# TO DETERMINE WHAT EFFECTS THE AMOUNT AND KIND OF BLEACH USED ON FLOUR HAVE IN RELATION TO ITS AGING

by

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# INTRODUCTION

The chemical and physical changes which take place when bleached or chemically treated flours are placed in storage have not been clearly determined. It is generally known that flour which has been stored for any length of time may show a decided change in both chemical and physical properties. Some investigators have suggested that the coloring matter present in a flour is a nitrogenous compound containing an amino radical. Others believe it is a non-nitrogenous body akin to xanthophyll and carotin ($C_{40}H_{56}$) the natural yellow pigments of plants. The coloring matter has certain of the characteristics of carotin such as decolorization by heat, light, and chemical reagents.

Color is a variable property in flour, and we may consider it as being permanent only after a change secured by the aging and maturing process which results from bleaching. The color of unbleached flour is generally taken as one index of quality, as it indicates the variety of wheat from which the flour was produced, and the extent to which the aging and maturing process has been carried. While in a general way, the changes in color which take place when flour is aged may be described, it is not

possible to measure them with the same degree of accuracy as is used in the determination of other characteristics.

## Reasons for Flour Bleaching

We may more fully appreciate the rapid advance which bleaching has made in the milling industry, and its universal acceptance as essential, if we remember that bleached flour is a comparatively new article of food which at the present time is receiving considerable attention.

The first commercial reason for the bleaching of flour was the decided advantage which the northwestern mills had in producing a whiter flour from the hard northern wheats than the southwestern mills could produce from the hard winter wheats. The southwestern mills found that by bleaching their flour, that it commanded as high a price as the flour produced by the northern mills. This led to a rivalry between the mills of these two sections which finally induced government intervention and led to the seizure and confiscation of flour shipments.

The early conceptions of the significance of flour bleaching varied considerably from our present views. Mill superintendents and millers did not agree on the benefits that bleaching would have for the industry. The artificial bleaching process was called into question under the pure

food laws under the contention that it added a poisonous, antiseptic ingredient, injured quality and made the flour to appear of better grade. The statement "There can be no honest milling as long as we have bleaching" was made by the leading mill superintendents of the country fifteen to twenty years ago. Since color is an important factor in judging the quality of a particular food, there are very few products in which an attempt is not made to indicate falsely by means of modified color some genuine quality much desired by consumers.

This controversy over the bleaching of flour was finally taken in charge by the Federal Board of Food and Drug Inspection, and the Secretary of Agriculture who stated that bleaching should be held as an adulteration prohibited under the Federal Food and Drug Act. Many mills approved the stand taken by the federal government on the bleaching of flour, and many disapproved the action of the government contending that it had materially lessened the possibility of opening new trade channels, and caused a curtailment of mill operations. Flour shipments were inspected by government officials, with orders to confiscate any flour which showed evidence of having been artificially bleached. The question of the bleaching of flour was forcibly brought before the industry by the seizure of a

car of flour milled by the Lexington Mill and Elevator Company of Lexington, Nebraska, consigned to B.O. Terry, at Castle, Sullivan County, Missouri. The seizure of this car of flour had been previously arranged by the federal authorities with the Lexington Mill and Elevator Company in order to test the validity of flour bleaching, and the government's stand on future problems of this nature.

It was charged that the flour in question was treated by a process for bleaching flour known as the Alsop process, and that nitrites or nitrite reacting materials had been added which injuriously affected its quality and strength. It was further charged that the freshness or age of the flour was concealed by the treatment of the flour with the Alsop process, and that this process had concealed the inferiority by giving it the appearance of a better grade of flour than it really was.

It was further charged that the flour was made from wheat inferior to that generally used for this grade of flour which was usually made from first quality hard wheat, and that therefore it was misbranded, due to the fact that it was milled in part from irrigated wheat grown in the immediate vicinity of Lexington. This wheat had the characteristics known as yellow berry, and constituted from ten to twenty-five per cent of the total wheat used in making the flour. The yellow berry wheat was considered

by millers as less desirable and of less value commercially.

The fact that the Patent Office at Washington had issued a patent for the Alsop process did not in any way warrant the adulteration of the flour, was forcibly brought out by the prosecution in their attempt to show that not only was the flour which was seized, misbranded, but that it was likewise adulterated. The trial which lasted for several weeks was finally brought to a close when the jury returned two verdicts, stating that the flour was adulterated, and that it was also misbranded.

This case was finally referred to the Circuit Court of Appeals who held that the testimony was insufficient to show that the flour was bleached primarily to conceal its inferiority, and that there was no substantial proof to warrant the conviction of the defendant. Later the government issued a permit allowing bleached flour to go into interstate trade on condition that the containers were labeled: "bleached" or "artificially matured."

## Principal Chemical Bleaches

Nitrogen Peroxide. The four chemical substances or the reagents which are employed for the bleaching of flour at the present time are: nitrogen peroxide, chlorine, nitrogen trichloride and benzoyl peroxide. Nitrogen peroxide is the oldest of these flour bleaching reagents. In combination with carotin ($C_{40}H_{56}$) it forms a colorless compound of un-

known composition.

The production of nitrogen peroxide for flour bleaching purposes is generally accomplished by the aid of a continuous electric arc, over which a current of air is passed in excessive volume. Under these conditions a small quantity of nitric oxide (NO) is formed from the nitrogen and oxygen of the air. This colorless gas rapidly oxidizes and becomes nitrogen peroxide, which is a reddish brown gas which is given the empirical formula $N_2O_5$, but which in reality is merely a mixture of $NO_2$ and $NO_3$. The current of air with its content of nitrogen peroxide is conducted into an agitator holding the flour which is being thoroughly stirred causing the flour to be bleached. This is the so called Alsop process. Flour that has been treated with nitrogen peroxide in this way is often described as having been electrically treated, although the flour itself has not been subjected to any such influence.

When nitrogen peroxide is applied to the flour it acts not only upon the carotin, but reacts also with the water which is present in the flour. This reaction with the water takes place according to the equation:

$$2\,NO_2 + H_2O \longrightarrow \underset{\text{Nitrous acid}}{HNO_2} + \underset{\text{Nitric acid}}{HNO_3}$$

Benzoyl Peroxide or Novadelox-B. Benzoyl peroxide is a white crystalline product and has been used under the trade name of "Lucidol" for many years in bleaching fatty oils. It is somewhat explosive, and for this reason is properly blended with carrying agents and ground to a powder for flour bleaching purposes.

Novadelox, which has been used extensively in recent years, is said to contain 25 per cent benzoyl peroxide and 75 per cent acid calcium phosphate. The action of Novadelox is due to the fact that benzoyl peroxide easily releases its oxygen thereby changing into benzoic acid, while the oxygen reacts with the carotin on the flour. The property that makes benzoyl peroxide preferable to others as a bleaching reagent for flour is evidently its solubility in fats. Carotin is likewise soluble in fats, and is probably present in the wheat combined with the fats. It is then evident that a bleaching reagent which is soluble in the fatty constituents of the flour must be more active than one that is not.

The reaction of benzoyl peroxide is:

$$O + (C_6H_5CO)$$

$$O + (C_6H_5CO) + H_2O \rightarrow 2\ C_6H_5COOH + O_2$$

Benzoyl peroxide — Benzoic Acid

Benzoic acid is a harmless germicide, and it does not affect the chemical composition of the flour in any manner. Any traces of benzoic acid are expelled during baking.

Chlorine. Chlorine for flour bleaching purposes is handled commercially in a liquid state. A mixture of chlorine with a little nitrosyl chloride is very frequently used as a flour bleaching reagent. Nitrosyl chloride (NOCL) is at ordinary temperatures and pressure a yellow gas, which may be easily condensed to a reddish yellow liquid. Nitrosyl chloride is a very effective bleaching agent, but is not employed alone in practice as it is not suitable for transporting in steel containers.

Nitrosyl chloride with a very large admixture of chlorine may however be kept in steel drums and such a mixture is considered to be more efficient as a bleaching agent than pure chlorine. The German product "Golo" is a mixture of 99 per cent chlorine with 1 per cent nitrosyl chloride, while the American bleaching agent "Beta-Chlora" is said to contain 99.5 per cent chlorine and .5 per cent nitrosyl chloride.

When chlorine is applied to flour it not only united with the carotin but also with other constituents, and in particular the fat present in the flour. The fat in a chlorine bleached flour will thus contain a larger proportion of the chlorine present than that of a corresponding

kind of flour which has not been bleached with chlorine. This will be treated later more thoroughly as it is of importance in the analytical detection of the bleaching of flour with chlorine. The maturing of flour with chlorine bleach is used extensively, in that it assures optimum results in a very limited time. The gluten of the flour is so modified that flours properly bleached, will produce maximum baking characteristics shortly after bleaching.

Nitrogen Trichloride or Agene. Nitrogen trichloride is the active substance employed in the Agene flour bleaching process. It is generated by combining chlorine dissolved in water with a solution of ammonium chloride. The two substances react to form nitrogen trichloride which is removed from the water by a current of air. This is done by passing the solution downward through a tower filled with marbles, and blowing a current of air upwards thus completely removing the compound from solution. This air contains nitrogen trichloride gas and is used to the amount of one to five grams of nitrogen trichloride per barrel, depending upon the type of flour and the amount of bleaching desired. The air carrying the nitrogen trichloride gas is highly saturated with moisture, and reaches the flour with nearly one hundred per cent humidity.

The gas, which is thoroughly agitated with the flour in the presence of moist air, reacts with the flour so that

the gas is completely absorbed and converted to its final reaction products. None of the free gas remains in the flour, nor are any materials present which might further increase the oxidation.

When Agene is applied to the flour, it does not alter the ash content, titrable acidity, wet and dry gluten, total protein or water soluble proteins to any extent which can be determined by the ordinary laboratory methods. The properties which it does alter are those of color, texture, loaf volume in the ordinary method of baking, and all other characteristics which are associated with a loaf made from matured or aged flour. The titrable acidity of the flour is not increased, but by very careful work, it is not difficult to detect an increase in the hydrogen ion concentration when the application is made in excess of 2 to 3 gm. per barrel although even in these extreme cases the increases are very slight.

Nitrogen trichloride gas is formed according to the following equation:

$$3\ Cl_2 + 3\ MgO \longrightarrow 3\ NOCl + 3\ [illegible]$$

$$3\ NOCl + NH_4Cl \longrightarrow [illegible]_3 + 3\ MgO + HCl$$

## PURPOSE OF THE PRESENT INVESTIGATION

The purpose of this investigation is to determine what effect different rates of treatment with the common commercial chemical bleaching reagents will have on stored flour.

Flours that have been bleached and placed in storage undergo both chemical and physical changes. With this thought in mind, we planned to study the changes which take place in the stored flours after they have been bleached with varying amounts of chemical reagents, and the effect which these bleaching reagents have upon the baking characteristics.

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## EQUIPMENT USED

The conditioning of the wheat and the milling was done on the 60 barrel experimental mill of the Milling Industry department of the Kansas State College of Agriculture and Applied Sciences. The flour was bleached at varying rates by the use of the three different bleaching equipments of the Milling Industry department. It was stored in a flour storage room which had been properly fumigated to kill any insect infestation.

All baking tests were conducted in the research laboratory using the high speed mechanical mixer (Swanson and Working, 1925), also the cylindrical baking pans (Swanson, Millard and Fitz, 1915). A standard proofing cabinet equipped with a humidifier, electric oven, volume tester and cooling rack were included in the baking equipment.

Hydrogen-ion, viscosity, ash, protein and moisture tests were made by using the equipment of the research laboratory.

Photographs of the finished baked products were taken by the Illustrations department, Kansas State College of Agriculture and Applied Sciences.

## METHOD OF PROCEDURE

Realizing that a comparative study of flours made from wheat of the 1929 crop, and wheat of the 1930 crop would be more valuable, it was decided that sufficient wheat should be purchased from each crop to be used in the experiment. Sufficient wheat to make approximately fourteen forty-eight pound sacks of flour was needed from each crop. The flour was not bleached at the time of milling, but later, within 24 hours, by using the carefully controlled agitators. The following well known commercial bleaches were used: nitrogen trichloride, Novadelox-B, and chlorine. The flour was a 95 per cent standard patent, which would correspond to the greater bulk of flours being sold by mills to commercial bakeries. The flours were bleached at the following rates: 1/3 bleach, 2/3 bleach, 3/3 bleach(full), and 6/3 bleach (double). The exact amount of bleach added in each case was as follows:

### Novadelox

Using one pound of Novadelox-B
to forty barrels of flour.

| | | | | |
|---|---|---|---|---|
| 1/3 | Bleach | . . . . . | 3.8 gm. | per barrel. |
| 2/3 | " | . . . . . | 7.6 " | " " |
| 3/3 | " | . . . . . | 11.3 " | " " |
| 6/3 | " | . . . . . | 22.6 " | " " |

## Nitrogen Trichloride

Using 4.4 gm. of nitrogen trichloride gas per barrel of flour as standard bleach.

| | | | | |
|---|---|---|---|---|
| 1/3 | Bleach | 1.47 | gm. per | barrel |
| 2/3 | " | 2.94 | " " | " |
| 3/3 | " | 4.40 | " " | " |
| 6/3 | " | 8.80 | " " | " |

## Chlorine

Using 1½ ounces of chlorine gas to the barrel of flour as a standard bleach.

| | | | | |
|---|---|---|---|---|
| 1/3 | Bleach | ½ | oz. per | barrel. |
| 2/3 | " | 1 | " " | " |
| 3/3 | " | 1½ | " " | " |
| 6/3 | " | 3 | " " | " |

The Pekar test was used immediately after the flours were bleached to determine the relative accuracy of the bleaching. This showed a range from a decided yellowish tint to the usual white flour color. The ash, protein, and moisture were determined on samples of the 1929 and 1930 flours, and special attention had been given to the selection of the wheat so both lots of the flour would have nearly the same chemical analysis. A further analysis consisting of hydrogen-ion, and viscosity determinations were made of the flours from time to time to ascertain if any changes were taking place such as could be measured by these tests.

Four methods were used in making the baking tests: the sponge-dough; the two hour short fermentation straight dough; mechanical modification; and the potassium bromate differential baking test. All the loaves were baked in duplicate except when the potassium bromate differential test was used.

The amounts of ingredients used and the details of the different baking methods were as follows:

The Sponge-dough.

| Sponge | | Dough | |
|---|---|---|---|
| 300 gm. | Flour . . . . | 200 | gm. |
| 6 " | Yeast . . . . | 4 | " |
| | Salt . . . . | 9 | " |
| | Sugar . . . . | 15 | " |
| | Shortening . | 5 | " |
| | *Water . . . . | 5 | " |

* Correct absorption determined on the flour.

Sponge fermentation 4 hours at 26° C.
Sponge-dough fermentation 45 minutes at 26°C.
Proofing temperature 26°C.
Oven temperature 230°C.
Dough scaled at 418 gm.
Mixing time of sponge with dough 1½ minutes.

In this method the slack sponge which was mixed by hand contained 60 per cent of the total flour used. The fermentation of the sponge was for a period of 4 hours at 26° C. The remaining flour and yeast together with the sugar, salt and shortening was then added. These ingredients together with the sponge were then mixed for 1½ minutes on the

Swanson (1928) mixer. The mixed dough was then taken from the mixer and placed in a jar, and permitted to rise for 45 minutes during which time it was given two punches. The dough was scaled to 418 gm. to insure equal amounts of dough for every baked loaf.

The proofing was done at the same temperature as the fermentation, using the Swanson, Willard and Fitz (1915) cylindrical aluminum baking pans to eliminate as much as possible the error of moulding and over-proofing. The loaves were baked for 40 minutes at 230° C., and the volume taken after cooling. The following day the loaves were scored with the assistance of someone in the department, and photographs taken of such loaves as seemed advisable.

The Two Hour Short Fermentation Straight Dough

| | |
|---|---|
| Flour . . . . . | 500 gm. |
| Yeast . . . . . | 15 " |
| Salt . . . . . | 9 " |
| Sugar . . . . . | 20 " |
| Shortening . . . . . | 6.5" |
| *Water | |

* Correct absorption determined.

Fermentation and proofing temperature 32° C.
Oven temperature 230°C.
Doughs scaled at 418 gm.
Mixing time of dough 2 minutes.

In this method all the flour was mixed with the other ingredients at the start on the Swanson (1928) mixer for a period of 2 minutes. Two punches were given during the fermentation process. These doughs were likewise scaled at 413 gm., and all loaves were baked in duplicate. The proofing and the rest of the process was the same as for the sponge-dough method.

The Potassium Bromate Differential Baking Test.

| | |
|---|---|
| Flour . . . . . | 250 gm. |
| Salt . . . . . | 4.5 gm. |
| Sugar . . . . . | 11.5 " |
| Shortening . . . . | 4.5 " |
| Yeast . . . . . | 7.5 " |
| Water as determined by absorption. | |

Fermentation time 3 hours divided as follows:

| | | | |
|---|---|---|---|
| 1st. | punch . . . . . | 1 hr. | 30 minutes. |
| 2nd. | " . . . . . | " | 45 " |
| 3rd. | " . . . . . | " | 30 " |
| 4th | " . . . . . | " | 15 " |

Fermentation and proofing temperature at 32°C.
Doughs scaled at 413 gm.
Oven temperature 230°C.
Mixing time of dough 2 minutes.

In this method the ingredients were mixed in the same way as in the preceding method. During fermentation the dough was given 4 punches, and the total fermentation time was 3 hours at 32° C., and the proofing temperature was also 32°C. The potassium bromate solution was made so that 1 cc. of the solution was equivalent to 2.5 mg. of potassium

bromate, and 2 cc. to 5 mg. of potassium bromate. The potassium bromate solution was added directly when the dough was mixed and in the following amounts: To the first loaf, no bromate. The second loaf, 1 cc. and to the third loaf 2 cc. of bromate was added.

Mechanical Modification Method

| | |
|---|---|
| Flour . . . . . | 250 gm. |
| Salt . . . . . | 4.5 gm. |
| Sugar . . . . . | 11.5 " |
| Yeast . . . . . | 7.5 " |
| Shortening . . . | 4.5 " |
| Lactic acid . . . | ½ cc. |

Water as determined by absorption.

Mix doughs 5 minutes at high speed.
Scale at 418 gm.
Proofing temperature 32° C.
Pan loaves directly from mixer without fermentation of dough.

In this method all the ingredients were mixed at one time for a period of 5 minutes at high speed on the Swanson (1928) mixer. The dough was placed in the cylindrical baking pan directly from the mixer without any previous fermentation of the dough. The proofing temperature was 32°C.

The volumes were taken by a seed displacement volume tester, and all volumes reported in cubic centimeters as an average of duplicate baked loaves.

A loaf baked from standard unbleached flour for both Kanred and Blackhull was used for comparison in scoring the loaves.

## EXPERIMENTAL DATA AND RESULTS

The wheats used for this experiment were of the hard red winter varieties, Kanred and Blackhull. The Kanred wheat of the crop year 1929 had been stored in the bins of the Milling Industry department prior to its milling. The Kanred and Blackhull wheats for 1930 were purchased just at the beginning of harvest and the Kanred was a combine harvested wheat. Only enough Blackhull wheat was purchased to make approximately 4 - 48 pound sacks of flour, and this was bleached only with nitrogen trichloride.

### Analysis of 1929 Kanred Flour

| | | |
|---|---|---|
| Ash . . . . . | .422 | per cent. |
| Protein . . . . . | 11.20 | " " |
| Moisture . . . . . | 13.00 | " " |

### Analysis of 1930 Kanred Flour

| | | |
|---|---|---|
| Ash . . . . . | .432 | per cent. |
| Protein . . . . . | 10.65 | " " |
| Moisture . . . . . | 12.93 | " " |

### Analysis of 1930 Blackhull Flour

| | | |
|---|---|---|
| Ash . . . . . | .425 | per cent. |
| Protein . . . . . | 10.48 | " " |
| Moisture . . . . . | 12.28 | " " |

In a study of the data obtained on the various flours, it was found that a difference of less than two points in the score of crumb color and texture, and a difference in volume of 30 cc. was not significant. Reference to a discussion of the data obtained will be made by table number and plate number.

Novadel Bleached, Sponge Dough, Kanred 1929,
Table I, Plate I.

The results obtained in the baking from June 20 to August 13 show a fairly uniform increase in loaf volume, and a corresponding improvement in crumb color and texture. These improved materially with further aging of the flour as is shown by comparison with the results on the unbleached flour which was used as a standard. The slight decrease in volume of the loaves baked on December 2 is probably due to an error in measuring absorption rather than to an aging effect.

The data shows that the quality of the flour was not impaired in any way even with an excess of Novadel bleach.

A gradual improvement in crumb color and texture was noted in the unbleached flour.

PLATE 1 Sponge-Dough Method of Novadel Bleached Flour. Kanred 1929, Baked June 20,1930.


TABLE 1 Baking results on dates as shown

| Loaf No. | Amount of Bleach | June 20 | June 27 | July 7 | July 23 | Aug. 13 | Dec. 2 |
|---|---|---|---|---|---|---|---|
| 1 | Unbleached | 1565 | 1550 | 1545 | 1553 | 1520 | 1520 |
| 2 | 1/3 Bleach | 1585 | 1575 | 1570 | 1575 | 1623 | 1535 |
| 3 | 2/3 Bleach | 1570 | 1588 | 1575 | 1565 | 1577 | 1533 |
| 4 | 3/3 Bleach | 1605 | 1570 | 1585 | 1575 | 1610 | 1568 |
| 5 | 6/3 Bleach | 1567 | 1545 | 1580 | 1585 | 1575 | 1530 |
| | Color of Crumb | | | | | | |
| 1 | Unbleached | 94 | 95 | 96 | 97 | 97 | 97 |
| 2 | 1/3 Bleach | 95 | 96 | 97 | 97 | 98 | 96 |
| 3 | 2/3 Bleach | 96 | 96 | 98 | 98 | 98 | 96 |
| 4 | 3/3 Bleach | 97 | 97 | 98 | 98 | 98 | 97 |
| 5 | 6/3 Bleach | 98 | 98 | 99 | 99 | 98 | 98 |
| | Texture of Loaf | | | | | | |
| 1 | Unbleached | 94 | 96 | 97 | 98 | 98 | 98 |
| 2 | 1/3 Bleach | 96 | 97 | 98 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 96 | 96 | 98 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 97 | 98 | 98 | 98 | 97 | 96 |
| 5 | 6/3 Bleach | 97 | 96 | 98 | 98 | 97 | 99 |

Agene Bleached, Sponge Dough, Kanred, 1929,
Table II, Plate II.

The results in the bakings from June 22 to December 5 show a gradual improvement in crumb color. The volume of the loaves did not improve with the subsequent additional aging in storage of the bleached flour as shown by the data obtained. No improvement was noted in volume, crumb color or texture of the unbleached flour after July 26. The slight decrease in volume of the loaves baked on December 5 is probably due to an error in measuring absorption rather than to an aging effect.

The quality of the flour did not seem to be impaired in any way by high rates of Agene bleach as shown by the baking results.

PLATE 2 Sponge-Dough Method of Agene Bleached Flour. Kanred 1929, Baked June 22, 1930.


TABLE 2 Baking results on dates as shown

| Loaf No. | Amount of Bleach | June 22 | June 29 | July 9 | July 26 | Dec. 5 |
|---|---|---|---|---|---|---|
| 1 | Unbleached | 1560 | 1550 | 1545 | 1555 | 1550 |
| 2 | 1/3 Bleach | 1580 | 1570 | 1588 | 1615 | 1550 |
| 3 | 2/3 Bleach | 1610 | 1600 | 1590 | 1605 | 1555 |
| 4 | 3/3 Bleach | 1596 | 1605 | 1575 | 1590 | 1528 |
| 5 | 6/3 Bleach | 1623 | 1605 | 1595 | 1590 | 1545 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 94 | 95 | 97 | 97 | 97 |
| 2 | 1/3 Bleach | 95 | 97 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 96 | 98 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 96 | 98 | 98 | 98 | 98 |
| 5 | 6/3 Bleach | 98 | 99 | 99 | 99 | 99 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 96 | 96 | 98 | 98 | 97 |
| 2 | 1/3 Bleach | 98 | 97 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 98 | 97 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 98 | 98 | 98 | 98 | 98 |
| 5 | 6/3 Bleach | 97 | 97 | 98 | 98 | 98 |

Chlorine Bleached, Sponge Dough, Kanred, 1929,
Table III, Plate III

The results as shown by Table III represent only the full and double chlorine bleached flour as compared with the unbleached standard.

A decided decrease in loaf volume was noted with the high rates of chlorine bleach, while the crumb color and texture seemed to remain fairly constant. The baking results of the unbleached flour showed a corresponding improvement in crumb color and texture, but the loaf volume remained practically unchanged.

The further aging of the flour due to storage did not improve the baking characteristics of the bleached flour, but showed that high rates of chlorine bleach may seriously impair the baking qualities of the flour.

PLATE 3 Sponge-Dough Method of Chlorine Bleached Flour. Kanred 1929, Baked June 21, 1930.


TABLE 3 Baking results on dates as shown

| Loaf No. | Amount of Bleach | June 21 | June 28 | July 11 | July 25 | Dec. 8 |
|---|---|---|---|---|---|---|
| 1 | Unbleached | 1563 | 1590 | 1612 | 1560 | 1575 |
| 2 | 3/3 Bleach | 1575 | 1598 | 1595 | 1512 | 1515 |
| 3 | 6/3 Bleach | 1575 | 1565 | 1552 | 1500 | 1525 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 94 | 94 | 96 | 97 | 97 |
| 2 | 3/3 Bleach | 97 | 96 | 97 | 98 | 98 |
| 3 | 6/3 Bleach | 98 | 98 | 98 | 99 | 99 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 96 | 96 | 97 | 97 | 98 |
| 2 | 3/3 Bleach | 95 | 98 | 97 | 98 | 98 |
| 3 | 6/3 Bleach | 95 | 95 | 96 | 95 | 96 |

Novadel Bleached, Sponge Dough, Kanred, 1930,
Table IV, late IV.

The results obtained in baking from August 16, 1930, to January 22, 1931, show a fairly constant loaf volume, with a slight improvement of crumb color and texture of the loaves.

The full and double Novadel bleached flour showed an improvement in crumb color, as compared with the unbleached standard. Later this difference was not so apparent due to a further aging and change in the color of the unbleached flour. The data shows that the quality of the flour was not impaired in any way even with an excess rate of Novadel bleach.

The score of the crumb color would indicate that apparently a yellowish cast was still noticeable in the baked loaves.

PLATE 4 Sponge-Dough Method of Novadel Bleached Flour. Kanred 1930, Baked August 16, 1930.


TABLE 4 Baking results on dates as shown

| Loaf No. | Amount of Bleach | Aug. 16 | Aug. 20 | Sept. 9 | Oct. 13 | Jan. 22 |
|---|---|---|---|---|---|---|
| 1 | Unbleached | 1545 | 1505 | 1510 | 1515 | 1520 |
| 2 | 1/3 Bleach | 1515 | 1500 | 1515 | 1508 | 1490 |
| 3 | 2/3 Bleach | 1595 | 1490 | 1495 | 1500 | 1545 |
| 4 | 3/3 Bleach | 1490 | 1505 | 1510 | 1505 | 1530 |
| 5 | 6/3 Bleach | 1485 | 1473 | 1480 | 1490 | 1597 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 95 | 95 | 96 | 97 | 98 |
| 2 | 1/3 Bleach | 95 | 96 | 96 | 97 | 97 |
| 3 | 2/3 Bleach | 95 | 96 | 96 | 97 | 97 |
| 4 | 3/3 Bleach | 96 | 96 | 96 | 98 | 97 |
| 5 | 6/3 Bleach | 97 | 97 | 98 | 98 | 98 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 95 | 96 | 98 | 98 | 98 |
| 2 | 1/3 Bleach | 95 | 97 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 95 | 97 | 97 | 98 | 98 |
| 4 | 3/3 Bleach | 95 | 97 | 97 | 97 | 98 |
| 5 | 6/3 Bleach | 96 | 97 | 98 | 97 | 98 |

Agene Bleached, Sponge-Dough, Kanred, 1930,
Table V, Plate V.

The baking results of the 1930 Kanred flour which was bleached with Agene and baked by the Sponge-Dough method shows a fairly consistent loaf volume, crumb color and texture of the loaves throughout the entire period of the investigation.

From the data obtained, it is apparent that the maturing effect of the Agene bleach made it possible to obtain optimum results at the very beginning of the experiment. The beneficial maturing effect is noted by comparing the data obtained on the unbleached flour with that of the full and double bleached flour.

The crumb color and texture of the bleached flours did not improve materially with the aging of the flour, and at no time did an excess of the Agene bleach seem to impair the baking characteristics of the flour.

PLATE 5 Sponge-Dough Method of Agene Bleached Flour. Kanred 1930, Baked August 21,1930.


TABLE 5 Baking results on dates as shown

| Loaf No. | Amount of Bleach | Aug. 21 | Sept.10 | Sept.19 | Oct. 20 | Jan. 24 |
|---|---|---|---|---|---|---|
| 1 | Unbleached | 1515 | 1510 | 1490 | 1490 | 1500 |
| 2 | 1/3 Bleach | 1515 | 1505 | 1480 | 1505 | 1520 |
| 3 | 2/3 Bleach | 1587 | 1547 | 1515 | 1530 | 1555 |
| 4 | 3/3 Bleach | 1555 | 1520 | 1520 | 1545 | 1550 |
| 5 | 6/3 Bleach | 1567 | 1550 | 1535 | 1520 | 1535 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 95 | 95 | 96 | 96 | 97 |
| 2 | 1/3 Bleach | 96 | 98 | 96 | 97 | 97 |
| 3 | 2/3 Bleach | 98 | 99 | 98 | 98 | 99 |
| 4 | 3/3 Bleach | 98 | 99 | 98 | 99 | 99 |
| 5 | 6/3 Bleach | 98 | 99 | 98 | 99 | 99 |
| | T xture of Loaf | | | | | |
| 1 | Unbleached | 93 | 97 | 96 | 97 | 98 |
| 2 | 1/3 Bleach | 97 | 97 | 97 | 98 | 98 |
| 3 | 2/3 Bleach | 98 | 98 | 97 | 98 | 98 |
| 4 | 3/3 Bleach | 98 | 97 | 98 | 98 | 98 |
| 5 | 6/3 Bleach | 98 | 98 | 98 | 98 | 98 |

Chlorine Bleached, Sponge-Dough, Kanred, 1930,
Table VI, Plate VI.

Referring to Table VI of the chlorine bleached Kanred flour for 1930, a rather definite decrease in loaf volume was noted in the double bleached flour from the very beginning of the investigation.

The crumb color and texture of the loaves did not decrease proportionally with the decrease in loaf volume. The maturing and bleaching effect of the chlorine bleach made it possible to obtain maximum color of the crumb at the beginning, and only a slightly inferior texture was noticeable in the double bleached flour as indicated by the score.

The data obtained on January 26, 1931, compared very favorably with that of the other tests, which showed that no further development of better or inferior characteristics could be noted due to a longer period of storage.

Only in the double bleached flour was any harmful effect noted, and that was primarily a decrease of loaf volume.

PLATE 5 Sponge-Dough Method of Chlorine Bleached Flour. Farred 1930. Baked August 19, 1930.

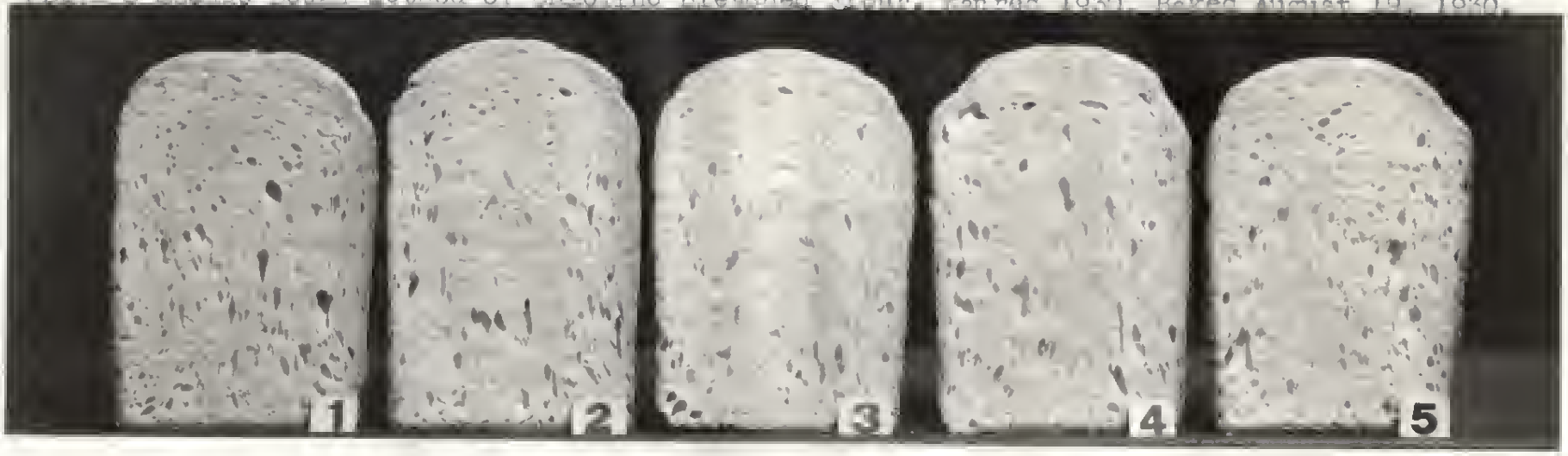


TABLE 6 Baking results on dates as shown

| Loaf No. | Amount of Bleach | Aug. 19 | Sept. 10 | Sept. 22 | Oct. 22 | Jan. 26 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | Unbleached | 1507 | 1507 | 1510 | 1520 | 1540 |
| 2 | 1/3 Bleach | 1495 | 1505 | 1500 | 1525 | 1490 |
| 3 | 2/3 Bleach | 1483 | 1490 | 1463 | 1535 | 1510 |
| 4 | 3/3 Bleach | 1505 | 1520 | 1487 | 1540 | 1510 |
| 5 | 6/3 Bleach | 1455 | 1460 | 1440 | 1480 | 1500 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 95 | 96 | 97 | 97 | 97 |
| 2 | 1/3 Bleach | 97 | 97 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 98 | 97 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 99 | 99 | 99 | 99 | 99 |
| 5 | 6/3 Bleach | 99 | 97 | 99 | 99 | 99 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 96 | 96 | 97 | 97 | 98 |
| 2 | 1/3 Bleach | 96 | 97 | 97 | 98 | 98 |
| 3 | 2/3 Bleach | 96 | 96 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 97 | 98 | 98 | 97 | 98 |
| 5 | 6/3 Bleach | 96 | 96 | 97 | 97 | 97 |

Table I. Experimental Data for Ammonium Acetates-Ammonia Mixtures at 20°C.

| Mols/liter salt | Density of solution | Cap. Height cm.(Corr.) | Radius of Cap.cm. | Surface tension dynes cm. |
|---|---|---|---|---|
| 0.0000* | .6103* | | | 22.03* |
| 1.670 | .6887 | 1.9551 | .03458 | 22.98 |
| 1.9374 | .6991 | 2.0640 | .03332 | 23.35 |
| 2.6680 | .7289 | 1.9759 | .03333 | 25.72 |
| 3.458 | .7625 | 1.9037 | .03477 | 24.54 |
| 4.1732 | .7950 | 1.9663 | .03335 | 26.49 |
| 4.1980 | .7898 | 1.9266 | .03477 | 25.28 |
| 4.4870 | .8021 | 2.0133 | .03325 | 26.12 |
| 5.3300 | .8430 | 1.9604 | .03477 | 27.97 |
| 5.8940 | .8506 | 2.0562 | .03328 | 28.64 |
| 6.0910 | .86285 | 2.0104 | .03477 | 29.37 |
| Pure Acetic Acid | | | | |
| Observed | 1.0497 | | | 27.70 |

* Determined by King, Hall and Ware

up to .8628. The surface tension-concentration diagram (Fig.1) shows a downward divergence from a straight line. The density concentration diagram (Fig.2) shows very little divergence from a straight line.

In the ammonium butyrate-ammonia mixtures, Table II, the surface tension increased up to 29.75 dynes cm. The surface tension-concentration diagram (Fig.3) also gives a marked downward divergence from a straight line. The density

PLATE 7 Straight Dough Method of Novadel Bleached Flour. Kanred 1929, Baked July 3, 1930.


TABLE 7 Baking results on dates as shown

| Loaf No. | Amount of Bleach | June 23 | July 3 | July 12 | Aug. 1 | Aug. 8 | Aug. 10 |
|---|---|---|---|---|---|---|---|
| 1 | Unbleached | 1585 | 1557 | 1555 | 1535 | 1560 | 1545 |
| 2 | 1/3 Bleach | 1567 | 1545 | 1555 | 1543 | 1553 | 1530 |
| 3 | 2/3 Bleach | 1580 | 1560 | 1540 | 1558 | 1550 | 1527 |
| 4 | 3/3 Bleach | 1565 | 1550 | 1587 | 1565 | 1575 | 1510 |
| 5 | 6/3 Bleach | 1585 | 1550 | 1550 | 1560 | 1550 | 1520 |
| | Color of Crumb | | | | | | |
| 1 | Unbleached | 94 | 96 | 97 | 97 | 97 | 97 |
| 2 | 1/3 Bleach | 95 | 96 | 98 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 96 | 97 | 97 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 97 | 97 | 98 | 99 | 99 | 98 |
| 5 | 6/3 Bleach | 98 | 98 | 99 | 99 | 99 | 99 |
| | Texture of Loaf | | | | | | |
| 1 | Unbleached | 96 | 97 | 98 | 98 | 98 | 99 |
| 2 | 1/3 Bleach | 98 | 97 | 97 | 97 | 98 | 99 |
| 3 | 2/3 Bleach | 97 | 98 | 97 | 98 | 98 | 99 |
| 4 | 3/3 Bleach | 97 | 98 | 98 | 98 | 98 | 99 |
| 5 | 6/3 Bleach | 95 | 93 | 98 | 98 | 98 | 99 |

Agene Bleached, Straight Dough, Kanred, 1929,
Table VIII, Plate VIII.

No increase in loaf volume, or improvement of crumb color and texture of the loaves is noted in the Agene bleached flour after June 25, 1930, at which time the optimum baking results were obtained by the straight dough method of the 1929 Kanred flour.

The slight decrease in volume of the loaves baked on December 14 is probably due to an error in measuring absorption rather than to an aging effect.

A further aging of the flour due to storage did not improve the baking characteristics of the flour, nor did high rates of Agene bleach seem to impair the baking quality.

PLATE 6 Straight Dough Method of Agene Bleached Flour. Kanred 1929, Baked July 2, 1930.


TABLE 8 Baking results on dates as shown

| Loaf No. | Amount of Bleach | June 25 | July 2 | July 14 | Aug. 4 | Dec. 14 |
|---|---|---|---|---|---|---|
| 1 | Unbleached | 1580 | 1560 | 1590 | 1570 | 1540 |
| 2 | 1/3 Bleach | 1590 | 1585 | 1587 | 1583 | 1527 |
| 3 | 2/3 Bleach | 1600 | 1580 | 1585 | 1590 | 1546 |
| 4 | 3/3 Bleach | 1560 | 1563 | 1570 | 1590 | 1527 |
| 5 | 6/3 Bleach | 1570 | 1560 | 1555 | 1565 | 1540 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 95 | 96 | 98 | 98 | 98 |
| 2 | 1/3 Bleach | 96 | 97 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 97 | 98 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 97 | 98 | 99 | 98 | 98 |
| 5 | 6/3 Bleach | 98 | 99 | 99 | 99 | 99 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 96 | 98 | 98 | 98 | 98 |
| 2 | 1/3 Bleach | 96 | 98 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 97 | 98 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 97 | 98 | 99 | 98 | 98 |
| 5 | 6/3 Bleach | 97 | 98 | 97 | 97 | 97 |

Chlorine Bleached, Straight Dough, Kanred, 1929,
Table IX, Plate IX.

The results shown by Table IX represent only the full and double chlorine bleached flour, as compared with the unbleached standard.

A rather definite decrease in loaf volume was noted with the high rates of chlorine bleach, and a corresponding decrease in crumb color and texture of the loaves is noticeable in the bleached flour when a comparison is made with the unbleached standard.

A further aging in storage is responsible for a definite decrease in loaf texture of the double bleached flour, while apparently the loaf volume and crumb color was not changed.

The data shows that high rates of chlorine bleach may seriously impair the baking results of the flour.

PLATE 9 Straight Dough Method of Chlorine Bleached Flour. Kanred 1929. Baked June 24, 1930.


TABLE 9 Baking results on dates as shown

| Loaf No. | Amount of Bleach | June 24 | July 5 | July 23 | Aug. 6 | Dec. 17 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | Unbleached | 1605 | 1605 | 1590 | 1565 | 1560 |
| 2 | 3/3 Bleach | 1570 | 1575 | 1570 | 1567 | 1537 |
| 3 | 6/3 Bleach | 1453 | 1450 | 1475 | 1485 | 1490 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 94 | 95 | 97 | 97 | 97 |
| 2 | 3/3 Bleach | 98 | 98 | 98 | 98 | 98 |
| 3 | 6/3 Bleach | 97 | 97 | 98 | 98 | 98 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 96 | 96 | 98 | 98 | 98 |
| 2 | 3/3 Bleach | 96 | 97 | 96 | 98 | 98 |
| 3 | 6/3 Bleach | 93 | 92 | 90 | 90 | 88 |

Novadel Bleached, Straight Dough, Kanred, 1930
Table X, Plate X.

The results obtained in baking from August 25, 1930 to January 27, 1931 shows a substantial improvement in crumb color and texture of the loaves, while the loaf volume did not increase greatly.

A gradual improvement of the unbleached standard in loaf volume, crumb color and texture was noted, but this increase did not seem to continue after January 27, 1931.

The loaf volume of the full and double bleached flour increased slightly with the high rates of Novadelox-B.

PLATE 10 Straight Dough Method of Novadel Bleached Flour. Kanred 1930, Baked August 25, 1930.


TABLE 10 Baking results on dates as shown

| Loaf No. | Amount of Bleach | Aug. 25 | Sept. 17 | Oct. 31 | Nov. 15 | Jan. 27 |
|---|---|---|---|---|---|---|
| 1 | Unbleached | 1480 | 1465 | 1515 | 1525 | 1540 |
| 2 | 1/3 Bleach | 1488 | 1500 | 1513 | 1505 | 1537 |
| 3 | 2/3 Bleach | 1473 | 1485 | 1505 | 1505 | 1500 |
| 4 | 3/3 Bleach | 1450 | 1450 | 1480 | 1490 | 1587 |
| 5 | 6/3 Bleach | 1300 | 1500 | 1515 | 1480 | 1590 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 95 | 97 | 96 | 98 | 98 |
| 2 | 1/3 Bleach | 97 | 97 | 97 | 97 | 98 |
| 3 | 2/3 Bleach | 97 | 97 | 97 | 97 | 98 |
| 4 | 3/3 Bleach | 97 | 97 | 98 | 97 | 99 |
| 5 | 6/3 Bleach | 98 | 98 | 98 | 98 | 99 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 95 | 98 | 97 | 98 | 98 |
| 2 | 1/3 Bleach | 97 | 98 | 98 | 97 | 98 |
| 3 | 2/3 Bleach | 97 | 97 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 98 | 98 | 98 | 98 | 98 |
| 5 | 6/3 Bleach | 98 | 97 | 98 | 98 | 98 |

Agene Bleached, Straight Dough, Kanred, 1930,
Table XI, Plate XI.

The baking results of the 1930 Kanred flour which was bleached with Agene and baked by the straight dough method shows a fairly consistent loaf volume, crumb color and texture of the loaves throughout the entire investigation.

That optimum results were obtained shortly after bleaching, is apparent by referring to the data obtained in baking.

A further aging of the flour due to storage did not materially improve the baking characteristics of the flour, nor did the excessive rates of Agene bleach seem to impair the baking quality of the flour.

PLATE 11 Straight Dough Method of Agene Bleached Flour, Canned 1930, Baked August 26, 1930.

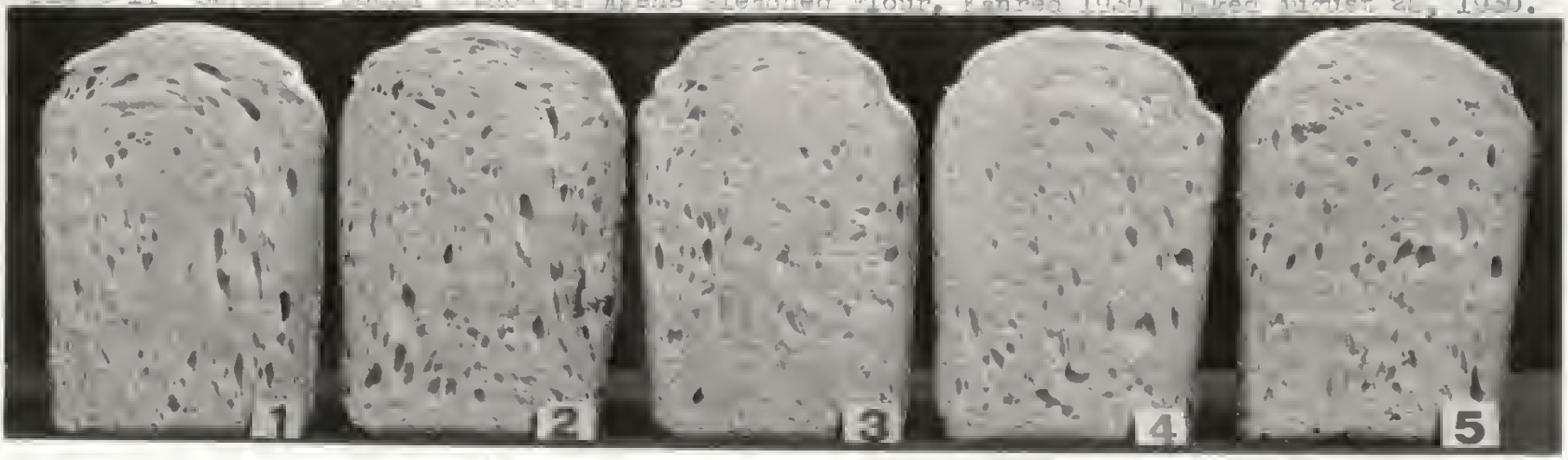


TABLE 11 Baking results on dates as shown

| Loaf No. | Amount of Bleach | Aug. 26 | Sept. 12 | Sept. 29 | Oct. 6 | Jan. 29 |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | Unbleached | 1495 | 1530 | 1525 | 1552 | 1555 |
| 2 | 1/3 Bleach | 1500 | 1495 | 1515 | 1455 | 1505 |
| 3 | 2/3 Bleach | 1515 | 1510 | 1500 | 1495 | 1510 |
| 4 | 3/3 Bleach | 1500 | 1493 | 1490 | 1510 | 1520 |
| 5 | 6/3 Bleach | 1495 | 1500 | 1515 | 1517 | 1507 |
| | Color of Crumb | | | | | |
| 1 | Unbleached | 96 | 96 | 98 | 98 | 97 |
| 2 | 1/3 Bleach | 96 | 97 | 98 | 98 | 98 |
| 3 | 2/3 Bleach | 98 | 98 | 99 | 99 | 99 |
| 4 | 3/3 Bleach | 97 | 98 | 99 | 99 | 99 |
| 5 | 6/3 Bleach | 97 | 98 | 99 | 99 | 99 |
| | Texture of Loaf | | | | | |
| 1 | Unbleached | 96 | 98 | 98 | 98 | 98 |
| 2 | 1/3 Bleach | 95 | 96 | 97 | 97 | 98 |
| 3 | 2/3 Bleach | 98 | 98 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 96 | 98 | 98 | 97 | 98 |
| 5 | 6/3 Bleach | 95 | 98 | 98 | 98 | 98 |

Chlorine Bleach, Straight Dough, Kanred, 1930,
Table XII, Plate XII.

Table XII shows a rather definite decrease in loaf volume when a comparison is made with the unbleached flour.

The volume of the loaves did not seem to decrease materially, but a noticeable inferiority in the texture of the loaves could be noted, which accounts for the lower score.

The baking results obtained showed similar characteristics to the other chlorine bleached flours, and clearly tended to prove that excessive rates of chlorine will impair the baking quality of the flour.

PLATE 12 Straight Dough Method of Chlorine Bleached Flour. Kanred 1930. Baked August 27, 1930.

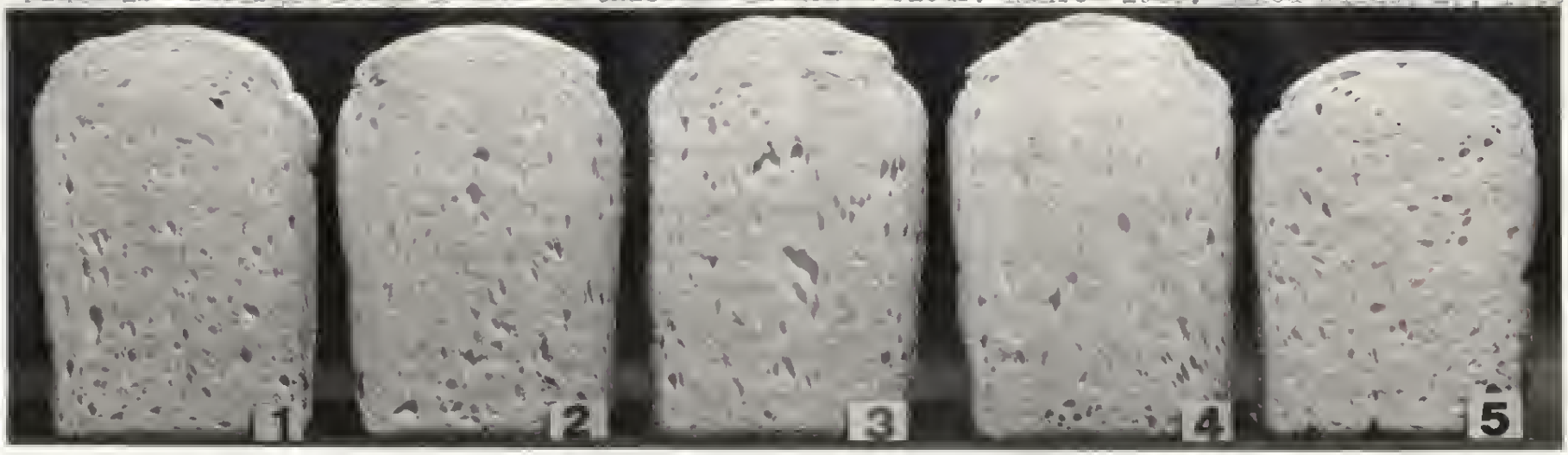


TABLE 12 Baking results on dates as shown

| Loaf No. | Amount of Bleach | Aug. 27 | Sept. 15 | Nov. 10 | Jan. 30 |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Unbleached | 1497 | 1492 | 1540 | 1520 |
| 2 | 1/3 Bleach | 1475 | 1470 | 1470 | 1475 |
| 3 | 2/3 Bleach | 1493 | 1490 | 1490 | 1505 |
| 4 | 3/3 Bleach | 1500 | 1495 | 1487 | 1480 |
| 5 | 6/3 Bleach | 1450 | 1430 | 1435 | 1437 |
| | Color of Crumb | | | | |
| 1 | Unbleached | 96 | 97 | 98 | 97 |
| 2 | 1/3 Bleach | 97 | 97 | 98 | 98 |
| 3 | 2/3 Bleach | 97 | 98 | 98 | 98 |
| 4 | 3/3 Bleach | 98 | 98 | 99 | 99 |
| 5 | 6/3 Bleach | 97 | 98 | 98 | 98 |
| | Texture of Loaf | | | | |
| 1 | Unbleached | 96 | 98 | 98 | 98 |
| 2 | 1/3 Bleach | 97 | 96 | 98 | 98 |
| 3 | 2/3 Bleach | 97 | 97 | 97 | 98 |
| 4 | 3/3 Bleach | 98 | 97 | 98 | 98 |
| 5 | 6/3 Bleach | 97 | 97 | 97 | 97 |

Novadel Bleached, Potassium Bromate Method, Kanred, 1929-30, Table XIII, Plate XIII.

The results obtained in the baking of the Novadel bleached Kanred flours of 1929 and 1930 by the potassium bromate differential baking test shows very little variation in loaf volume, crumb color or texture of the loaves due to the addition of the bromate.

This would further prove that Novadel as a bleaching reagent does not seem to be a strong oxidizing agent, and excess rates of Novadel did not prove harmful to the flour.

Table XIII Baking result of February 8, 1951.

| Amount of Bleach | Kind of Bleach | KBrO3 Added | Year | Loaf Volume | Color | Texture |
|---|---|---|---|---|---|---|
| 3/3 | Novadel | none | 1929 | 1565 | 99 | 97 |
| 3/3 | " | 1 cc. | 1929 | 1530 | 99 | 97 |
| 3/3 | " | 2 cc. | 1929 | 1580 | 99 | 96 |
| 6/3 | " | none | 1929 | 1540 | 99 | 98 |
| 6/3 | " | 1 cc. | 1929 | 1560 | 99 | 99 |
| 6/3 | " | 2 cc. | 1929 | 1590 | 99 | 98 |
| 3/3 | " | none | 1930 | 1570 | 99 | 95 |
| 3/3 | " | 1 cc. | 1930 | 1555 | 99 | 95 |
| 3/3 | " | 2 cc. | 1930 | 1530 | 98 | 97 |
| 6/3 | " | none | 1930 | 1530 | 99 | 95 |
| 6/3 | " | 1 cc. | 1930 | 1530 | 99 | 97 |
| 6/3 | " | 2 cc. | 1930 | 1540 | 98 | 95 |

PLATE 13 Potassium Bromate Method of Novadel Bleached Flour. Kanred 1929 - 1930.

Agene Bleached, Potassium Bromate Method, Kanred, 1929-30, Table XIV, Plate XIV.

The Agene bleached Kanred flours of 1929 and 1930 baked by the potassium bromate differential baking test clearly showed that the baking quality of the flour may be impaired when bromate is added to the full and double bleached flour.

Not only is there a pronounced decrease in loaf volume, but a decrease in texture of the loaves and crumb color.

Table XIV Baking result of February 5, 1931.

| Amount of Bleach | Kind of Bleach | KBRo3 added | Year | Loaf Volume | Texture | Color |
|---|---|---|---|---|---|---|
| 3/3 | Agene | none | 1929 | 1550 | 99 | 98 |
| 3/3 | " | 1 cc. | 1929 | 1500 | 99 | 98 |
| 3/3 | " | 2 cc. | 1929 | 1470 | 98 | 98 |
| 6/3 | " | none | 1929 | 1540 | 99 | 99 |
| 6/3 | " | 1 cc. | 1929 | 1535 | 99 | 99 |
| 6/3 | " | 2 cc. | 1929 | 1240 | 92 | 96 |
| 3/3 | " | none | 1930 | 1480 | 98 | 99 |
| 3/3 | " | 1 cc. | 1930 | 1505 | 98 | 98 |
| 3/3 | " | 2 cc. | 1930 | 1420 | 96 | 98 |
| 6/3 | " | none | 1930 | 1515 | 98 | 99 |
| 6/3 | " | 1 cc. | 1930 | 1440 | 98 | 99 |
| 6/3 | " | 2 cc. | 1930 | 1370 | 92 | 95 |

PLATE 14 Potassium Bromate Method of Agene Bleached Flour. Kanred 1929 - 1930.

Unbleached and Chlorine Bleached, Potassium Bromate Method, Kanred, Table XV, Plate XV.

The chlorine bleached Kanred flour of 1930 baked by the potassium bromate differential baking test shows a decided decrease in loaf volume, and texture of the loaves. The crumb color does not seem to decrease proportionally with the loaf volume, as indicated by the score.

The fact that chlorine is such an active bleaching reagent accounts for the low volume of the loaves due to oxidation.

The unbleached Kanred flour of 1929 and 1930 by the same baking method shows a distinct improvement in loaf volume, color of crumb and texture of the loaves by successive additions of one or two cubic centimeters of the bromate solution.

Table XV Baking results of January 31, 1931.

| Amount of Bleach | Kind of Bleach | $KBrO_3$ added | Year | Loaf Volume | Color | Texture |
|---|---|---|---|---|---|---|
| 3/3 | Chlorine | none | 1930 | 1520 | 99 | 98 |
| 3/3 | " | 1 cc. | 1930 | 1500 | 99 | 98 |
| 3/3 | " | 2 cc. | 1930 | 1460 | 99 | 94 |
| 6/3 | " | none | 1930 | 1585 | 99 | 94 |
| 6/3 | " | 1 cc. | 1930 | 1370 | 99 | 90 |
| 6/3 | " | 2 cc. | 1930 | 1300 | 99 | 90 |
| None | Unbleached | none | 1929 | 1300 | 95 | 88 |
| " | " | 1 cc. | 1929 | 1400 | 95 | 92 |
| " | " | 2 cc. | 1929 | 1445 | 97 | 98 |
| " | " | none | 1930 | 1490 | 95 | 96 |
| " | " | 1 cc. | 1930 | 1590 | 97 | 98 |
| " | " | 2 cc. | 1930 | 1520 | 97 | 98 |

PLATE 15 Potassium Bromate Method of Chlorine Bleached 1930 and Unbleached. Kanred 1929-1930.

Agene Bleach, Potassium Bromate Method, Kanred and Blackhull, Table XVI, Plate XVI.

A decided decrease in loaf volume was noted in the double bleached Blackhull flour as compared with the double bleached Kanred flour of 1930, in the comparative baking test of February 18, 1931, by the potassium bromate differential baking test.

The texture of the loaves of the Blackhull flour was poorer than that of the Kanred while only the crumb color of the double bleached Blackhull was decidedly lower.

From the baking data obtained, it was apparent that the Blackhull flour did not withstand the high rates of Agene bleach as well as the Kanred flour.

Table XVI Baking Results of February 18, 1931.

| Amount of Bleach | Kind of Bleach | KBRo3 added | Year | Loaf Volume | Color | Texture |
|---|---|---|---|---|---|---|
| | | KANRED | | | | |
| 3/3 | Agene | none | 1930 | 1500 | 99 | 98 |
| 3/3 | " | 1 cc. | 1930 | 1490 | 99 | 98 |
| 3/3 | " | 2 cc. | 1930 | 1455 | 99 | 94 |
| 6/3 | " | none | 1930 | 1540 | 99 | 98 |
| 6/3 | " | 1 cc. | 1930 | 1490 | 99 | 97 |
| 6/3 | " | 2 cc. | 1930 | 1480 | 99 | 97 |
| | | BLACKHULL | | | | |
| 3/3 | Agene | none | 1930 | 1480 | 99 | 97 |
| 3/3 | " | 1 cc. | 1930 | 1490 | 99 | 94 |
| 3/3 | " | 2 cc. | 1930 | 1460 | 99 | 94 |
| 6/3 | " | none | 1930 | 1360 | 95 | 89 |
| 6/3 | " | 1 cc. | 1930 | 1340 | 95 | 87 |
| 6/3 | " | 2 cc. | 1930 | 1350 | 95 | 88 |

PLATE 16 Potassium Bromate Method Showing Comparison of Kanred and Blackhull 1930 Flour

Agene Bleach, Sponge Dough, Kanred and Blackhull,
Table XVII, Plate XVII.

The comparative baking results of Kanred and Blackhull flour by the sponge-dough method show no significant differences in loaf volume, crumb color or texture of the loaves.

The loaf volumes of the unbleached Kanred seemed slightly larger than that of the unbleached Blackhull flour.

PLATE 17 Sponge-Dough Method Showing Comparison of Kanred and Blackhull Flour 1930.


TABLE 17 Baking results of September 25, 1930.

| Amount of Bleach | Kind of Bleach | Loaf No. | Kind of Flour | Loaf Volume | Crumb Color | Texture |
|---|---|---|---|---|---|---|
| None | Unbleached | 1 | Kanred | 1527 | 97 | 98 |
| 3/3 Bleach | Agene | 2 | " | 1510 | 98 | 98 |
| 6/3 Bleach | Agene | 3 | " | 1502 | 98 | 98 |
| None | Unbleached | 4 | Blackhull | 1485 | 97 | 97 |
| 3/3 Bleach | Agene | 5 | " | 1497 | 98 | 97 |
| 6/3 Bleach | Agene | 6 | " | 1495 | 98 | 97 |

Agene Bleach, Straight Dough, Kanred and Blackhull,
Table XVIII, Plate XVIII.

The results obtained by the straight dough baking method were nearly identical with those of the sponge-dough method.

No differences could be noted in loaf volume, except in the unbleached samples. The score of the texture of the loaves and crumb color showed that no appreciable difference existed between the two flours.

PLATE 18 Straight Dough Method Showing Comparison of Kanred and Blackhull Flour, 1930.

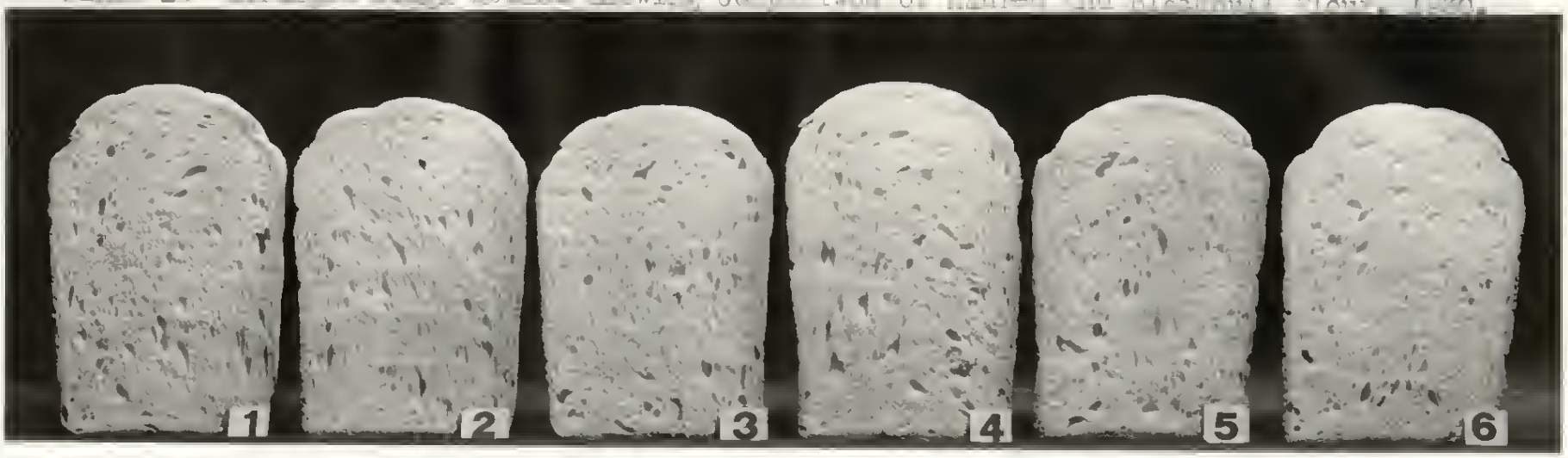


TABLE 18 Baking results of November 10, 1930.

| Amount of Bleach | Kind of Bleach | Loaf No. | Kind of Flour | Loaf Volume | Crumb Color | Texture |
|---|---|---|---|---|---|---|
| None | Unbleached | 1 | Kanred | 1485 | 97 | 97 |
| 3/3 Bleach | Agene | 2 | " | 1530 | 97 | 99 |
| 6/3 Bleach | Agene | 3 | " | 1430 | 97 | 99 |
| None | Unbleached | 4 | Blackhull | 1587 | 98 | 98 |
| 3/3 Bleach | Agene | 5 | " | 1520 | 98 | 98 |
| 6/3 Bleach | Agene | 6 | " | 1497 | 98 | 98 |

Agene Bleach, Mechanical Modification, Kanred and Blackhull, Table XIX, Plate XIX.

The results obtained in the baking of the Kanred and the Blackhull flour by the mechanical modification baking test, shows a decided smaller loaf volume, lower number for crumb color, and texture of the Blackhull flour. This difference may be due partially to wheat variety, rather than to bleaching, as it seems that Blackhull flour will not withstand the severe mechanical mixing to which it was subjected.

PLATE 19 Mechanical Modification Method Showing Comparison of Kanred and Blackhull Flour. 1930


TABLE 19 Baking results of October 17,1930.

| Amount of Bleach | Kind of Bleach | Loaf No. | Kind of Flour | Loaf Volume | Crumb Color | Texture |
|---|---|---|---|---|---|---|
| None | Unbleached | 1 | Kanred | 1415 | 95 | 93 |
| 3/3 Bleach | Agene | 2 | " | 1470 | 95 | 98 |
| 6/3 Bleach | Agene | 3 | " | 1500 | 97 | 98 |
| None | Unbleached | 4 | Blackhull | 1375 | 89 | 92 |
| 3/3 Bleach | Agene | 5 | " | 1410 | 89 | 95 |
| 6/3 Bleach | Agene | 6 | " | 1340 | 89 | 90 |

Viscosity, Kanred, 1929, Bleached Flour, Table XX.

The viscosity readings in degrees (MacMichael) show a fairly uniform and consistent average. No appreciable differences can be noted except in the high rates of chlorine bleach, which seems to give a lower reading.

No definite correlation exists between the viscosity readings and the loaf volume, although a lower reading of the full and double bleach chlorine flours compares favorably with a lower loaf volume of these bleaches. The viscosity reading of the unbleached standard seemed to increase slightly with the age of the flour.

Table XX Viscosity tests of bleached 1929 Kanred flour.

| Amount of Bleach | Viscosity Reading of June 27 | Viscosity Reading August 5 |
|---|---|---|
| | NOVADEL BLEACHED FLOUR | |
| 1/3 | 237 | 252 |
| 2/3 | 234 | 245 |
| 3/3 | 236 | 245 |
| 6/3 | 239 | 248 |
| | AGENE BLEACHED FLOUR | |
| 1/3 | 237 | 245 |
| 2/3 | 244 | 244 |
| 3/3 | 243 | 240 |
| 6/3 | 244 | 239 |
| | CHLORINE BLEACHED FLOUR | |
| 3/3 | 244 | 254 |
| 6/3 | 236 | 249 |
| Unbleached Standard: | 238 | 246 |

Flour used, 22.5 gm.
Size of wire, No. 27.
Lactic acid added, 2 cc.
$H_2O$ added, 100 cc.
Room Temperature, 34° C.
Digestion time, 60 minutes.

Viscosity, Kanred, 1930, Bleached Flour, Table XXI.

The viscosity readings show similar results to those of the 1929 bleached flours. Only the double bleached chlorine flour seemed to give a slightly lower reading which would indicate that the gluten has been altered, and which is shown by a lower loaf volume in the baking test. Lower viscosity readings due to the high rates of chlorine bleach seem to indicate that the flour has been impaired in its baking quality.

Table XXI Viscosity tests of bleached 1930 Kanred flour.

| Amount of Bleach | Viscosity Reading August 26 | Viscosity Reading September 10. |
|---|---|---|
| | NOVADEL BLEACHED FLOURS | |
| 1/3 | 215 | 210 |
| 2/3 | 240 | 230 |
| 3/3 | 240 | 230 |
| 6/3 | 237 | 240 |
| | AGENE BLEACHED FLOUR | |
| 1/3 | 236 | 230 |
| 2/3 | 205 | 210 |
| 3/3 | 212 | 230 |
| 6/3 | 197 | 200 |
| | CHLORINE BLEACHED FLOUR | |
| 1/3 | 242 | 239 |
| 2/3 | 235 | 230 |
| 3/3 | 197 | 215 |
| 6/3 | 215 | 209 |
| Unbleached Standard: | 213 | 220 |

Flour used, 22.5 gm.
Size of wire, No. 27.
Lactic acid added, 2 cc.
$H_2O$ added, 100 cc.
Room temperature, 26°C.
Digestion time, 60 minutes.

Hydrogen-ion, Kanred, 1929, Bleached Flour, Table XXII.

The acidity of the flour did not show any appreciable difference with the Novadel and Agene bleach. A slight increase in hydrogen-ion concentration, however, is noted in the chlorine bleached flours. The hydrogen-ion determination of April 15, 1931 shows a slight increase in acidity of all the bleached flours due to storage.

Table XXII Hydrogen-ion Concentration of Bleached 1929 Kanred Flour

| Amount of Bleach | Kind of bleach | Reading July 31 | Reading Nov. 14 | Reading April 15 1931 |
|---|---|---|---|---|
| 1/3 | Novadel | pH - 5.90 | pH - 5.67 | pH - 5.57 |
| 2/3 | " | pH - 5.92 | pH - 5.78 | pH - 5.56 |
| 3/3 | " | pH - 5.95 | pH - 5.78 | pH - 5.56 |
| 6/3 | " | pH - 5.90 | pH - 5.60 | pH - 5.40 |
| 1/3 | Agene | pH - 5.90 | pH - 5.72 | pH - 5.56 |
| 2/3 | " | pH - 5.92 | pH - 5.84 | pH - 5.50 |
| 3/3 | " | pH - 5.90 | pH - 5.90 | pH - 5.57 |
| 6/3 | " | pH - 5.90 | pH - 5.88 | pH - 5.55 |
| 3/3 | Chlorine | pH - 5.42 | pH - 5.30 | pH - 5.12 |
| 6/3 | " | pH - 5.05 | pH - 5.20 | pH - 5.00 |
| Standard | Unbleached | | pH - 5.85 | pH - 5.74 |

Hydrogen-ion, Kanred, 1930, Bleached Flour, Table XXIII.

The acidity of the 1930 Kanred bleached flour showed similar results to that of 1929. The hydrogen-ion concentration was the most marked in the chlorine bleached flour showing a slight increase in acidity. The acidity of the flour of 1930 made on April 15, 1931, compares quite favorably with the reading made the same date on the 1929 flour.

Table XXIII Hydrogen-ion concentration of bleached 1930 Kanred flour

| Amount of Bleach | Kind of Bleach | Reading Aug. 20 1930 | Reading Nov. 14 1930 | Reading April 15 1931 |
|---|---|---|---|---|
| 1/3 | Novadel | pH - 5.92 | pH - 5.90 | pH - 5.55 |
| 2/3 | " | pH - 5.96 | pH - 5.95 | pH - 5.57 |
| 3/3 | " | pH - 6.05 | pH - 5.95 | pH - 5.55 |
| 6/3 | " | pH - 6.13 | pH - 5.93 | pH - 5.55 |
| 1/3 | Agene | pH - 5.95 | pH - 5.85 | pH - 5.53 |
| 2/3 | " | pH - 5.95 | pH - 5.80 | pH - 5.40 |
| 3/3 | " | pH - 6.03 | pH - 5.82 | pH - 5.40 |
| 6/3 | " | pH - 5.95 | pH - 5.80 | pH - 5.35 |
| 1/3 | Chlorine | pH - 5.87 | pH - 5.70 | pH - 5.50 |
| 2/3 | " | pH - 5.85 | pH - 5.68 | pH - 5.52 |
| 3/3 | " | pH - 5.72 | pH - 5.45 | pH - 5.55 |
| 6/3 | " | pH - 5.37 | pH - 5.05 | pH - 5.05 |

## SUMMARY AND CONCLUSIONS

The volume, texture and crumb color of the 1929 bleached Kanred flour seemed to be slightly better than any of the bleached Kanred samples of the 1930 crop.

No variation from the degree of bleaching could be noticed in the flours after nine months, as was so apparent at the beginning of the baking tests of the flour.

There seemed to be no difference in the viscosity of the different bleached flours, with the exception of the full and double chlorine bleached flours which showed slightly lower results.

The hydrogen-ion determinations of the bleached flours showed the chlorine to be slightly higher.

No significant differences could be noted between Kanred and Blackhull flours except by means of the mechanical modification baking method, which difference is attributed to variety rather than to bleaching.

No detrimental effect on gluten quality was noticeable with any of the bleaches, with the exception of chlorine, and the differences in baking were noted only when high rates of the bleach was used.

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