A STUDY OF THE CONSISTENCY OF STARCHES
FROM KANSAS IRISH AND SWEET POTATOES

by

JOHN ALLEN WAGONER

B. S., Kansas State Teachers College
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## INTRODUCTION

Starch is potentially a great source of raw material, and, since Kansas is preeminently an agricultural state raising mostly starchy crops, it would seem that a comparison of Kansas starches from the consistency viewpoint should be of practical as well as scientific value.

Two of the important crops of Kansas are sweet and Irish potatoes, both of which are good sources of starch and up to the present time the only utilization of these potatoes has been for human consumption. However, in the process of grading and sorting, a large share of the crop is discarded as culls. These culls are potatoes too large or too small, and cut or misshaped. In addition to this, in some years there is a surplus of potatoes, and as a consequence much of these are a drug on the market. From these culls and surplus potatoes may be obtained a vast amount of starch (10).

Irish potato starch is used quite extensively in the sizing of paper and cloth. The qualities that make this starch desirable for this purpose are brought out in a study of its consistency. However, in Kansas there is the sweet potato crop to supplement the source of the tuber starches. While it is known there are some differences between the two starches, their comparison with each other and with commercial starches appears to be essential before much use can be made of them commercially.

The utilization of the culls and surplus of the two potatoes is of importance to national as well as state economy, since up to the past few years a large share of potato starch has been imported from Europe. Starch importations have held back the progress of developing a starch industry which uses these heretofore waste products. It has been further retarded by a supply that might be too small to erect an extraction plant for just the one type of potato. But, if in a particular locality starch from both Irish and sweet potatoes could be used, then this objection is lessened by the increased sources and would help the potato growers to use those portions of their crops which are now wasted.

In the fall of 1939 a project was started to determine the quantity and quality of the starches obtained from Kansas potatoes. Kramer (10) worked on the quantitative aspect of the problem and found as far as quantity was concerned, the Kansas potatoes were comparable to the others. At the same time he removed a quantity of the starch from his samples and preserved it for the study of quality. Williams (22) made a microscopic study of these starches with emphasis upon such qualities as the granule size, granule size distribution, and the gelatinization temperature. These properties help differentiate the starches, but since most of the starches are used in the paste form, a measurement of the consistency of the pastes would furnish additional information upon the quality of these starches.

When starches are heated in water close to their gelat-
inization temperature, they lose their usual form of the
granules and make a semi-solid paste. The measurement of this
"pastiness" is sometimes called the "elasticity", or the "mold-
ing quality", but a combination of these is called the "con-
sistency", so in this paper the measurement of these qualities
will be called the consistency.

With these problems in mind, this study was made to com-
pare the Kansas grown starches with the ones generally used
commercially, and to see if it would be feasible to use those
starches from Kansas products. Also it was made to determine
the effects of locale, curing, time of harvest, variety and
type of soils upon the character of the starch pastes.

## SURVEY OF THE LITERATURE

It has been known for a long time that certain starches were better suited for sizing of cloth and paper and in the formation of pastes, but according to Bergquist (2) a chemical analysis of the constituents gives little insight into the character of these starch pastes. As a consequence, many machines and devices were made to determine the qualities of a starch for a given purpose and to be able to measure in some terms the relative amounts of these qualities in any given starch. These machines have been roughly divided into two classes by MacMichael (11): first, those in which time was measured for a definite amount of the liquid to flow under a given force, and second, those in which the force to move a definite amount of fluid in a certain time was measured. In the first class, Thomson (21) recommended in 1886 that an iron spindle should be placed in the paste and the time it took for it to fall through a certain space was measured. Cappenberg (7) used spheres of a known weight in a like manner. Ermen (8) used a Redwood viscometer; Farrow and Lowe (9) used Ostwald, Ubbenhold and interchangeable cappilary tube types of viscometers, all of which measure the time necessary for a definite volume of liquid to run through a capillary tube or orfice under a standard hydrostatic pressure. By the use of this method only starch pastes of a very low concentration could be used (9) and, since it did not follow Poiseuille's Law exactly, many

correction factors were involved. The temperature of the pastes, the time of cooking, the hydrostatic pressure and the types of instruments used made a great deal of difference in the results, thereby making duplicate trials hard to reproduce.

Saare and Martin (17) suggested a round plate 22 m.m. in diameter to be placed into a paste solution three centimeters from the top and letting the paste set for 24 hours. They then measured the force necessary to withdraw this plate. MacMichael (11) improved Couettes' machine, which had a cylinder in a revolving container filled with the starch paste, by attaching a torison wire to the cylinder from which he could measure the torque. Porst and Moskowitz (14) and Bergquist (2) advised using a plastometer and more concentrated solutions since they claimed that at too low a concentration, the starches "thin down" and, therefore, the true consistency was not being measured. Caesar (5) and Caesar and Moore (6) used a stirring device in which they measured the wattage of electricity necessary to keep the stirrer at a set speed. This instrument had an advantage over any of the preceeding as it was possible to get a continuous record of the consistency of the pastes while heating, cooking or cooling. Radley (16) used the same type of an instrument but kept the wattage of electricity constant and recorded the revolutions per minute. By this method he obtained the curves which were almost identical with Caesar's except that they were inverted. Seck, Dittman and Blume (18) claimed that the consistency is greatly

reduced by too much stirring and as a consequence the latter part of Caesar's consistency curves may be lower than the true value.

Caesar (4) suggested that the consistency depended upon the swelling of the starch cells, and Ermen in 1907 (8) advocated the use of sodium hydroxide and other alkalies and electrolytes to induce swelling of the granules which should be an indication of their viscosity. Buel (3) and others used this method but Wolff (23) said that since the consistency of starch depends principally upon its colloidal behavior rather than the chemical composition, alkalies and salts or even hydrant water should not be used.

From some viscometric measurements Ravizza (15) observed that starches showing the largest maximum value were the most satisfactory for the stiffening of textiles. Sprockhoff and Wolff (20) disagreed in part with him as they held that all starches fall in one of two groups; first, those whose consistency starts at a low temperature and increases to a maximum but giving only a slight decrease in consistency when boiled a long time, and second, those whose consistency starts at a higher temperature but when boiled, thin out greatly. They considered the latter better for sizing since from their graphs the minimum thinning of the latter starches was still higher than the maximum of the former. Parlow and Dull (13) from their measurements preferred the first type because they found the second varied too much. Radley (16) stated that for sizing of paper the starch may be added as the raw starch

or as a starch paste. If the raw starch is added, the starch should be a very thin boiling starch but if the starch is added as a paste, the stiffer the paste the better. In the manufacture of textiles, starch sizing is added to impart extra tensile strength. Potato starches are good for the reason that they do not break down with heating to the same extent as do some other starches. He also added that the thicker the paste the better it is picked up by the fibers. Therefore, sizing depends a very great deal upon the consistency and not so much on the concentration. Very viscous pastes will give less loss in weight when run through the squeezing rollers and, thereby, the cloth will have a heavier finish. Sprockhoff (19) observed that increasing the concentration of starch pastes to 3.6 percent, the point of maximum consistency was shifted to a slightly lower temperature. This is confirmed by Caesar and Moore (6) who also added that an increase of concentration up to 30 percent will decrease the initial gelatinization temperature.

## EXPERIMENTAL PROCEDURE

### Outline of Investigation

The procedure followed somewhat in this manner:

1. Starches that had been collected from Irish and sweet potatoes were analyzed for their starch content. A complete history of each sample was kept showing its soil and harvest conditions, whether cured or not and the locale in which it was grown.

2. The starches were made into "starch milks" and their consistency was studied during heating,

cooking and cooling. In addition, various concentrations and different rates of shear were applied to these suspensions to find the behavior under these varied conditions.

## Chemical Analysis

The starch samples were analyzed only by the A.O.A.C.[1] Official Direct Acid Hydrolysis Method, XXVII-31, as this was suggested by Kramer (10) as giving the most accurate, quick and reliable results of an analysis for Irish and sweet potatoes. Duplicate samples were run and whenever results varied more than 0.2 percent another sample was run. Thus the analysis of each starch varied less than 0.2 percent.

## Description of the Consistometer

The consistometer used was designed in the laboratory by Barham and Reed (1) to eliminate several objections found in other types. A brass cup 15 cm. tall and 7.8 cm. in diameter with hollow metal centerpiece was heavily gold plated. This left a doughnut shaped volume in which to place the starch paste. A smooth, inverted, gold plated cup was suspended from above so that it could revolve in the doughnut shaped volume. The outer cup was rotated by a one-tenth horse power electric motor at a constant speed which could be varied by changing the gear ratios. The inner cup had a pulley attached to the end of the suspending shaft to which a string

1. Association of Official Agricultural Chemists (12)

was attached connecting to an arm balance. Thus when the outer cup rotated, a restraining torque was applied to the inner cup by the balance to measure the consistency of the pastes. The cups were mounted in an oil bath whose retaining walls contained electric heaters which could be regulated from 0-900 watts. Just inside this wall were copper water pipes in which water could be circulated to cool the oil. An oil seal and cooling condenser were attached to return the bulk of the evaporated water to the paste which was freed by the higher temperature. The temperature of the paste was measured by a thin thermocouple of Chromel-Alumel wire mounted from above and penetrating the surface of the starch but not enough to cause a current or irregularity in the paste. The cold junction was kept at $0^{\circ}C$. in a thermos bottle and the current was measured on a Leeds and Northup type K. potentiometer.

## Method of Using the Consistometer

The consistometer was assembled and the outer cup rotated by the motor. The oil bath was heated to a temperature four degrees lower than the lower limit of the gelatinization temperature range for these starches. Table 1 gives the gelatinization temperatures as found by Williams (22) for the starches used.

The water to be used in the paste was measured at $20^{\circ}$ C. and then heated to the same temperature as the oil bath.

Table 1.  Gelatinization temperatures of some Kansas
Irish and sweet potato starches.

| Sample | : | Temperature range of gelatinization | : | Mean gelatinization temperature |
|---|---|---|---|---|
| A- 1 | | 67.0 - 73.0° C. | | 70.0° C. |
| A- 2 | | 66.5 - 71.5 | | 69.0 |
| A- 3 | | 70.0 - 74.5 | | 72.5 |
| A- 4 | | 66.5 - 72.5 | | 69.5 |
| A-11 | | 66.0 - 76.0 | | 71.0 |
| A-13 | | 69.0 - 75.0 | | 72.0 |
| A-14 | | 69.5 - 75.0 | | 72.5 |
| A-15 | | 70.0 - 75.0 | | 72.5 |
| A-16 | | 67.0 - 73.0 | | 70.0 |
| B- 4 | | 70.5 - 76.5 | | 73.5 |
| B- 5 | | 70.5 - 77.0 | | 74.0 |
| B- 6 | | 70.0 - 79.5 | | 75.0 |
| B- 9 | | 69.5 - 77.5 | | 73.5 |
| B-10 | | 70.5 - 80.5 | | 75.5 |
| B-11 | | 72.5 - 79.5 | | 76.0 |
| B-12 | | 66.5 - 76.5 | | 71.5 |
| B-13 | | 67.0 - 72.5 | | 70.0 |
| B-14 | | 66.0 - 72.5 | | 69.5 |
| B-15 | | 68.0 - 78.0 | | 73.0 |
| B-16 | | 68.5 - 77.5 | | 73.0 |
| B-17 | | 68.5 - 76.0 | | 72.5 |

A weighed amount of starch was added quickly with just enough
stirring to mix it well with the water.  The "starch milk"
was added through a funnel to the outer cup and the heaters
adjusted to raise the oil bath temperature one-half degree
centigrade per minute up to 98° C.  The temperature was held
there for one-half hour and then the heating reduced and water
added to the cooling coils to bring the temperature of the
oil bath back to 30° C. at almost the same rate as it was rais-
ed.  At each minute interval readings were taken of oil bath

temperature, wattage of heaters, temperature of paste, and grams of torque applied to inner cup. From these data the temperature was plotted graphically on the vertical and grams torque on the horizontal axis.

### Determination of Optimum Conditions
### for use of Consistometer

Five to 20 percent concentrations of starch were used to test the consistometer for the best concentrations for comparison. The weight of the sample was corrected for water present and the suspension was made up to 400 grams for each determination. The angular velocity of the outer cup was used at 30, 60, 90 and 120 r.p.m. and from these experimental data a speed and concentration was decided upon that gave: first, the largest variation among the individual starches, second, the highest concentration usable, but yet not so thick it would give irregular results, third, the lowest angular velocity that will make stirring unnecessary after gelatinization begins, and fourth, a combined speed and concentration that could be used for both Irish and sweet potatoes to enable a comparison.

### RESULTS

These starches which were extracted from the samples of Irish and sweet potatoes were very uniform. Usually Irish potato starches have a distinctive odor but in these the odor was not so penetrating. The starches were white in color

having practically no dirt, cellulose or pigmented cells that
could be found with a microscopic examination. The results
of the chemical analyses of the Irish potato starches are
given in Table 2. It is noticed that the percent starch is
not uniform ranging from 75.55 to 82.41 percent. This vari-
ation was accounted for because after these starches were
extracted they were air dried, since no humidity controlled
drier was available. Consequently, these analyses had to be
run in order to make suspensions of a predetermined concen-
tration.

Table 2. Data on Irish potato starches.

| No. | Variety | Stage of harvest | Location grown | Percent starch |
|-----|---------|------------------|----------------|----------------|
| A- 1 | Irish Cobbler | Early | Edwardsville, Kansas | 81.98 |
| A-13 | Irish Cobbler | Late | Edwardsville, Kansas | 77.72 |
| A- 4 | Irish Cobbler | Early | Newman, Kansas | 75.55 |
| A-16 | Irish Cobbler | Late | Newman, Kansas | 80.59 |
| A-11 | Irish Cobbler | Regular | Manhattan, Kansas | 79.74 |
| A- 2 | Bliss Triumph | Early | Linwood, Kansas | 80.40 |
| A-15 | Bliss Triumph | Late | Linwood, Kansas | 79.93 |
| A- 3 | Warba | Early | Edwardsville, Kansas | 77.15 |
| A-14 | Warba | Late | Edwardsville, Kansas | 82.41 |

In Table 3, the analyses of the sweet potato starches
are given with their histories. These starches were prepar-
ed and treated in the same manner as the Irish potato starches,
and as a result were white, and had practically no impurities.

Table 3. Data on sweet potato starches.

| No.: | Variety | Stage of: harvest: | Cured: | Location: grown | Percent starch |
|------|---------|--------------------|--------|-----------------|----------------|
| B- 5 | Little Stem Jersey | Regular | No | Manhattan | 86.73 |
| B-16 | Little Stem Jersey | Regular | Yes | Manhattan | 87.91 |
| B-17 | Little Stem Jersey | Late | Yes | Manhattan | 86.92 |
| B- 6 | Improved Big Stem | Regular | No | Manhattan | 86.66 |
| B-15 | Improved Big Stem | Regular | Yes | Manhattan | 86.99 |
| B-12 | Red Bermuda | Regular | No | Manhattan | 87.71 |
| B-14 | Red Bermuda | Regular | Yes | Manhattan | 87.66 |
| B- 4 | Little Stem Jersey | Regular | No | Topeka | 86.05 |
| B-11 | Little Stem Jersey | Regular | No | Wichita | 87.56 |
| B- 9 | Nancy Hall | Regular | No | Wichita | 86.76 |
| B-13 | Nancy Hall | Regular | No | Manhattan | 89.38 |
| B-10 | Regular Big Stem | Regular | No | Mulvane | 87.47 |

## Standardization of the Consistometer

Figure 1 shows the effect of varying the concentration of a typical Irish potato starch from 5 to 15 percent. From this it is noted that a slight irregularity appears in the 11 percent suspension and become more irregular above that concentration. This irregularity is apparently caused by the starch paste becoming too thick and brittle, thus losing its tenacity. Figure 2 shows the same effect upon a typical sweet potato starch, but in this case there is no irregularity until suspensions over 15 percent are used.

Figures 3 and 4 represent the effect of varying the speed of the outer cup for Irish and sweet potato starch,
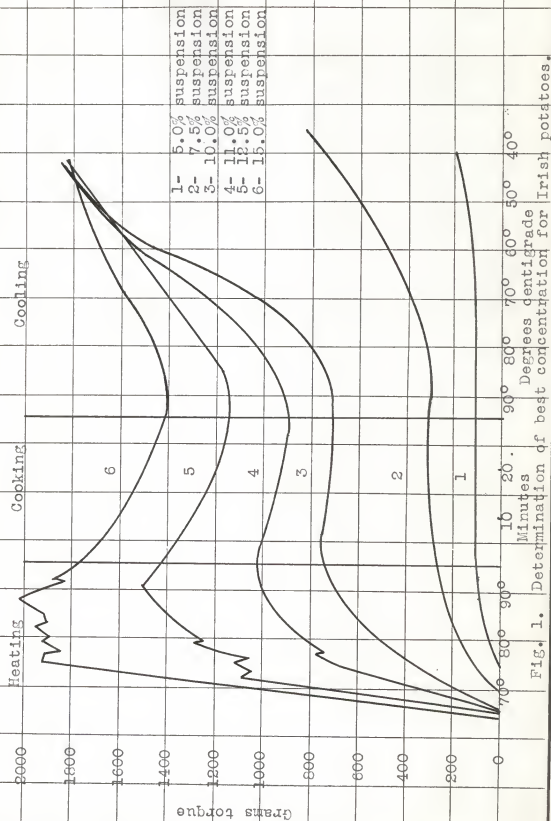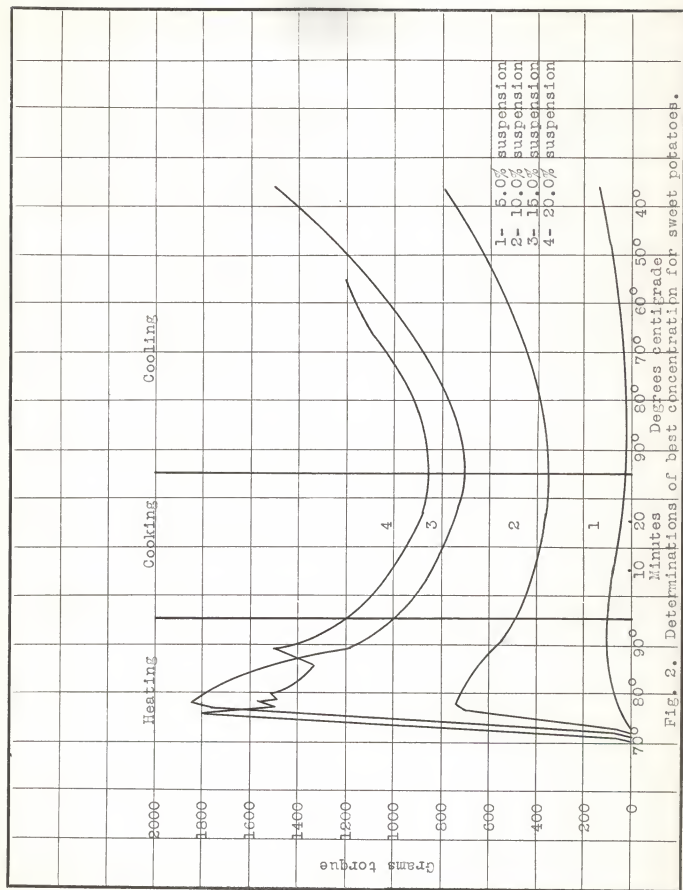
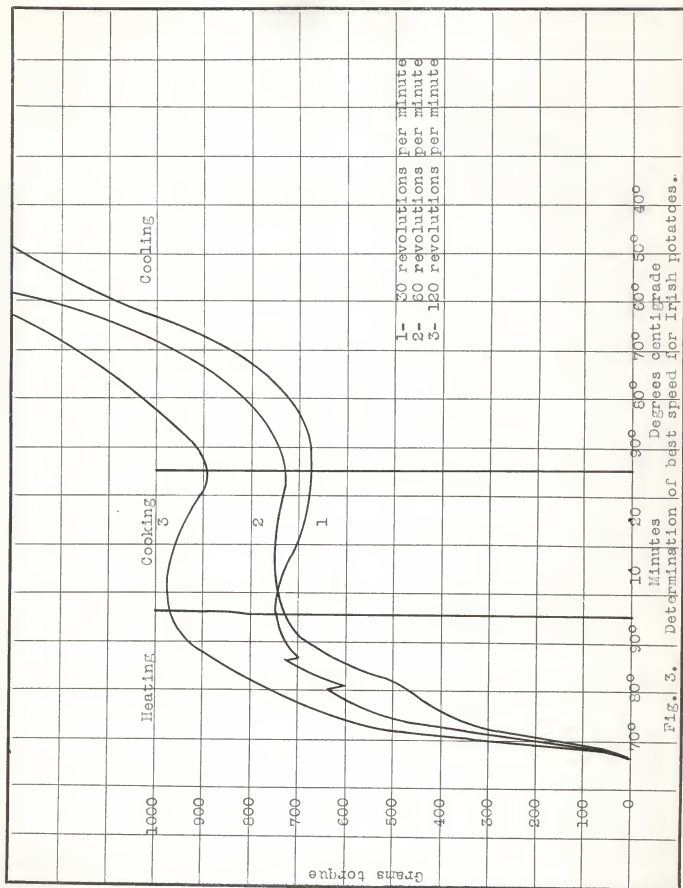Fig. 1. Determination of best concentration for Irish potatoes.

1— 5.0% suspension
2— 7.5% suspension
3— 10.0% suspension
4— 11.0% suspension
5— 12.5% suspension
6— 15.0% suspension

Fig. 2. Determinations of best concentration for sweet potatoes.

Fig. 3. Determination of best speed for Irish potatoes.

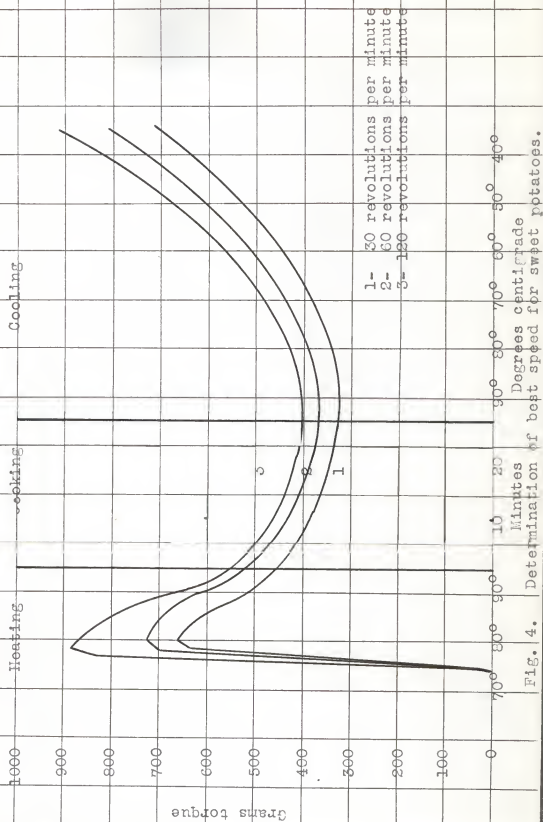Fig. 4. Determination of best speed for sweet potatoes.

1— 30 revolutions per minute
2— 60 revolutions per minute
3— 120 revolutions per minute

respectively. Since starch granules are so large (22) they
settle out quite rapidly, in order to remedy this, a speed of
over 60 r.p.m. was used, and, until the starch had gelatiniz-
ed, the suspension was stirred with a glass stirring rod.
Sweet potato starch, having smaller granules, may be used suc-
cessfully in speeds as low as 30 r.p.m. Figure 5 shows the
reproducibility of duplicate trials.

From these data it was decided to use ten percent solu-
tions of starch by weight and 60 r.p.m. for the comparison of
the two starches. By this method a minimum amount of stir-
ring was done and yet the particles were kept in suspension
in a maximum concentration.

### Consistency of Irish Potato Starches

In Figure 1, it is shown that the lower the concentra-
tion of the starch, the higher the temperature of the first
observed consistency. Furthermore, increasing the concen-
tration increases this consistency more than directly pro-
portional to the increase in concentration up to a point where
the concentration is too great for accurate reading. When
the Irish potato starches are too concentrated they become
brittle or "short" (6) and do not give accurate results. In
Figure 3, the increase of speed shows no effect upon the
temperature of initial consistency but does increase the ap-
parent maximum consistency. It is also noted that this in-
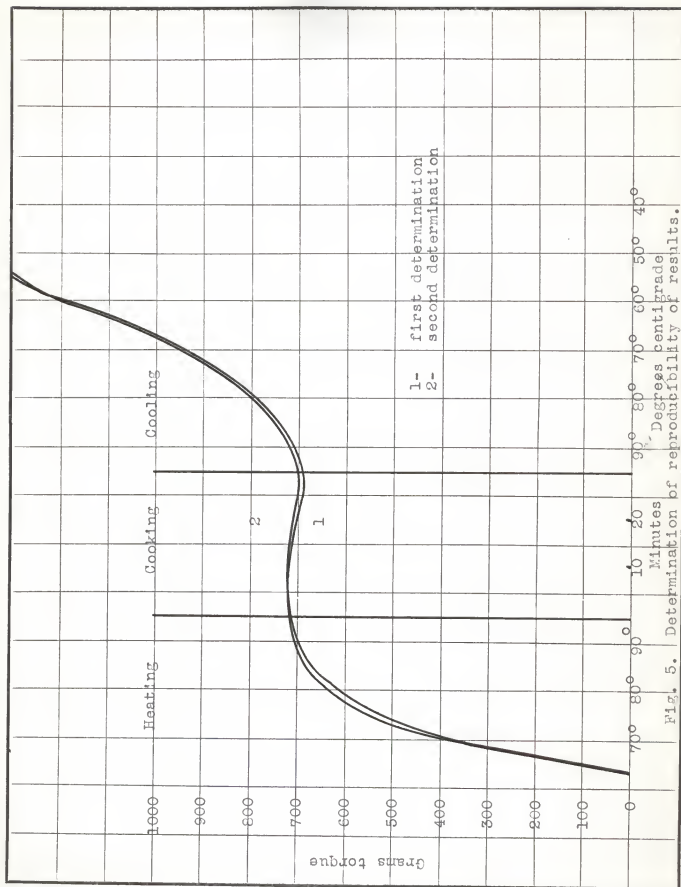crease is less than directly proportional to the speed and

Fig. 5. Determination of reproducibility of results.

can be explained as a thixotropic effect. If the speed is less than 60 r.p.m. the Irish potato starch granules settle out rapidly and cannot be kept in suspension satisfactorily with the limited amount of stirring that could be done with a stirring rod. In relation to the gelatinization temperature range found by Williams (22), the consistency curves of Irish potatoes always started below his lowest figure and continued to increase past the upper limit of the gelatinization temperature. The cooking of Irish potato starch at 93-94° C. for 30 minutes decreases the consistency very little. Late harvest, Figure 6 has the effect of lowering the initial gelatinization temperature, produces a greater initial consistency and then thins out more during the cooking range. When this late harvest starch paste is cooled, it returns to the heavier consistency but never attains the heaviest consistency of the early harvest. Figure 8 compares three common varieties for Kansas. The Warba has the lowest temperature for the start of the consistency curve, the least thinning and the highest observed consistency. The Cobbler has the lowest maximum consistency and thins out a little more.

The growing locale may have some effect but since there were but few samples and other factors were involved, the results were conflicting. This was also found the same for the soil types, and so no definite correlation can be made.
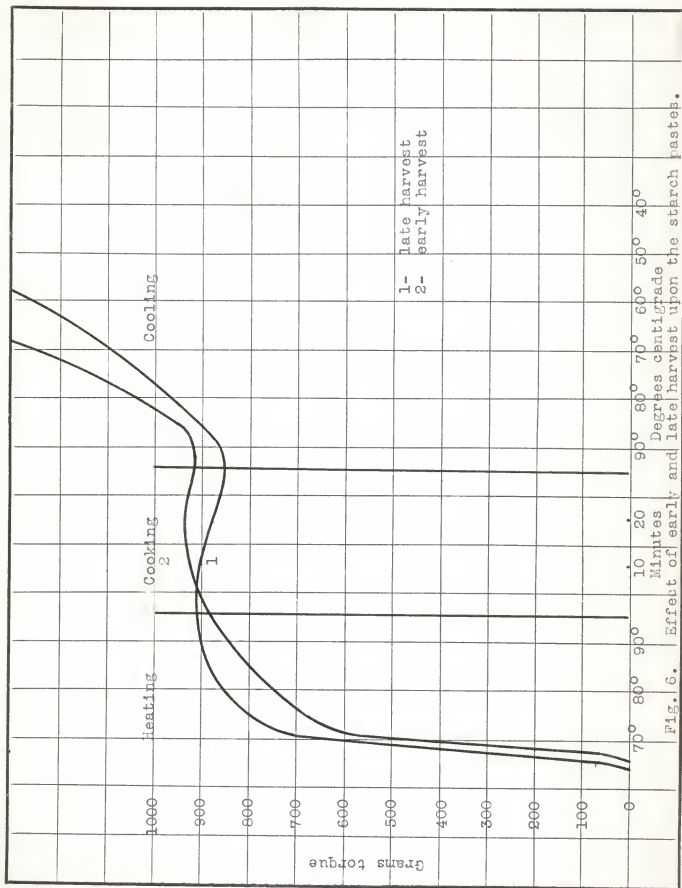
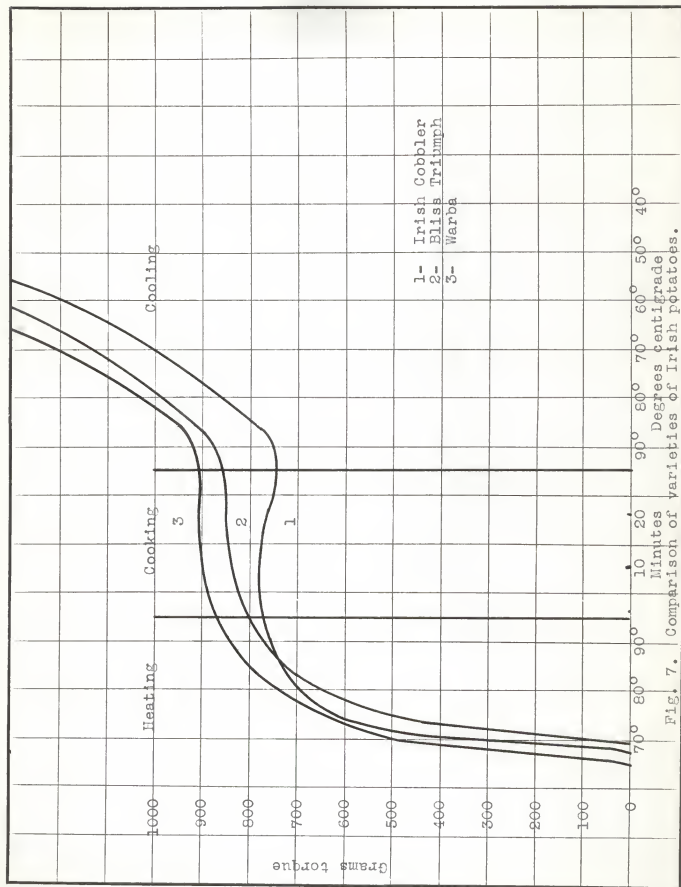Fig. 6. Effect of early and late harvest upon the starch pastes.
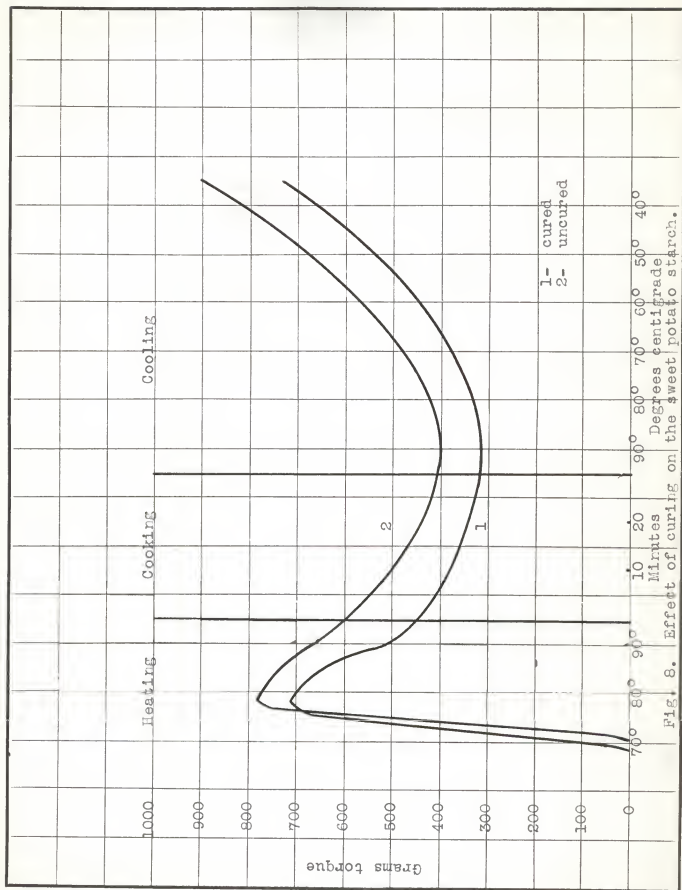
Fig. 7. Comparison of varieties of Irish potatoes.

1– Irish Cobbler
2– Bliss Triumph
3– Warba

Fig. 8. Effect of curing on the sweet potato starch.

1- cured
2- uncured

Heating  Cooling  Cooling

Grams torque

Minutes
Degrees centigrade

## Consistency of the Sweet Potato Starches

Sweet potato starch, as shown in Figure 2, can be used in a concentration as great as 15 percent in the consistometer. The increase in consistency is also greater than directly proportional to the increase in concentration. It is further noticed that increasing the concentration increases the tendency for the starch to thin out more at higher temperatures and lowers the temperature at which the thinning starts. Moreover, increasing the concentration decreases the temperature at which the consistency curve starts.

Figure 4 shows that increasing the speed of the outer cup has no effect upon the initial gelatinization temperature but does increase the consistency less, however, than directly proportional to within the limits of the instrument.

Figure 8 emphasizes the change that takes place in the curing of sweet potatoes. Curing decreases the viscosity and also lowers the temperature at which the consistency becomes apparent.

Figure 9 compares five varieties of sweet potatoes that were grown in the same locality. The Little Stem Jersey has the highest consistency curve and the least thinning out. Regular Big Stem has the lowest curve and show the most thinning out during cooking. As a whole the Jersey varieties start their consistency curves five degrees higher than either the Nancy Hall or the Red Bermuda. Furthermore, in all cases
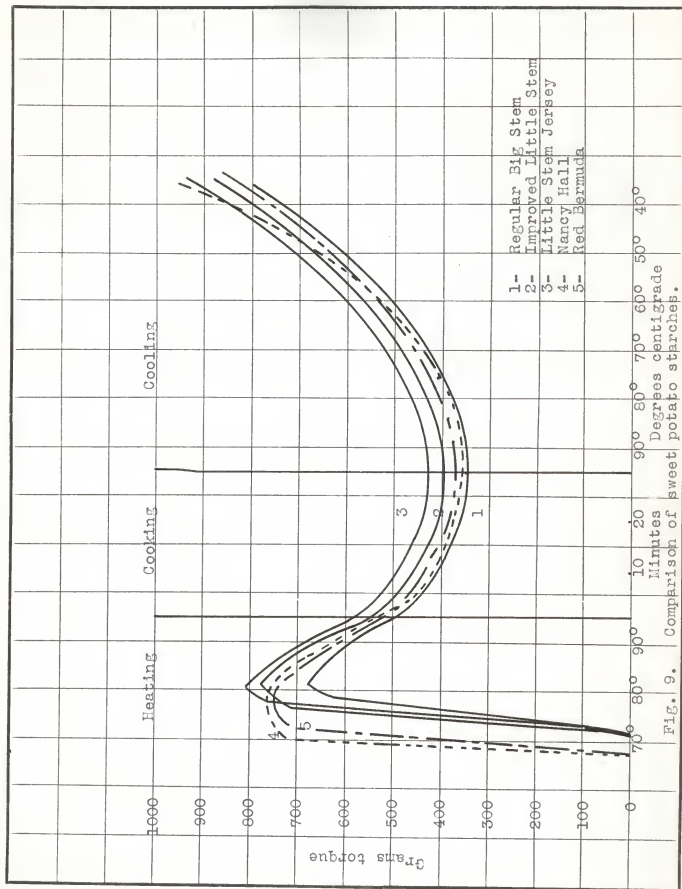
Fig. 9. Comparison of sweet potato starches.

1— Regular Big Stem
2— Improved Little Stem
3— Little Stem Jersey
4— Nancy Hall
5— Red Bermuda

these curves started at a higher temperature than the gelatinization temperature (22) and started to thin out at the top limit given by Williams.

### Comparison of Irish and Sweet Potato Starches

A comparison of Figures 7 and 9 reveals that the general shape of the curves are different. The Irish potato starch curve starts below its lower gelatinization temperature and increases after the upper limit is reached. In the sweet potato starches this is not so. The consistency curve begins above the lower limit of its gelatinization temperature range and as soon as the upper limit is reached the starch starts to thin out. Irish potato starch thins out very little and when cooled becomes very viscous. In fact, it becomes so viscous that the starch loses much of its tenacity when too concentrated a suspension is used. On the other hand, sweet potato starch thins out a great deal and, when cooled, regains most of its lost consistency.

### Comparison of Commercial and Kansas Starches

Figure 10 presents a comparison of a commercial domestic Irish potato starch of Stein Hall and Company with one that was prepared in the laboratory. There is a marked difference between them. The commercial starch has a five degree lower gelatinization temperature, a higher initial consistency and
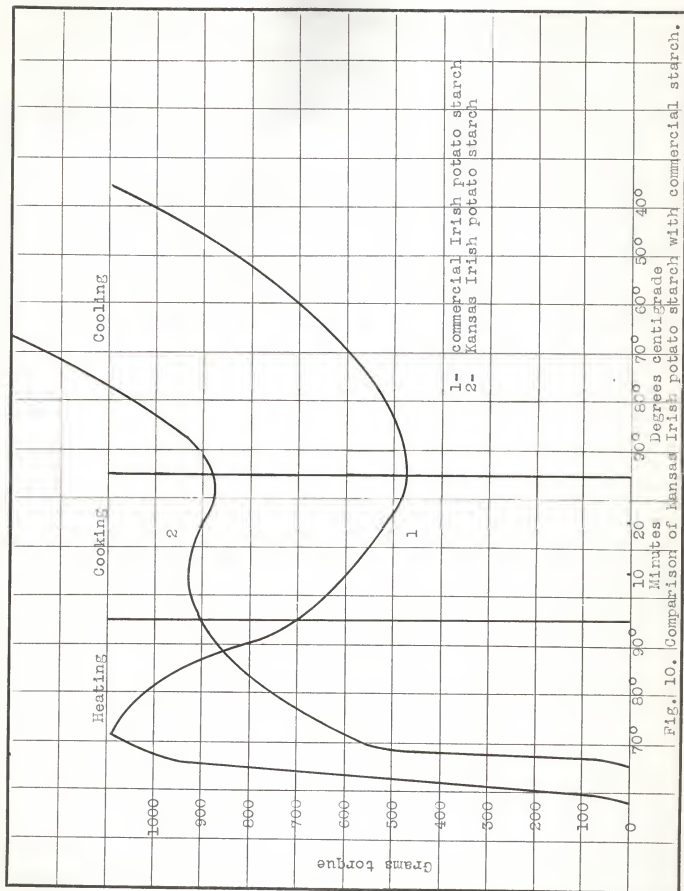
Fig. 10. Comparison of Kansas Irish potato starch with commercial starch.

a very great deal of thinning out during cooking. When the
starch is cooled it does not attain the high consistency of the
Kansas product, but appears much more like the common curve
obtained for sweet potatoes (Fig. 9).

In Figure 11, there are two curves of sweet potato starch-
es prepared in the laboratory and one prepared by Stein Hall
and Company. All three curves have the same general shape
but the commercial one has the highest initial consistency and
less thinning out. The gelatinization temperature of the com-
mercial starch is in the same range as the Nancy Hall and the
Red Bermuda which is lower than the Jersey varieties.

## DISCUSSION

Several common varieties of sweet and Irish potatoes
which were grown in different locations and under different
soil and climatic conditions, harvested at different times
and treated differently after harvest were brought into the
laboratory. The starch which was obtained from them was very
white and had practically no impurities, such as fiber, dirt
or any pigmented cells. Each starch was analyzed by the di-
rect acid hydrolysis method in order to make starch pastes of
a known concentration.

In order to use the consistometer to the best advantage,
a systematic check was made of the various speeds and con-
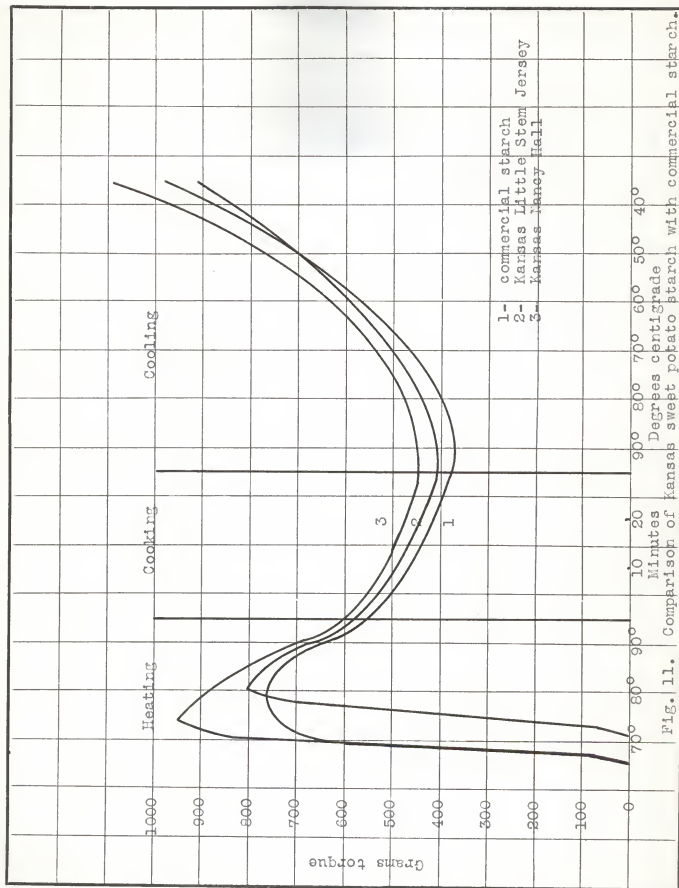centrations of pastes. It was found that a speed of 60 r.p.m.

Fig. 11. Comparison of Kansas sweet potato starch with commercial starch.

1- commercial starch
2- Kansas Little Stem Jersey
3- Kansas Nancy Hall

and a concentration of ten percent was the best for a compar-
ison of all starches. At this speed the paste was not stir-
red too vigorously nor were the pastes too thick and brittle.

It was found that there exists quite a difference be-
tween the sweet potato and Irish potato starches, as the
sweet potato starch thins out much more and never attains the
heavy consistency of the Irish potato starches.

There appears to be a great difference within the varie-
ties of both types of potatoes grown under similar conditions.
In conjunction with this it is observed that soil differences
in the same locality will cause some differences in the same
variety, but because of inadequate sampling no definite con-
clusions may be drawn.

Several samples of both kinds of potatoes grown in the
Kaw valley and the Arkansas valley were measured but the
results were somewhat conflicting. Since there are so many
variables that could cause differences within one variety of
potato more samples and careful selection of soils, crops
preceeding and control of moisture will be needed before a
definite conclusion can be drawn.

The comparison of commercial Irish potato starch with
the starches prepared in the laboratory seem to indicate
that the Kansas product would be better for the sizing of
paper and textiles. It does not thin out so much and has a
greater consistency at all times except at the initial part

of the heating. The sweet potato starch was not quite so
viscous as the commercial starch and might be more suited to
be used as a thin boiling starch in sizing. The difference
between the two was not so very great and so possibly where
one would be suitable, the other would do with only slight
modification.

## CONCLUSIONS

1. The consistometer measures accurately the differ-
ences in starch among types, varieties and conditions to
which the potatoes have been subjected.

2. The smaller the concentration of starch the higher
the temperature at which the consistency curves start.

3. An increase of concentration is more than directly
proportional to the increase in consistency, within the limits
of the instrument.

4. Consistency curves of Irish potato starches start
below the lower point and continue to increase after the upper
limit of the gelatinization temperature range has been reached.

5. Consistency curves of sweet potato starches start
above the lower gelatinization temperature and start to thin
out at the upper limit of this range.

6. Sweet potato starches thin out much more than Irish
potato starches.

7. Late harvesting of Irish potatoes affects the starch
as it lowers the temperature of the start of the consistency

curves, produces a greater initial consistency and then thins
out more than the early harvest.

8. There is a difference in varieties from the same
locality. Warba of the Irish potatoes and Little Stem Jersey
of the sweet potatoes seem to have a higher consistency and
less thinning out. The lowest in these two types are the
Irish Cobbler and the Regular Big Stem.

9. Curing of sweet potatoes decreases the consistency,
lowers the initial temperature of the consistency curve and
increases the tendency to thin out.

10. Location may have some effect upon the varieties
but the results were not consistent with the few samples used.

11. Kansas Irish potato starches are much more viscous
after the initial part of the consistency curve, do not thin
out so much and have a higher gelatinization temperature than
the samples of commercial potato starch tested. Therefore,
Kansas Irish potato starches will make as good, if not better,
thick starch pastes.

12. The commercial and Kansas sweet potato starches dif-
fered but little, the commercial starches being slightly more
viscous and having a lower gelatinization temperature than
the Jersey varieties. Nancy Hall variety gave a starch that
was more nearly like the commercial product but it was not
quite so viscous and thinned out more. As a consequence, the
starch from Kansas sweet potatoes would be suitable in processes
in which the thinning out would be of no consequence.

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APPENDIX

APPENDIX

History of Potatoes from which the Starches were Prepared

Irish Potatoes

A- 1  IRISH COBBLER - EARLY HARVEST.
       This sample was grown on sandy loam soil by Paul
       Mellott, Edwardsville, Kansas.  It was dug July 6,
       and received July 8, 1939.  The sample was clean,
       irregular in shape, non-uniform in size, and con-
       sisted mainly of small potatoes.

A- 2  BLISS TRIUMPH - EARLY HARVEST.
       This sample was grown on sandy loam soil by O.
       Browning, Linwood, Kansas.  It was dug July 5, and
       received July 8, 1939.  The sample was clean, high-
       ly uniform in size, and regular in shape.

A- 3  WARBA - EARLY HARVEST.
       This sample was grown on sandy loam soil by Paul
       Mellott, Edwardsville, Kansas.  It was dug July 6,
       and received July 8, 1939.  The sample was clean,
       uniform, and regular in size and shape.

A- 4  IRISH COBBLER - EARLY HARVEST.
       This sample was grown on fine sandy loam soil at
       Newman Plots, Newman, Kansas.  It was dug July 7,
       and received July 8, 1939.  The sample was clean,
       fairly uniform, large, and regular in size and
       shape.  It was grown on soil that had grown
       potatoes following potatoes.

A-11  IRISH COBBLER - REGULAR HARVEST.
       This sample was grown on sandy loam soil by A. W.
       Travis, Manhattan, Kansas.  It was dug July 14, and
       received July 14, 1939.  The sample was clean,
       fairly uniform in size and shape, but small.  They
       were grade 2.  The sample was stored at 42° F.,
       July 14, 1939.

A-13  IRISH COBBLER - LATE HARVEST.
       This sample was grown on sandy loam soil by Paul
       Mellott, Edwardsville, Kansas.  It was dug July
       19, and received July 19, 1939.  The sample was
       clean, large, and fairly uniform in shape.  Some
       had rotten spots inside the potatoes while others
       showed external rotting.

A-14 WARBA - LATE HARVEST.
This sample was grown on sandy loam soil by Paul
Mellott, Edwardsville, Kansas. It was dug July
19, and received July 19, 1939. The sample was
clean, fairly large, and rather irregular in shape.
There was some internal rotting of the potatoes.

A-15 BLISS TRIUMPH - LATE HARVEST.
This sample was grown on sandy loam soil by O.
Browning, Linwood, Kansas. The sample was dug
July 19, and received July 24, 1939. It was clean,
uniform in size and shape, but contained consider-
able rot throughout. The sample had been mis-
placed in storage and was not found for several
days.

A-16 IRISH COBBLER - LATE HARVEST.
This sample was grown on fine sandy loam soil at
Newman Plots, Newman, Kansas. It was dug July 25,
1939. The sample was clean, uniform in size and
shape, and was rather large in size.

Sweet Potatoes

B- 4 LITTLE STEM JERSEY.
Mature (Priestleys) - Before Curing. This sample
was grown by R. Skinner, Topeka, Kansas. It was
dug September 27, and was received September 27,
1939. The sample was not very clean; it was uni-
form in size and shape.

B- 5 LITTLE STEM JERSEY.
Regular Harvest - Before Curing. This sample was
grown by A. W. Travis, Manhattan, Kansas. It was
dug October 2, and was received October 3, 1939.
The sample was clean, fairly large size, and was
uniform in size and shape.

B- 6 IMPROVED BIG STEM JERSEY.
Regular Harvest - Before Curing. This sample was
grown by A. W. Travis, Manhattan, Kansas. It was
dug October 2, and was received October 3, 1939.
The sample was clean, uniform in shape, but ir-
regular in shape.

B- 9 NANCY HALL.
Regular Harvest - Before Curing. This sample was
grown by Kirby Brothers, R.F.D. 6, Wichita, Kansas.
It was dug October 6, and was received October 9,

1939. The sample was clean, medium size but regular, and uniform in shape.

B-10  REGULAR BIG STEM.
Regular Harvest - Before Curing. This sample was grown by P. B. Farber, R.F.D. 2, Mulvane, Kansas. It was dug October 6, and was received October 9, 1939. The sample was clean and of a good size and shape.

B-11  LITTLE STEM JERSEY.
Regular Harvest - Before Curing. This sample was grown by Kirby Brothers, R.F.D. 6, Wichita, Kansas. It was dug October 6, and was received October 9, 1939. The sample was of a small size, uniform in shape, and clean.

B-12  RED BERMUDA.
Regular Harvest - Before Curing. This sample was grown by A. W. Travis, Manhattan, Kansas. It was dug October 13, and was received October 16, 1939. The sample was of a large size, uniform in shape, and fairly clean.

B-13  NANCY HALL.
Regular Harvest - Before Curing. This sample was grown by A. W. Travis, Manhattan, Kansas. It was dug October 13, and was received October 16, 1939. The sample was fairly clean and was of a large and uniform size and shape.

B-14  RED BERMUDA.
Regular Harvest - After Curing. This sample was grown by A. W. Travis, Manhattan, Kansas. It was dug October 13, and was received November 13, 1939. The sample was clean, large, and uniform in size.

B-15  IMPROVED BIG STEM JERSEY.
Regular Harvest - After Curing. This sample was grown by A. W. Travis, Manhattan, Kansas. It was dug October 2, and was received November 13, 1939. The potatoes were of a medium size, fairly clean, and uniform in size and shape.

B-16  LITTLE STEM JERSEY.
Regular Harvest - After Curing. This sample was grown by A. W. Travis, Manhattan, Kansas. It was dug October 2, and was received November 13, 1939. The sample was of a medium size, fairly clean,

uniform in size and shape, and the potatoes were quite solid.

B-17   LITTLE STEM JERSEY.
Regular Harvest - After Curing.  This sample was grown by A. W. Travis, Manhattan, Kansas.  It was dug October 13, and was received November 13, 1939. The potatoes were medium sized, clean, uniform in size and shape, and were solid.