meredith (1970). The acidinactivation was tested by a modified Falling Number method, 5g flour was given 20 shakes with 12.5ml 0.1 N HCl. After 20min standing at 26.7oC , 12.5ml O.1N NaOH was added and 20 further shakes were given. The remainder of the procedure was the same as the standard Falling Number method. The pH of an inactivated flour slurry was the same as that of a flour-water slurry.

The experiment showed that acidification of a wheat flour slurry to pH 2.5 or below irreversibly inactivates flour alpha-amylase. Inactivation is completed in only a few minutes at room temperature. Beta-amylase is also largely destroyed under these conditions.

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MATERIAL AND METHODS

Flours milled from certain wheat varieties yield sticky doughs. Among them was 150A ANZA (sample 3) from California Wheat Commission; a 50:50 blend of two unnamed varieties (Sample 1) (Courtesy of Bread Research Institute, Sidney); a US Wheat Siouxland (sample 4); and 154A ANZA (sample 2)--- a second flour from California (Courtesy of California Wheat Commission). These wheats were used for our initial work. Sticky doughs were found with samples 1, 3, and 4. Dough made from sample 2 was not sticky. The sticky and nonsticky doughs in this study are similar to those illustrated in Fig. 1 and Fig. 2.

Basic Information on Flour Samples

Moisture Content of Flour Samples

The moisture content of flour samples was determined by AACC method 44-15A. They were 13.0%, 14.0%, 13.7%, and 12.9% respectively (Table 1).

Optimum Water Absorption and Peak Time Determination

It is well known that both adding too much water to flour or overmixing result in sticky dough (Mecham, 1964). In order to precisely measure the variation in stickiness between flour doughs, optimum water absorption and mixing time must be used.

Figure 1. Demonstration of Nonsticky Dough (Courtesy of
Dr. David Martin, Toowooba, Queenslord Austraiia).

Figure 2. Demonstration of Sticky Dough (Courtesy of
        Dr. David Martin, Toowooba, Queenslord Australia).

TABLE 1. MOISTURE CONTENT OF SAMPLES

SAMPLE	MOISTURE CONTENT (%)	STANDARD DEVIATION
FLOUR 1	13.0	0.14
FLOUR 2	14.0	0.10
FLOUR 3	13.7	0.14
FLOUR 4	12.9	0.14

The standard AACC Mixograph procedure (54-40) was employed to determine these two optimum values. At least three different water absorption levels were compared for each sample. The amount of flour sample used each time was 10 grams. The Mixograph is available from National Manufacturing A Division of TMCO,Inc. 554 "J" Street Lincoln, Nebraska 68508.

Determination of Dough Stickiness

Sticky and nonsticky dough in this study were defined as follow: if a dough ball could be made after optimum mixing with optimum water absorption, the dough was called nonsticky one, otherwise, the dough was called sticky one.

Enzyme Activities in Flour Samples

Cereals contain two types of amylases. Alpha-amylase is an endoenzyme which hydrolyses alpha-1, 4-glucosidic bonds on a nearly random basis. The result of the enzyme action is to rapidly decrease the size of large starch molecules and thereby to rapidly reduce the viscosity of a starch slurry.

The standard Falling Number Method was used in determining alpha-amylase activity (AACC Approved Method 56-81B). The instrument used in this step was Falling Number 1400 manufactured by Falling Number AB, Norlandsgaton 16 in Stockholm, Sweden.

The action of beta-amylase working on starch polymers results in dextrins that are still quite large. Therefore beta-amylase has practically no effect on the viscosity of starch slurries. However, because of the presence of beta-amylases, the level of maltose increases.

Beta-amylase activity was estimated by using the AACC diastatic activity Method 22-15. Measurement of beta-amylase activity by itself is generally difficult, as the "activity" measured by maltose production, is influenced by the level of alpha-amylase present. The maltose value is actually a measure of the action of the combination of those two enzymes.

Modification of Flour Samples

Inactivation of Enzymes in Sample 1,2,3

Wheat flours were acidified to pH 2.5 using hydrochloric acid. The flour samples were neutralized with sodium hydroxide. The goal of this was to reduce the enzyme activity in the samples. The flours were than dried and made into doughs to determine dough stickiness.

To test for changes in dough stickiness, the acid inactivation was also applied to the dough making process. Optimum water absorption of the sample obtained from Mixograph was used and sufficient 0.1 N HCl was used to give a pH of 2.5. The acid-flour mixture was slightly stirred (10 times), and 0.1 N NaOH was added to neutralize the acid,

the flour was then mixed to a dough with optimum mixing time. Dough stickiness was then determined as described above. The acidification method can irreversibly inactivate flour alpha-amylase and most of the beta-amylase (Meredith, 1970). To verify that conclusion, both alpha-amylase and beta-amylase activities were checked after the treatment.

The Falling Number (FN) method used was to take 7g flour sample and mix it with 12.5 ml 0.1 N HCL, then shake 20 times. After 20 minute standing at 26.7oC, 12.5ml 0.1 N NaOH was added and the sample shook for another 20 times. The remainder of the procedure was the same as the standard FN method. The small amount of NaCl introduced by this technique has an insignificant effect on the FN value.

Enzyme Treatment

Enzymes used in this study were all obtained from SIGMA Chemical Company. Alpha-amylase (A 6380) used is 1,4-alpha-D- Glucan glucanohydrolase which is obtained from Bacillus species, type 11-A, which is a 4 x Crystallized, lyophilized power.

Beta-amylase (A 7005) used was 1,4-alpha-D-Glucan malto hydrolase from sweet potato, type 1-B, which is crystallized suspension in 2.3 M (NH4)2S04 solution.

Isoamylase (I 2758) was a suspension in 2.0 M (NH4)2S04 solution. Pseudomones amyloderamosa is the major source of such isoamylase.

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Pullulan 6-glucanohydrolase are actually named as Pullulanase (P 2138) which is often obtained from Enterobacter aerogenes. The pullulanase used in this study was a suspension in 3.2 M $(NH_4)_2SO_4$.

The alpha-amylase treatment was conducted using the following procedure: weigh 10g flour samples into different mixing bowls. The alpha-amylase powder was diluted to 255 units / 1 ml with distilled water. A dough was made using 1 ml (220 units) of the enzyme solution and sufficient water to give optimum absorption and then mixing to optimum. The stickiness of the dough was determined. Three different levels of alpha-amylase solution were tested.

The other three enzymes, beta-amylase, pullulanase, iso-amylase and the combination of alpha- and beta-amylase were used by substituting the enzyme for alpha-amylase. A number of doughs were made from the mixtures of 10g flour and one of the enzyme solution.

Effect of Alpha- and Beta-Amylase on Dough Stickiness

In this experiment, a flour sample having low alpha-and beta-amylase activities, i.e. sample 2, was used. The alpha-amylase activity of the original flour was determined. HPLC was used to measure the amount of maltose produced by 10g flour in 5 min. This was taken as an estimation of beta-amylase activity. Optimum water absorption and mixing time were determined from the mixograph. The details of the

procedure are as follows:

1. Weigh 10g flour.

2. Add 91 units of alpha-amylase and optimum water absorption.

3. Mix to form a dough based on the optimum mixing time from mixograph. Test the dough for stickiness.

4. Apply different levels of alpha-amylase, 182 units, 273 units, 364 units, and 455 units, etc. Repeat step 2 and 3 until the first sticky dough is obtained. At this point, measure the alpha-amylase and beta-amylase activity as described in step 7 and 8, respectively. Take this point as "initial sticky point", then reduce the alpha-amylase by 0.5 ml and test for stickiness again. If the dough is sticky, the corresponding alpha- and beta-amylase activities will determine one point, otherwise, the "initial sticky point" will be a point on the curve.

5. Add 1117 units of beta-amylase solution to the flour sample. Repeat step 2 through 4 to obtain the critical point on the curve.

6. Add various levels of beta-amylase activity, i.e. 2234 units, 3352 units, and 4469 units separately, to the flour sample and repeat step 2 through 4 above three times.

7. Determination of alpha-amylase activity.

Weigh 7g flour sample and place it into the viscometer tube. Add alpha-amylase activity which is proportional to the amount used in the first sticky dough of 10g flour sample.

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Then determine alpha-amylase activity using standard Falling Number procedure.

8. Determination of beta-amylase activity. The beta-amylase activity is determined by weighing a 10g flour sample. Add water to give a ratio of flour to water of 1:5. Stir for 5 min., then centrifuge at 2000 rpm for 15 min. The supernatant is treated with 95% ethanol to give a ratio of 80ml : 20ml between ethanol and water. After 30 min. standing at room temperature, the ethanol treated solution is centrifuged again. The supernatant is taken as the sample for the determination of amount of maltose in 10g flour using standard HPLC technique.

9. An existing computer software program (SAS) was utilized to make a non-linear regression analysis on these data points. The best fitted equation was selected.

RESULTS AND DISCUSSION

Optimum Water Absorption and Mixing Time

Three different water absorption levels for each sample
were tested. As an example, mixograms of sample 1 with
water absorption level of 57%, 58% and 59% are shown in Fig.
3, Fig. 4, and Fig. 5. The wild swings found in Fig. 3
indicates that the dough is too dry. The relatively narrow
curve for 59% of water in the flour dough is shown in Fig.
4. Fig. 5 appears to be optimum and, therefore, it was
chosen as the indication of optimum water absorption and
mixing time. The optimum water absorption for samples 2, 3,
and 4 were selected by the same procedure. Results are
shown in Fig. 6, Fig. 7 and Fig. 8, respectively. From
these mixograms, the optimum water absorption and mixing
time was determined (Table 2).

Enzyme Activity in Flour Samples

Relatively low Falling Number values indicating high
alpha-amylase activity were found for sample 1, 3 and 4.
They are shown in Table 3. These results are in agreement
with the work of Suckow et al (1983) that problem wheats
have a high amylolytic activity. Sample 2 which gives a
normal dough shows much lower alpha-amylase activity than
the other samples.

Maltose production, a combined action of alpha- and

Figure 3. The Mixogram of Sample 1 with 57% Water Absorption

RESISTANCE

MIXING TIME (MIN.)
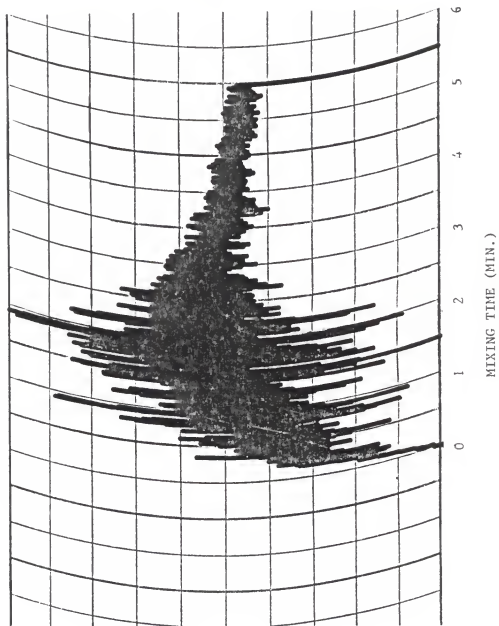
Figure 4. The Mixogram of Sample 1 with 59% Water Absorption.

RESISTANCE

MIXING TIME (MIN.)
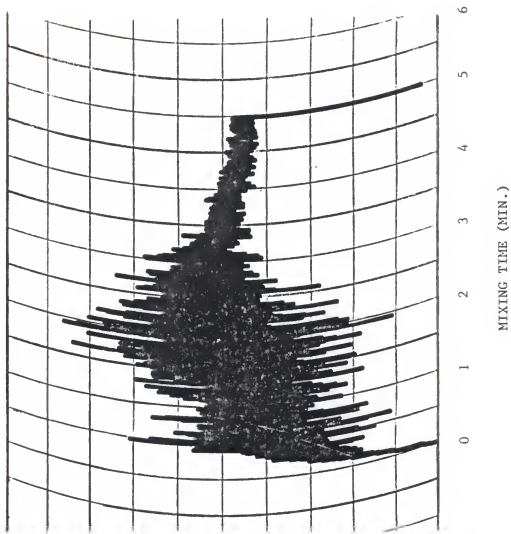
Figure 5. The Optimum Mixogram of Sample 1.

RESISTANCE

MIXING TIME (MIN.)
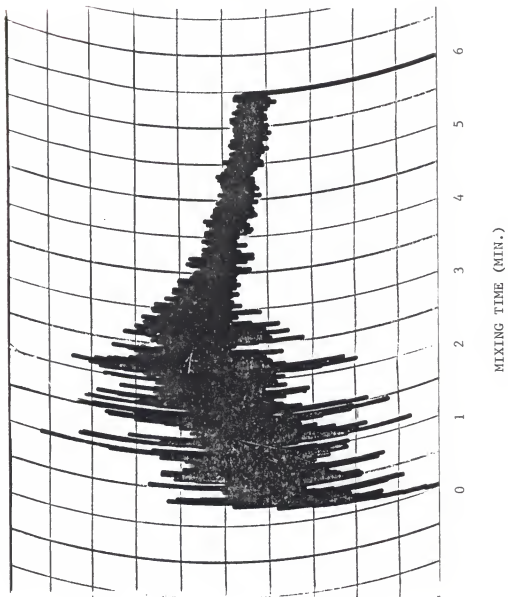
Figure 6. The Optimum Mixogram of Sample 2.

RESISTANCE

MIXING TIME (MIN.)

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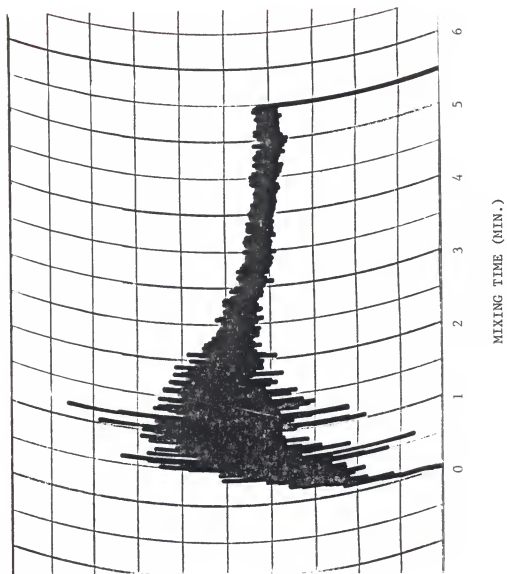
Figure 7. The Optimum Mixogram of Sample 3.

RESISTANCE

MIXING TIME (MIN.)
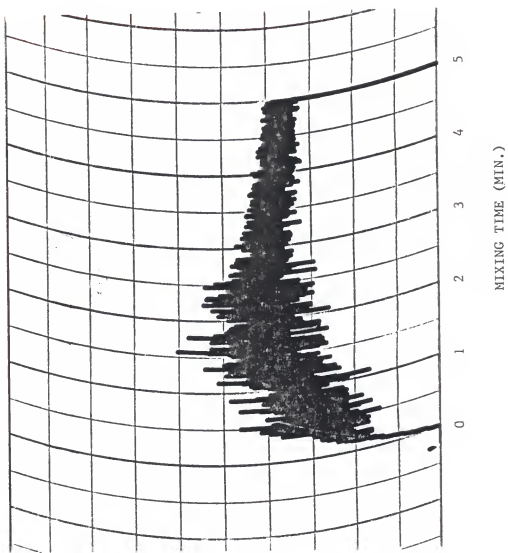
Figure 8. The Optimum Mixogram of Sample 4.

RESISTANCE

MIXING TIME (MIN.)
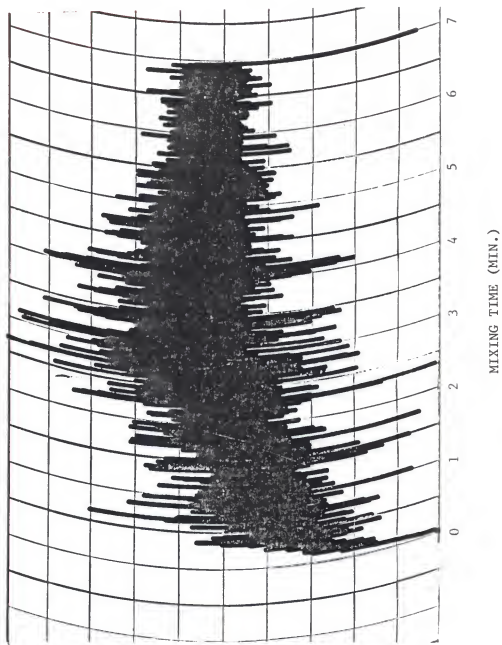
TABLE 2. DATA FROM MIXOGRAPH

SAMPLE	WATER ABSORPTION (%)	PEAK TIME (min.)
FLOUR 1	58	2.25
FLOUR 2	53	1.75
FLOUR 3	57	1.00
FLOUR 4	60	3.50

TABLE 3. FALLING NUMBER OF FLOUR
(BEFORE ACID TREATMENT)

SAMPLE	MEAN FN	STANDARD DEVIATION
1	248	2.83
2	438	3.61
3	310	4.24
4	298	3.61

beta-amylase was also tested. The same tendency as found with alpha-amylase activity, that is, sample 2 had lower beta-amylase activity than the other samples (Table 4). In general, it was concluded that the enzyme activity in the flour creating sticky dough were higher than those in normal flour.

Effects of Acid treatment on Dough Stickiness

Both alpha- and beta-amylase activities are decreased after acid inactivation as shown in Tables 5 and 6. Changes of enzyme activities in sample 1 and 4 were significant. Falling Number values for sample 1 increased from 248 to 319; for sample 4, from 298 to 387. The maltose produced from 10 grams flour in sample 1 decreased from 338 to 276; for sample 4, from 235 to 203. These results are in good agreement with the previous results by Meredith and his coworkers (1970). Unlike sample 1 and 4, the Falling Number and maltose value for sample 3 were not significantly changed by the acid treatment (Table 7). The reason for this is still unclear.

Doughs made from sample 1, 3, and 4 become nonsticky after acid treatment (Table 8). According to Meredith (1970), acid treatment has little or no effect on flour components, such as protein and starch. Therefore, it is reasonable to conclude that the levels of enzyme activities are the major factors causing the change of dough stickiness.

TABLE 4. MALTOSE PRODUCED BEFORE ACID TREATMENT.

SAMPLE	AMOUNT OF MALTOSE (mg/10g flour)	STANDARD DEVIATION
1	338	13.0
2	154	3.6
3	182	8.4
4	235	5.0

TABLE 5. FALLING NUMBER OF FLOUR
(AFTER ACID TREATMENT)

SAMPLE	FALLING NUMBER	STANDARD DEVIATION
1	319	2.24
3	317	1.41
4	387	2.13

TABLE 6. MALTOSE PRODUCED AFTER ACID TREATMENT.

SAMPLE	AMOUNT OF MALTOSE (mg/10g flour)	STANDARD DEVIATION
1	276	6.40
3	167	9.22
4	203	12.04

TABLE 7. CHANGES OF ENZYME ACTIVITIES IN SMAPLE 3 (BEFORE AND AFTER ACID TREATMENT)

ENZYME ACTIVITIES	BEFORE ACID TREATMENT	AFTER ACID TREATMENT
alpha-amylase (falling number)	310	317
beta-amylase (mg/10g flour)	182	167

TABLE 8. EFFECT OF ACID TREATMENT ON DOUGH STICKINESS

ACID TREATMENT	SAMPLE 1	SAMPLE 3	SAMPLE 4
BEFORE	STICKY	STICKY	STICKY
AFTER	NONSTICKY	NONSTICKY	NONSTICKY

Starch is a polymers of alpha-D-glucose. Chemically, at least two types of polymers are distinguishable, amylose and amylopectin. Both alpha and beta-amylase have the ability to cleave alpha 1,4-glucosidic bond of amylose and amylopectin. Beta-amylase produces maltose and large molecular weight limit dextrins. Alpha-amylase produces oligosaccharide also known as dextrins. The higher the enzyme activity, the more the low molecular weight dextrins will be produced. These small dextrins are suspected to be the factor causing the sticky doughs.

Effects of Enzymes on Dough Stickiness

It was essential to have a flour sample which was very low in enzyme activity to study the effect of enzyme treatment. Sample 2 was a nonsticky sample that also had low alpha- and beta-amylase activities.

Effect of Alpha-amylase

Three different levels of alpha-amylase activity were used in the test. When 255 units of alpha-amylase per 10 gram flour were added, no changes were observed. However, when 510 units were added, the dough made from sample 2 was sticky. At that level of alpha-amylase the sticky doughs from sample 1,3 and 4 appeared more moist than before. Extremely moist and sticky doughs were found using 765 units of alpha-amylase. We assume that phenomenon occurred

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because of the amount of small dextrins produced in the dough.

Effect of Beta-amylase

Sticky doughs were not produced by adding beta-amylase (55860 units/10g flour) to dough making process. Beta-amylase alone is not able to create small dextrins, the products are maltose and beta-limit dextrins of large molecular size. However, beta-amylase has the ability to reduce the size of small dextrins produced by alpha-amylase. When only 255 units/10g flour of alpha-amylase was used, no changes on dough stickiness were observed, whereas the sticky dough was obtained when the combination of 255 units/10g flour of alpha-amylase and 3352 units/10g flour of beta-amylase was used. This apparently is because the majority of the small dextrins produced by alpha-amylase were reduced to a particular size range. Their size and amount were sufficient to just reach the sticky level. Therefore, one can predict that if no beta-amylase activity exists, it is impossible to produce sticky dough. In general, the experimental results suggest that raising enzyme activities in wheat flour will result in a sticky dough becoming more sticky, and a nonsticky doughs becoming sticky.

Effect of Isoamylase

TABLE 9. EFFECT OF ENZYME TREATMENT ON DOUGH STICKINESS

ENZYME	QUANTITY ADDED (UNITS)	STICKY DOUGH	NONSTICKY DOUGH
alpha-amylase	255	sticky	nonsticky
	510	sticky	sticky
	765	sticky	sticky
beta-amylase	2793	sticky	nonsticky
	5586	sticky	nonsticky
	55860	sticky	nonsticky
alpha-amylase + beta-amylase	255+1117	sticky	nonsticky
	255+2234	sticky	nonsticky
	255+3352	sticky	sticky
isoamylase	13	sticky	nonsticky
	130	nonsticky	nonsticky
	260	nonsticky	nonsticky
pullulanse	18	nonsticky	nonsticky
	36	nonsticky	nonsticky
	55	nonsticky	nonsticky

The dough made from sample 2 remained nonsticky after treatment with various levels of isoamylase (Table 9). Doughs made from sample 1, 3, and 4 were still sticky until 130 or more units of isoamylase per 10g flour were added.

Isoamylase is a debranching enzyme which breaks only alpha-1,6-glucosidic bonds to yield linear dextrins. These linear dextrins can then be degraded to maltose by beta-amylase.

Effect of Pullulanase

Pullulanase is another debranching enzyme which also cleaves alpha-1,6-glucosidic linkages. The difference between pullulanase and isoamylase is that pullulanase debranches side chains of two or more glucose units, whereas isoamylase requires a side chain of at least three glucose units.

In sticky dough, both alpha- and beta-amylase are involved in degrading starch molecules. Beta-amylase is known to have a fast action on soluble starch. When isoamylase is added to the flour-water system, some branched dextrins with side chains of only 2 glucose units are resistant to isoamylase action. However, pullulanase is capable of debranched those structures. Because of this, the sticky dough which was still sticky after low level of isoamylase treatment (Table 9) might become nonsticky as a result of the action of pullulanase. After pullulanase

treatment of sample 1, 3 and 4, non-sticky doughs were produced.

The Establishment of a Stickiness Map

Various combination of alpha-amylase and beta-amylase were used to determine the critical points at which sticky dough will be produced. Five such critical points were located and are listed in Table 10.

Five curves were obtained from HPLC as shown in Fig. 9 through Fig. 13. These large peaks eluting first from the HPLC column are dextrin peaks. The second peak is maltose. The areas under the maltose peaks were determined and the value converted to the amount of maltose in 10 grams of flour sample as illustrated in Table 11.

The data plot was drawn based on the data of enzyme activities at each critical points shown in Table 12, and the best fitted equation was selected as:

$$\text{AMOUNT OF MALTOSE} = 42.52*\text{EXP}(0.0059*\text{FN}) \quad (R^2=0.94)$$

The 'stickiness map' was established and shown in Fig. 14. The combination of alpha- and beta-amylase activity on or above stickiness curve results in a sticky dough.

Sample 1, 3, and 4 produce sticky doughs. The combination of alpha- and beta-amylase activity in sample 1 and 4 fell into the range resulting in a sticky dough. The enzyme

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TABLE 10. AMOUNT OF ADDED ENZYME AT POINTS THAT
START TO GIVE A STICKY DOUGH.

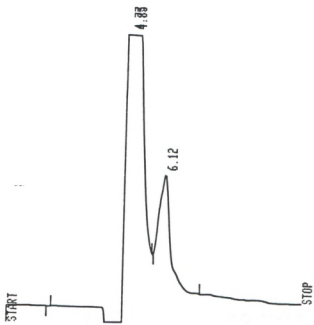| POINTS	ALPHA-AMYLASE (UNITS)	BETA-AMYLASE (UNITS)
1	455	0
2	364	1117
3	273	2234
4	182	3352
5	91	4469

Figure 9. Dextrin and Maltose Peaks for Point 1
Giving A Sticky Dough.

Figure 10. Dextrin and Maltose Peaks for Point 2 Giving
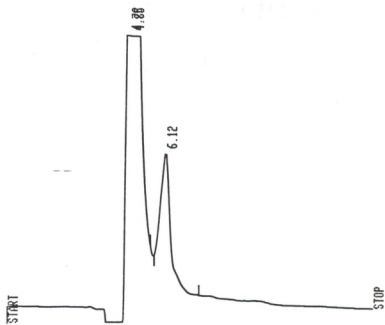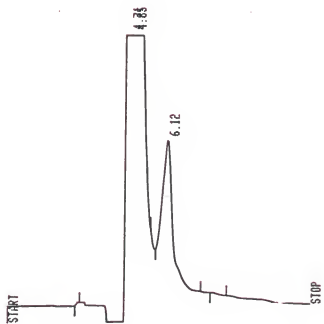A Sticky Dough.

START   4.80   6.12   STOP

Figure 11. Dextrin and Maltose Peaks for Point 3
Giving A Sticky Dough.

Figure 12. Dextrin and Maltose Peaks for Point 4
         Giving A Sticky Dough.

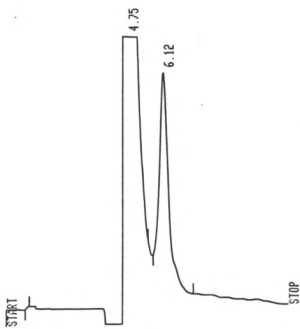START

4.75

6.12

STOP

Figure 13. Dextrin and Maltose Peaks for Point 5
Giving A Sticky Dough.
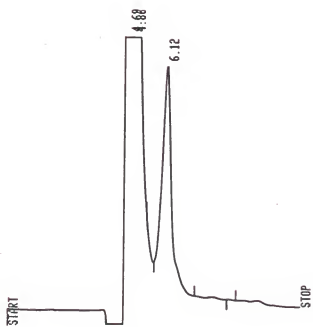
TABLE 11. AREAS OF MALTOSE PEAKS VS. AMOUNT
OF MALTOSE

POINTS	AREAS OF MALTOSE PEAKS	AMOUNT OF MALTOSE (mg/10g flour)
1	52096	154
2	66547	195
3	72101	205
4	117510	342
5	129420	376

TABLE 12. ENZYME ACTIVITIES AT POINTS THAT START TO GIVE A STICKY DOUGH.

POINTS	MALTOSE QUANTITIES (mg/10g flour)	FALLING NUMBERS
1	154	202
2	195	265
3	205	290
4	342	345
5	376	365

Figure 14. The Stickiness Map.
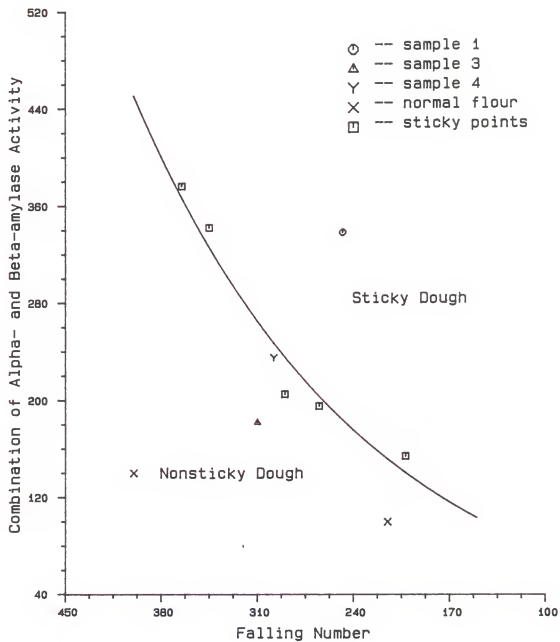
activity in sample 3 was in the range giving nonsticky dough. However, the point was not far away from the curve. This could be explained as the stickiness curve has its own standard deviation and sample 3 was probably still in the two standard deviation range.

As shown in Figure 14, normal flours usually have low beta-amylase activity (below 140 mg/10g flour per 5 min), which results in that the points representing different levels of enzyme activity for normal flours were below the stickiness curve, although sometimes they do have high alpha-amylase activity. Therefore, sticky doughs were not produced.

CONCLUSIONS

Previous work indicates that sticky doughs have relatively high levels of enzyme activities (Suckow et al 1983). In this study, it is verified that high enzyme activity is associated with dough stickiness.

Although the exact dextrin structure causing flour dough stickiness is still unknown, it is clear that relatively low molecular weight branched dextrins play a vitally important role in creating sticky dough.

The debranching enzymes, isoamylase and pullulanase, were found to be able to reduce the stickiness of flour doughs.

Acid inactivation of the amylases allows a non-sticky dough to be made from a normally sticky dough producing flour. However, careful control of the conditions is necessary to avoid denaturation of other flour components.

The "Stickiness Curve" points out that low alpha-amylase activity requires high beta-amylase activity to create sticky dough, and vice versa. Value above and to the right of the stickiness curve results in sticky dough.

LITERATURE CITED

Bolling, H.: Getreideanaiytische Methoden - Ihre Bewertung
    Hinsichtli-chderbackqualitatunter besonderer
    Berucksichtigung des Ausmahlungsgrades. Die Muhle und
    Mischfuttertechnik 111 (1974) 379.

Bolling, H., Gerstenkorn, P.: Die Qualitat der decetschen
    Weizenernte 1980. Die Muhle und Mischfutter technik 117
    (1980) 42, 559.

Bolling, H. 1975. On the problem of wheats "unsuitable for
    breadmaking" a rapid method for recognizing them.
    Muhle. Mischfuttertechnik 112 (15): 256.

Fuller, P. Hutchinson, J.B., McDermott, E.E. and Stewart,
    B.A. 1970. Inactivation of alpha-amylase in wheat and
    flour with acid. J. Sci. Fd. Agric., Vol. 21:27.

Mecham, D.K. 1964. Changes in flour proteins during dough
    mixing. The Baker's Digest, Vol. 38: 46.

Meredith, P. 1970. Inactivation of cereal alpha-amylase by
    brief acidification: the pasting strength of wheat
    flour. Cereal Chem. 47: 492.

Rietzel, P.: Neue Bewertungsmerkmale fur Weizensorten.
    Hannoversche Land und Forstwirtschafts-Zeitung 30
    (1975).

Rohrlich, M., Friedel, K.: Uber Haftprotein-Starke, Freie
    Starkeund Windsichtung von Weizenmehl. Chem. Mikrobiol.
    Technol. Lebensm. 2 (1973) 165.

Suckow, P., Abdel-Gawad, A. and Meuser, F. 1983.
    Experiments to explain the Anomalous Technological
    Behavior of Non-bakable Wheat. Technische Universitat:
    Berlin.

A STUDY OF WHEAT FLOUR DOUGH STICKINESS

by

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Four enzymes were used in structure determination of the
dextrin which could be the factor causing wheat flour dough
sticky.   The effect of various levels of those enzymes on
dough stickiness was examined.

The low molecular weight branched dextrins were shown to
result in sticky dough.   The levels of alpha-amylase and
beta-amylase activity and their combinations were found to
be the critical factor determining the degree of dough
stickiness.   Isoamylase and pullulanase were shown to
eliminate or reduce dough stickiness.

The acid inactivation of alpha-amylase and beta-amylase
activities in wheat flours by O.1N HCL treatment, followed
by neutralization with O.1N NaOH was used.   Both alpha- and
betaamylase activities were considerably reduced after such
treatment, and dough stickiness was eliminated.

A so-called "stickiness curve " was established that was
helpful to predict what flours will give sticky doughs.