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Factors affecting the pop-ability of pop corn

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FACTORS AFFECTING THE POP-ABILITY OF POP CORN

By

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Table of Contents

FACTORS AFFECTING THE POP-ABILITY OF POP CORN

Introduction

Compared with our leading crops pop corn is of minor importance from the standpoints of both world and domestic production. However, it holds an important place in many states, especially in certain localities.

The census report gives the acreage of pop corn in 1909 for the eleven leading pop corn producing states, namely, Iowa, Nebraska, Illinois, Kansas, Ohio, Michigan, California, Indiana, New York, Minnesota, and Wisconsin as 11,343 acres; valued at $285,286. Although the average farm usually grows a small acreage as high as 1000 acres is reported as being grown by one Iowa producer.

Pop corn not only furnishes a pleasing treat during the long winter evenings but also gives a product of considerable food value, especially when served with butter or prepared in the many ways to which it lends itself.

Due to the above facts and the limited work done on factors affecting the pop-ability the author in choosing this topic felt that there was a need for research on this subject.

HISTORICAL

Theory of Popping

Brewer (1) has shown in his work that the oil content is not a factor in determining pop-ability as was generally believed. He contended that "the popping is apparently due to the bursting of the starch grains. Only the flinty types 'pop'. These are more compact in structure, and as the starch grains expand with the heat the hard exterior is burst".

Kraemer (5) states that the structural characteristics of the starch grains in the altered areas of the different pop corns would seem to indicate that the popping of the grain of corn results from the expansion of the individual starch grains, the degree of expansion depending upon the relative amount of water and air in the grains. As an illustration of this he states that perfectly fresh pop corn or pop corn that has been soaked in water for twenty four hours will pop but little in the true sense of the word. On the other hand, a pop corn which

[illegible]

[illegible]

[illegible]

[illegible]

was seven years old, but had not lost its germinating power, would not pop unless first soaked in water and then allowed to dry from four to twelve hours. That this property probably resides in the starch grain is further shown by the fact that individual pieces of the pop corn kernel will pop.

Storer (8) after experimenting on kernel treatments concludes "that the skin of the grain exerts a very decided influence on the act of popping. It would appear, indeed, that both the structure of the individual starch grains in the kernel and the toughness of the restraining skin which envelopes the kernel, act to control or modify the manner in which the moisture in the starch grains when suddenly heated is converted into steam of such high tension that the explosive act of popping results, whereby both the skin of the seed itself and the envelopes of most of the starch grains in the seed are ruptured". He also disproved the opinion that popping is due to the presence of oil in the grain.

Wilbert (10) from observation and experiment concluded that the popping of pop corn is caused by the expansion of moisture in the starch cells and based his conclusions on the following grounds, namely, that "old and dry corn did not pop readily". Such corn will at best only split open from a number of cells near the center of the corn kernel. If the application of heat be made slowly, it is possible to dry the kernels of corn, parch and even char them without rupturing the outer coat in any way. It was also noted that at the base of the kernels, or at the point of attachment to the cob, the cells are less compact and are seldom, if ever, ruptured by the generated steam. It is from this point too that the kernels of corn appear to dry most rapidly. The bearing of this point on the theory that popping is caused by an explosion of steam is found in the fact that pop corn invariably bursts first at the densest portion of the kernel, and never at or near its base or point of attachment. When old and dry corn was soaked for twelve hours and

then dried for an equal time it did not pop well. If kernels were allowed to dry on the surface for twenty four hours longer the resulting kernels of pop corn were not only very large, light and flaky but had absolutely no suggestion of toughness.

Factors Affedting the Pop-ability

Hartley and Willier (3) state that pop corn pops best if it contains about 12% moisture, with not too much corn in the popper or about one kernel deep. The right degree of heat for the best results in popping should make good corn begin to pop in one and a half minutes. This should give maximum volume increase in popping.

Hartley and Willier (3) give two main factors as influencing the quality, and physical conditions. "Careful tests have shown that the pollination of white pop corn with pollen from yellow field corn affects the flavor, texture, and color of the popped kernels that were cross-pollinated. To give satisfactory results in popping, corn should ripen fully on

the standing stalk before frost comes and should then be stored where it will have sufficient ventilation, so it will not heat in curing. The kernels should be practically free from soft white matter in the endosperm".

The New Jersey Agricultural Experiment Station (7) states that there are many factors which enter into the study of pop-ability, some within and others without the grain. For example the moisture content is very important, grains can be too dry as well as too moist for the best results. Tests with variously cut and filed kernels show that any interference with the corneous envelope produce a weak place and prevents the full explosion caused by the heat. Degree of maturity influences the pop-ability. To determine this several stalks bearing three ears each were cut at various stages of their ear development so that a wide range of maturity in the grains were obtained. One hundred grains were selected from each of a set of three ears from the same stalk. Five additional sets

of three ears each, 100 grains for each popping, were also tested. The results show that the oldest ears gave a much larger percent of fully popped grains than the intermediate and least mature ears. In like manner the largest degree of pop-ability is associated with the heaviest grains and grestest specific gravity. A test for the influence of shape of grain upon pop-ability was made in connection with size and dentedness. The grains were selected from a cross of "Golden Queen" with "Voorhees Stowell". The tests show that the shape whether round, flat or dented, determines the pop-ability in the cross much more than size. While there is a great difference due to size those results also show that crosses between pop and sweet corn, even when the grains selected are small, are not possessed of a high degree of pop-ability. It is also possible that the smaller grains may be less mature than the larger ones being taken from nearer the tip of the ear. Position of grains on the ear have an influence

on pop-ability, grains just above the butt zone are the first to form, largest and best for planting.

Storer (8) conducted tests to determine the influence of skin on the popping of the kernels and the popping qualities of different parts of the kernel. Skinned kernels merely swelled to a slight degree but they did not pop. When kernels not skinned were cut in two crosswise, the halves nearest the cob end did not pop, while the outer halves popped readily. When the skin was removed, neither portion would pop. When the kernels were cut in two lengthwise, both parts popped readily. When unskinned kernels cut into quarters were tested it was found that none of the quarters from the cob end would pop. Some of the quarters from the outer end of the grain popped, though other specimens would not. When cut into halves crosswise, soaked in ether for five days, and dried, the halves which came from the pointed end of the kernels popped successfully while none of those from the inner end would pop. When the

skins were removed and the kernels were soaked in ether three or four days and dried, no success was met with on trying to pop them. "It is plain from the foregoing trials", the author states, "that the skin of the grain exerts a very decided influence on the act of popping."

Changes in Popping

Hartley and Willier (3) say that good grades of pop corn increase in volume from 12 to 20 times in popping. In popping there is 7 to 25% waste.

Wilbert (10), as regards the loss of weight in popping, noted that 100 kernels of whole or unpopped corn weighed 13 grams, the same quantity partially popped 11 grams, fully popped 9.2 grams, and dried and parched 7.5 grams.

Storer (8) in experiments "To determine whether popped corn contains any more soluble starch or other forms of dextrin, than is contained in the original grain" found that the amount of water soluble material was about the same in popped and unpopped corn, being 19.3%

in the popped corn and 21.12% in the unpopped corn on the dry matter basis. Tests with cupric oxide showed that no more than mere traces of reducing material were present in either the popped or unpopped samples. The tests made to determine whether soluble starch is formed by popping gave negative results. The author further states that after the act of popping less hygroscopic moisture was retained by the corn than was contained naturally, that is, before popping, Thus, on drying at 95 to 100 degrees centigrade samples of the meal from popped and unpopped corn, it appeared that the popped corn contained 7.45 per cent of moisture, while the unpopped corn held 12.13 per cent. The Tenth United States Census (8) shows that the principal change brought about by popping was a considerable loss of water due to the evaporation of moisture by the heat employed.

PURPOSES OF THE INVESTIGATION

General

1. To check some of the work already done and to submit data and photographs instead of statements, which have often been advanced without sufficient experimental evidence.

2. To investigate new phases that might be of scientific interest and practical value.

Specific

To study the following factors in relation to their effects on pop-ability:

1. Moisture
2. Age
3. Maturity
4. Kernel treatments
5. Size
6. Freezing

EXPERIMENTAL

Methods

Moisture Determination

The moisture content was determined by the Brown-Duval method and by heating in an electric oven at 100 - 105 degrees centigrade until weight was constant, or about 96 hours. As a check the samples that had been dried in the oven were run in the Brown-Duval tester but there was no moisture driven off. Five 50 - gram samples of a composite lot were run in each case with the following results:

Brown-Duval Method			Heated in Electric Oven at 100 degrees C		
Sample Number	Per cent Moisture	Average Per cent Moisture	Sample Number	Per cent Moisture	Average Per cent Moisture
1	9.0		1	11.24	
2	9.2		2	11.77	
3	8.6	8.4 ± .270	3	11.96	11.52 ± .118
4	6.8		4	11.41	
5	8.4		5	11.20	

Note: The probable error of the mean in this and all other experiments cited in this article was calculated by means of Peter's approximation formula, given by Mellor (1913) (6). The probable error of the mean is $\frac{0.8453 \Sigma(\pm v)}{\sqrt{n(n-1)}}$, in which $\Sigma(\pm v)$ is the sum of the deviations of all the individuals from the mean, without regard to the sign, and _n_ is the number of individuals. If the difference between means is 3.8 times its probable error, the chance is 30 to 1 (Wood and Stratton, 1910 (11) that the difference is significant.

Conclusions:

From the above data the electric oven method proved to drive off the greater percentage of moisture as well as checking more closely. For this reason throughout the entire work the latter method of moisture determination was used. Moisture determinations were on the dry basis in all cases.

Popping

The popping was done over three gas burners, on a steel plate supported by four tripods (a). In each case the flames were regulated to the same height in order to obtain the same heat. The ordinary wire popper as found on the market was used.

Type of Corn Used

A local improved type of Rice of rather large size (b). In each case special care was used to select the best, discarding cracked, diseased or otherwise damaged ears or kernels.

(a) Plate 1

(b) Plate 2

Experiment I

Moisture as Affecting Pop-ability

In order to obtain a wide range of moisture contents all samples were soaked an equal length of time (2½ hrs.) in water at 18° to 20°C. Then to obtain the range of moisture they were dried, at first in air and later in the electric oven at such temperature as necessary to bring the samples down to required moisture range. As far as possible a range of two per cent moisture was obtained. For popping samples of twenty grams each were used.

From Table I, it may be seen that at 1.85% of moisture no popping whatever occurred, not even a cracking except in case of a very few kernels. At and above 3.43% some in each case partially popped. None would pop fully below 7.53% or above 23.75%.

Referring to Chart I, it may be seen that the maximum volume percentage increase in popping took place at 11.89% moisture, the

Moisture as affecting pop-ability

Table I

Sample number	Percent moisture	Average percent moisture	Kernels number total	Percent fully popped	Average percent fully popped	Percent not cracked	Percent partially popped	Percent cracked longitudinally	Percent cracked cross-wise	Popping time min. sec.	Percent weight loss in popping	Total vol. CC	Average vol. CC	Vol. percent increase	Average vol. percent increase	
1	1.39		131	0.0		100.00	0.0	0.0	0.0	3 - 0	4.06	30		0.0		
2	1.95	1.85	136	0.0	0.0	97.06	0.0	2.94	0.0	3 - 0	3.95	30	30	0.0	0.0	± 0.0
3	1.89		136	0.0		100.00	0.0	0.0	0.0	3 - 0	1.61	30		0.0		
4	1.89	± 0.076	136	0.0		100.00	0.0	0.0	0.0	3 - 0	1.89	30		0.0		
5	2.11		139	0.0		97.12	0.0	2.88	0.0	3 - 0	3.12	30		0.0		
6	3.12		136	0.0		92.65	0.0	7.35	0.0	3 - 0	4.51	30		0.0		
7	3.56	3.43	132	0.0	0.0	71.97	12.12	15.90	0.0	3 - 0	5.79	40	32	33.0	6.6	± 2.23
8	3.67		134	0.0		94.78	1.49	3.73	0.0	3 - 0	4.56	30		0.0		
9	3.84	± 0.132	133	0.0		84.21	4.51	11.28	0.0	3 - 0	4.95	30		0.0		
10	2.95		131	0.0		91.60	0.76	6.87	0.76	3 - 0	4.73	30		0.0		
11	4.28		134	0.0		89.55	2.99	7.46	0.0	4 - 0	4.95	30		0.0		
12	5.90	5.32	134	0.0	0.0	64.18	14.92	20.89	0.0	3 - 0	5.29	50	62	67.0	106.8	± 15.76
13	4.90		136	0.0		27.94	51.47	20.59	0.0	3 - 0	7.12	85		183.0		
14	6.01	± 0.246	137	0.0		35.04	43.80	21.17	0.0	3 - 0	7.74	80		167.0		
15	5.51		136	0.0		63.97	27.21	8.82	0.0	2 - 30	6.12	65		117.0		
16	7.46		138	8.70		10.87	60.87	17.39	2.17	3 - 0	9.13	145		383.0		
17	7.62	7.53	138	5.80	7.93	28.26	45.65	17.39	2.90	3 - 0	8.85	105	118	250.0	293.4	± 41.62
18	7.96		135	13.33		8.15	57.04	21.48	0.0	2 - 20	9.63	165		450.0		
19	7.40	± 0.086	136	8.82		41.18	33.82	16.18	0.0	3 - 0	8.07	95		217.0		
20	7.23		133	3.01		42.10	35.34	19.55	0.0	3 - 0	7.90	80		167.0		
21	9.52		134	28.36		8.96	48.51	14.18	0.0	3 - 0	10.85	190		533.0		
22	9.35	9.37	133	19.55	27.03	11.28	57.14	12.03	0.0	3 - 30	10.85	165	189	450.0	529.8	± 18.53
23	9.40		129	34.88		10.08	44.19	10.85	0.0	2 - 30	10.52	205		583.0		
24	9.35	± 0.029	136	27.94		15.44	45.59	11.03	0.0	3 - 30	10.41	180		500.0		
25	9.24		135	24.44		8.15	59.26	8.15	0.0	2 - 30	10.80	205		583.0		
26	11.98		136	47.06		11.03	28.68	13.23	0.0	2 - 10	12.59	215		617.0		
27	11.85	11.89	134	55.97	50.48	4.48	29.85	9.70	0.0	2 - 20	13.36	245	233	717.0	677.0	± 21.98
28	11.80		133	59.39		0.75	31.58	7.52	0.75	2 - 10	13.30	260		767.0		
29	11.85	± 0.027	136	42.65		5.88	36.76	14.71	0.0	2 - 30	12.69	215		617.0		
30	11.96		131	47.33		5.34	36.64	10.69	0.0	2 - 25	13.19	230		667.0		

Moisture as affecting pop-ability

Table I continued

Sample number	Percent moisture	Average percent moisture	Kernels number total	Percent fully popped	Average percent fully popped	Percent not cracked	Percent partially popped	Percent cracked longitudinally	Percent cracked crosswise	Popping time min.sec.	Percent weight loss in popping	Total vol. CC	Average vol. CC	Vol. percent increase	Average vol. percent increase	
31	13.69		136	55.15		5.15	20.59	19.12	0.0	2 - 10	14.86	250		733.0		
32	13.98	13.92	132	46.97	47.25	12.88	28.79	11.36	0.0	2 - 20	14.23	245	225	717.0	649.8	± 2.10
33	13.98		139	51.80		16.55	18.71	12.95	0.0	2 - 10	13.48	250		733.0		
34	13.98	± 0.039	135	25.19		60.00	4.44	8.89	1.48	2 - 10	9.30	115(1)		283.0		
35	13.98		133	57.14		15.04	15.79	11.28	0.75	2 - 10	13.43	265		783.0		
36	15.64		142	12.68		10.56	39.44	32.39	4.93	2 - 0	13.26	120		300.0		
37	15.64	15.38	138	17.39	20.37	29.71	28.99	19.56	4.35	2 - 0	12.58	130	143	333.0	376.4	± 20.25
38	15.97		136	24.26		16.91	33.09	25.00	0.74	2 - 0	13.61	160		433.0		
39	14.47	± 0.191	133	21.05		9.77	33.08	30.08	6.02	2 - 10	13.86	145		383.0		
40	15.14		136	26.47		11.03	36.76	22.79	2.94	2 - 10	14.11	160		433.0		
41	17.97		132	11.36		12.88	39.39	30.30	6.06	2 - 10	17.25	125		317.0		
42	17.97	17.84	137	8.76	12.17	5.11	49.63	32.12	4.38	2 - 20	18.09	125	136	317.0	353.6	± 19.17
43	17.97		134	14.18		22.39	38.06	19.40	5.97	2 - 0	15.47	125		317.0		
44	17.64	± 0.066	135	8.89		15.56	47.41	23.70	4.44	2 - 0	15.80	135		350.0		
45	17.64		136	17.65		16.18	38.97	22.04	5.15	2 - 0	15.75	170		467.0		
46	19.87		127	6.30		18.11	29.92	34.64	11.02	2 - 20	16.25	85		183.0		
47	19.76	19.82	137	3.65	4.64	24.82	32.12	30.66	8.76	2 - 20	15.85	85	85	183.0	183.0	± 0.0
48	19.98		135	5.93		25.93	23.70	34.81	9.63	2 - 20	15.70	85		183.0		
49	19.48	± 0.069	135	3.70		27.41	35.56	22.22	11.11	2 - 20	16.14	85		183.0		
50	20.03		138	3.62		19.56	32.61	31.16	13.04	2 - 20	15.57	85		183.0		
51	21.94		135	1.48		18.52	41.48	28.89	9.63	2 - 20	17.93	90		200.0		
52	21.81	21.81	134	3.73	2.80	20.15	41.79	23.88	10.45	2 - 20	17.56	85	80	183.0	166.6	± 8.49
53	21.70		134	2.24		25.37	31.34	30.60	10.45	2 - 20	18.20	75		150.0		
54	21.73	± 0.033	142	2.11		35.92	23.24	27.46	11.27	2 - 20	16.61	70		133.0		
55	21.89		135	4.44		16.30	29.63	35.56	14.07	2 - 20	17.16	80		167.0		
56	23.72		136	2.94		30.88	27.21	27.94	11.03	2 - 20	18.70	70		133.0		
57	23.98	23.75	134	2.99	3.13	17.16	43.28	29.10	7.46	2 - 20	20.65	95	89	217.0	196.6	± 13.05
58	23.72		134	3.73		10.45	44.78	33.58	7.46	2 - 20	20.44	105		250.0		
59	23.51	± 0.049	132	3.89		13.64	37.12	31.82	13.64	2 - 20	19.22	85		183.0		
60	23.80		136	2.21		16.18	44.12	28.68	8.82	2 - 20	19.36	90		200.0		

(1) Not figured in probable error

Moisture as affecting pop-ability

Table I continued

Sample number	Percent moisture	Average percent moisture	Kernels number total	Percent fully popped	Average percent fully popped	Percent not cracked	Percent partially popped	Percent cracked longitudinally	Percent cracked crosswise	Popping time min. sec.	Percent weight loss in popping	Total vol. CC	Average vol. CC	Vol. percent increase	Average vol. percent increase
61	25.90		135	0.0		16.30	42.96	27.41	13.33	2 - 20	21.61	75		150.0	
62	25.54	25.60	134	0.0	0.0	20.15	35.07	30.60	14.18	2 - 20	19.87	75	77	150.0	156.8 ± 3.45
63	25.10		132	0.0		15.90	35.61	40.15	8.33	2 - 20	21.51	80		167.0	
64	25.93	± 0.105	136	0.0		22.04	37.50	25.00	15.44	2 - 20	20.48	75		150.0	
65	25.54		137	0.0		28.47	37.96	27.74	5.84	2 - 20	19.81	80		167.0	
66	26.82		137	0.0		23.36	28.47	31.39	16.79	2 - 30	21.48	65		117.0	
67	27.16	27.47	137	0.0	0.0	23.02	40.29	24.46	12.23	2 - 30	22.77	80	76	167.0	153.4 ± 7.30
68	27.77		133	0.0		18.80	39.10	30.83	11.28	2 - 30	22.58	75		150.0	
69	27.71	± 0.161	135	0.0		22.22	38.52	23.70	15.56	2 - 30	22.30	75		150.0	
70	27.88		141	0.0		20.57	39.72	24.82	14.89	2 - 30	22.96	85		183.0	
71	28.95		132	0.0		15.90	46.97	24.24	12.88	2 - 30	23.89	80		167.0	
72	29.60	29.66	134	0.0	0.0	20.14	35.82	32.09	11.94	2 - 30	24.37	70	73	133.0	143.2 ± 5.17
73	30.00		129	0.0		24.03	41.86	20.93	13.18	2 - 30	23.143	70		133.0	
74	29.92	± 0.130	137	0.0		23.36	41.61	21.90	13.14	2 - 30	25.19	75		150.0	
75	29.83		134	0.0		20.89	40.30	25.37	13.43	2 - 30	24.23	70		133.0	
76	30.05		135	0.0		26.67	37.04	25.93	10.37	2 - 40	23.48	70		133.0	
77	30.47	31.05	135	0.0	0.0	20.74	42.96	22.96	13.33	2 - 40	25.07	80	72	167.0	140.0 ± 6.26
78	31.27		136	0.0		25.73	41.18	22.04	11.03	2 - 40	25.10	70		133.0	
79	31.80	± 0.267	137	0.0		29.20	40.88	21.17	8.76	2 - 50	23.73	65		117.0	
80	31.67		133	0.0		24.06	40.60	24.06	11.28	2 - 50	25.33	75		150.0	
81	33.95		132	0.0		27.27	31.06	28.79	12.88	2 - 50	26.43	60		100.0	
82	33.95	33.78	139	0.0	0.0	28.06	25.90	28.78	17.27	2 - 40	26.88	60	62	100.0	106.6 ± 6.22
83	33.40		133	0.0		27.82	24.81	35.34	12.03	2 - 50	26.46	55		83.0	
84	33.91	± 0.079	133	0.0		24.81	32.33	26.32	16.54	2 - 50	25.73	65		117.0	
85	33.69		133	0.0		24.06	37.59	31.58	6.77	2 - 50	26.62	70		133.0	
86	35.36		133	0.0		31.58	38.35	20.30	9.77	2 - 50	26.91	65		117.0	
87	35.56	35.63	132	0.0	0.0	23.48	43.18	21.97	11.36	2 - 50	28.60	65	63	117.0	110.2 ± 3.45
88	35.85		138	0.0		28.26	31.16	28.26	12.32	2 - 50	27.84	60		100.0	
89	35.58	± 0.066	137	0.0		21.17	35.04	30.66	13.14	2 - 50	29.18	65		117.0	
90	35.80		136	0.0		35.29	32.35	22.79	9.56	2 - 50	25.84	60		100.0	

Moisture as affecting pop-ability

Table I continued

Sample number	Percent moisture	Average percent moisture	Kernels number total	Percent fully popped	Average percent fully popped	Percent not cracked	Percent partially popped	Percent cracked longitudinally	Percent cracked crosswise	Popping time min.sec.	Percent weight loss in popping	Total vol. CC	Average vol. CC	Vol. percent increase	Average vol. percent increase	
91	37.79		134	0.0		27.61	28.36	31.34	12.69	2 - 50	28.55	60		100.0		
92	37.84	37.74	132	0.0	0.0	24.24	41.68	21.21	12.88	2 - 40	30.26	70	63	133.0	110.0	± 6.26
93	37.52		132	0.0		27.27	42.42	19.70	10.61	2 - 50	29.00	65		117.0		
94	37.74	± 0.035	132	0.0		25.76	33.33	28.03	12.88	3 - 0	29.55	55		83.0		
95	37.79		132	0.0		21.97	40.15	25.76	12.12	2 - 50	28.94	65		117.0		
96	39.72		135	0.0		32.59	22.96	32.59	11.85	2 - 50	27.67	50		67.0		
97	39.96	39.65	128	0.0	0.0	27.34	31.25	24.22	17.19	3 - 0	29.67	65	61	117.0	103.6	± 6.80
98	39.79		129	0.0		26.36	42.64	23.26	7.75	3 - 0	29.38	65		117.0		
99	39.58	± 0.090	134	0.0		26.12	36.57	26.87	10.45	2 - 50	29.99	65		117.0		
100	39.18		134	0.0		25.37	35.07	27.61	11.94	2 - 50	29.83	60		100.0		
101	41.73		134	0.0		19.40	41.04	29.10	10.45	3 - 0	33.66	65		117.0		
102	41.90	41.80	137	0.0	0.0	23.36	43.80	24.82	8.03	2 - 50	32.16	65	65	117.0	115.8	± 2.84
103	42.04		135	0.0		24.44	39.26	25.19	11.11	3 - 0	32.30	65		117.0		
104	41.85	± 0.067	133	0.0		18.80	43.61	27.07	10.52	2 - 50	32.11	70		133.0		
105	41.46		136	0.0		25.93	35.56	28.89	9.63	3 - 0	34.32	60		100.0		
106	43.91		135	0.0		20.00	42.96	31.85	5.19	2 - 50	33.62	65		117.0		
107	43.74	43.80	131	0.0	0.0	19.85	41.22	31.30	7.63	2 - 50	34.34	65	63	117.0	110.0	± 6.26
108	43.92		138	0.0		20.29	36.96	30.43	12.32	3 - 10	34.68	60		100.0		
109	43.86	± 0.048	132	0.0		28.79	31.06	30.30	9.85	2 - 40	29.78	55		83.0		
110	43.58		136	0.0		19.85	52.94	19.85	7.35	2 - 50	33.96	70		133.0		
111	45.03		134	0.0		24.63	37.31	32.09	5.97	3 - 0	35.12	60		100.0		
112	45.63	45.99	134	0.0	0.0	23.13	46.27	22.39	8.21	3 - 0	35.00	65	60	117.0	100.0	± 2.87
113	47.54		132	0.0		26.52	34.85	28.03	10.60	3 - 0	35.65	60		100.0		
114	45.95	± 0.262	134	0.0		23.13	41.79	26.86	8.21	3 - 20	35.93	60		100.0		
115	45.80		136	0.0		29.41	38.97	27.21	4.41	3 - 0	33.56	55		83.0		

volume percentage decreasing rapidly as the percentage of moisture increased above 14% or decreased below 12%.

An idea of the increase or decrease in volume as the moisture increases or decreases may be obtained from Plate III and III-a.

This work is in accordance with previous work of Hartley and Willier (3) in that they found that pop corn popped best at twelve per cent moisture. It further shows that the right per cent of moisture is an essential factor for the best pop-ability and that the optimum moisture for popping varies within a few percent more or less than twelve.

Experiment II

Moisture as Affecting Pop-ability in New Corn Artificially Dried

Newly harvested corn was dried at 52° C. for the time necessary to obtain the range of moisture as given in Table II. Samples of twenty grams were used for popping in each case.

The table shows that at 28.88% moisture only a cracking of a portion of the kernels

Chart I

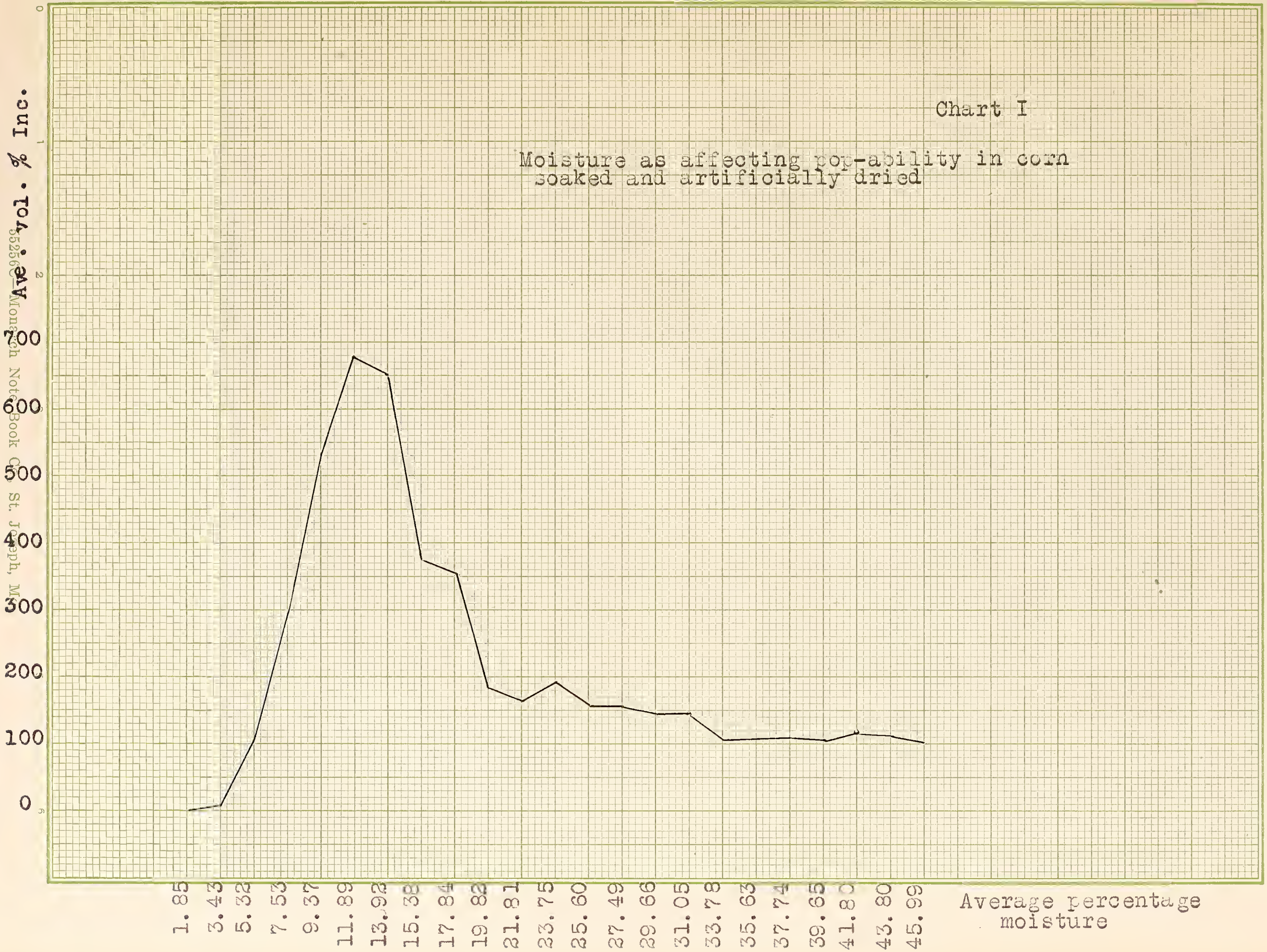
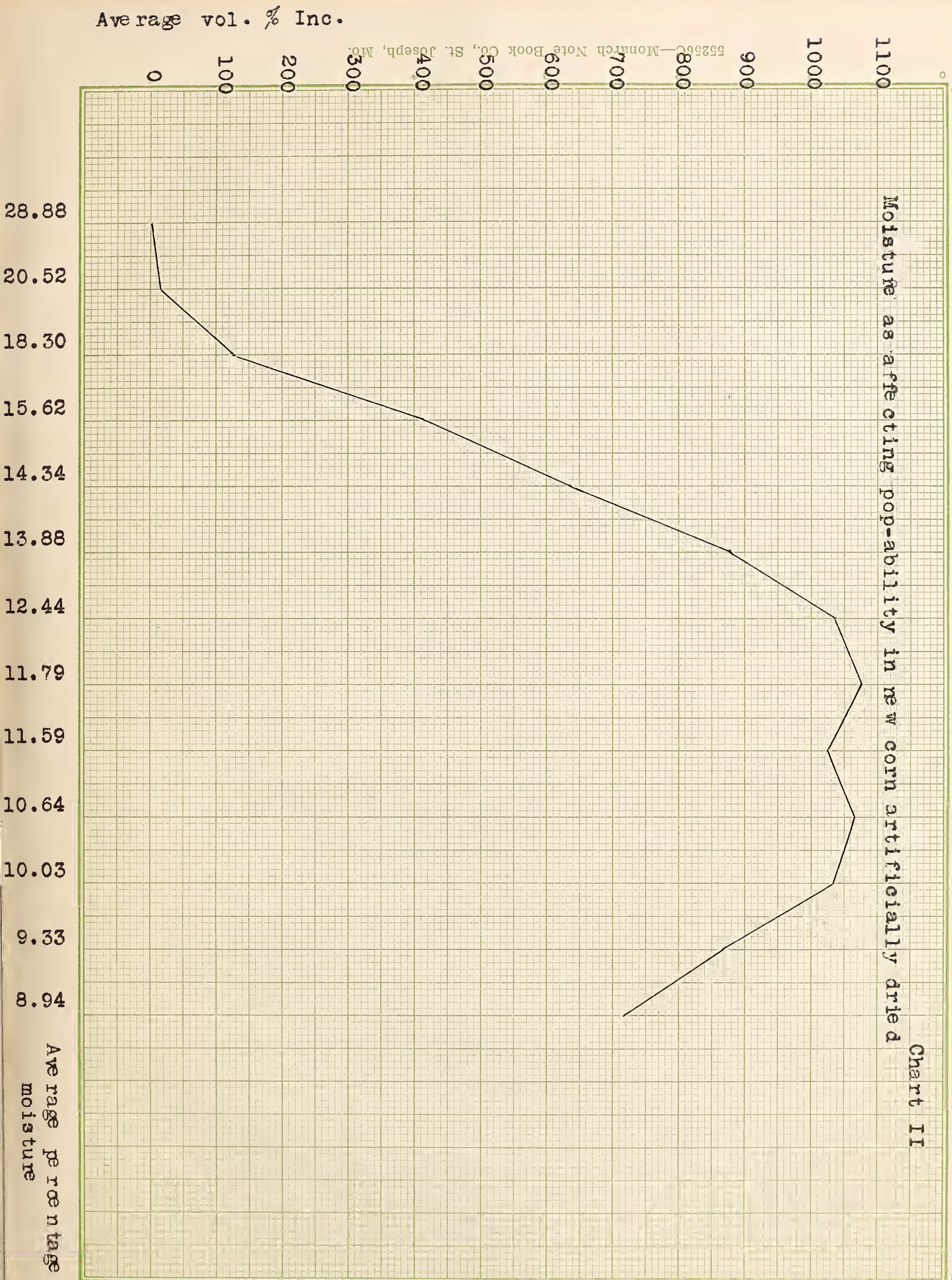


Chart I
Moisture as affecting pop-ability in corn
soaked and artificially dried
Ave. vol. % Inc.
0
100
200
300
400
500
600
700
1.85
3.43
5.32
7.53
9.37
11.89
13.92
15.38
17.84
19.82
21.81
23.75
25.60
27.49
29.66
31.05
33.78
35.63
37.74
39.65
41.80
43.80
45.99
Average percentage
moisture
55256—Monarch Note Book Co., St. Joseph, Mo.

Moisture as affecting pop-ability in new corn artificially dried

Table II

Sample number	Drying period hours	Per cent moisture	Average per cent moisture	Kernels number total	Per cent fully popped	Average per cent fully popped	Average per cent not cracked	Average per cent partially popped	Average per cent cracked longitudinally	Average per cent cracked crosswise	Popping time min.sec.	Per cent weight loss in popping	Total vol. CC	Average vol. CC	Vol. per cent increase	Average vol. per cent increase
1	0	28.88	28.88	93	0	0	16.21	0	72.98	10.81	3 - 0	22.70	30	30.0	0	0
2	0	28.88		92	0	0					3 - 0	23.92	30			
3	1	20.08	20.52	89	0	0	14.16	10.00	67.13	8.72	3 - 0	15.60	36	34.0	20.00	13.33
4	1	20.95		94	0	0					3 - 0	16.50	32		6.67	
5	2	18.39	18.30	93	23.66	21.83	9.23	17.53	47.58	3.84	3 - 0	15.35	70	68.0	133.3	137.7
6	2	18.21		90	20.00						3 - 0	15.24	66		120.0	
7	3	15.60	15.62	94	59.57	62.04	3.75	11.24	22.98	0	2 - 45	14.37	150	153.0	400.0	410.0
8	3	15.63		93	64.52						2 - 45	13.85	156		420.0	
9	4	14.53	14.34	95	71.58	69.68	2.72	9.13	18.48	0	2 - 30	13.98	225	220.0	650.0	633.5
10	4	14.15		90	67.78						2 - 30	12.64	215		616.7	
11	5	13.86	13.88	93	18.72	78.50	2.76	2.71	16.03	0	2 - 30	12.86	310	292.5	933.3	875.0
12	5	13.89		89	75.28						2 - 30	13.47	275		816.7	
13	6	12.28	12.44	89	82.02	83.48	1.64	2.18	12.71	0	2 - 30	13.28	325	240.0	983.3	1033.0
14	6	12.60		93	84.95						2 - 30	13.36	355		1083.0	
15	7	11.93	11.79	96	81.25	79.63	1.04	3.18	16.15	0	2 - 30	12.05	370	353.0	1133.0	1075.0
16	7	11.64		91	78.02						2 - 30	12.18	335		1017.0	
17	8	11.68	11.59	95	83.16	79.08	.52	5.76	14.65	0	2 - 30	12.41	350	338.0	1067.0	1023.5
18	8	11.50		96	75.00						2 - 30	12.33	325		983.3	
19	10	10.64	10.64	92	73.91	73.91	2.17	7.61	16.30	0	2 - 45	11.53	350	350.0	1067.0	1067.0
20	9	10.03	10.03	94	86.17	86.17	1.06	3.19	9.57	0	2 - 30	11.47	340	340.0	1033.0	1033.0
21	12	9.33	9.33	95	73.68	73.68	1.06	17.89	7.37	0	3 - 0	10.02	290	290.0	866.7	866.7
22	11	8.94	8.94	92	62.04	63.04	1.09	16.30	19.56	0	3 - 0	7.19	245	245.0	716.7	716.7


Average vol. % Inc.
0
100
200
300
400
500
600
700
800
900
1000
1100
28.88
20.52
18.30
15.62
14.34
13.88
12.44
11.79
11.59
10.64
10.03
9.33
8.94
Average percentage moisture
Moisture as affecting pop-ability in new corn artificially dried
Chart II
55256C—Monarch Note Book Co., St. Joseph, Mo.

took place; at 20.52% a few kernels partially popped; while at 18.30% a few kernels popped fully. It agrees with Table I in that the highest volume percentage increase was at around 12% moisture with a marked decrease as the per cent of moisture increased or decreased. The above facts are further illustrated by Chart II and Plate IV.

Experiment III

Age and Moisture as Affecting Pop-ability

A composite sample from newly harvested corn was selected at harvest time. Out of this lot two samples of twenty grams each were taken and allowed to dry slowly in air until at the desired percentage of moisture for popping. After three days or on October 6th the desired moisture content was reached and the corn was popped. Other samples of twenty grams each were selected from this composite lot (which was stored in a room where very gradual drying took place) at intervals of ten days, from October 3rd until February 19th. After the latter date

the moisture content fluctuated with atmospheric conditions. On March 13th samples taken from the same composite lot were dried down artificially to two percent of moisture, thereby having a range of 2 to 34.20% as in case of the newly harvested corn. Since throughout this period there were two variable factors, namely, moisture and age, samples from the same composite lot were first soaked for one hour (except the check) and dried to a moisture percentage corresponding to four points within the natural drying period, namely, October 6th to February 9th.

It may be seen from Chart III and Plate IV that the newly harvested corn, dried down immediately, gave a comparatively high per cent of pop-ability although not equal to that of December 6th where naturally dried two months longer. Therefore there may possibly be a slight beneficial change during the first two months after harvest. After this period as seen by results obtained on April 7th there is a decrease in pop-ability with age.

Age and moisture as affecting pop-ability

Table III

Sample number	Date of popping	Per cent moisture	Average per cent moisture	Kernels number total	Average per cent fully popped	Average per cent not cracked	Average per cent partially popped	Average per cent cracked longitudinally	Average per cent cracked crosswise	Popping time min.sec.	Per cent weight loss in popping	Total vol. CC	Average vol. CC	Vol. per-cent increase	Average vol. per cent increase
1	Oct. 3	34.09	34.20	110	0.0	11.98	0.0	64.52	23.50	5 - 0	39.62	30	30	0;0	0.0
2	Oct. 3	34.21		107						5 - 0	39.56	30		0.0	
3	Oct. 6	13.19	12.95	110	77.17	10.96	0.0	11.87	0.0	2 - 50	13.14	345	360	1050.0	1100.0
4	Oct. 6	12.70		109						2 - 50	15.74	375		1150.0	
5	Oct. 12	17.69	17.74	122	37.55	5.71	13.06	38.37	5.31	3 - 0	19.07	155	165	417.0	450.0
6	Oct. 12	17.79		123						3 - 0	17.48	175		483.0	
7	Oct. 17	16.19	15.92	124	85.14	1.21	0.80	1285	0.0	2 - 25	15.19	510	512	1600.0	1607.0
8	Oct. 17	15.65		125						2 - 25	15.50	514		1613.0	
9	Oct.27	14.31	14.26	126	79.84	1.98	1.19	16.99	0.0	2 - 50	13.51	480	463	1500.0	1442.0
10	Oct. 27	14.21		127						2 - 50	13.34	445		1383.0	
11	Nov. 6	13.82	13.86	123	82.11	1.63	4.88	11.38	0.0	3 0 0	14.11	475	448	1483.0	1392.0
12	Nov. 6	13.98		123						3 - 0	14.12	420		1300.0	
13	Nov. 16	13.27	13.25	133	82.44	1.15	3.82	12.59	0.0	2 - 50	13.59	430	438	1333.0	1358.0
14	Nov. 16	13.23		129						2 - 50	13.59	445		1383.0	
15	Nov. 26	14.00	14.00	124	84.74	0.0	3.62	11.65	0.0	2 - 50	14.36	436	438	1353.0	1360.0
16	Nov. 26	14.00		125						2 - 50	14.42	440		1367.0	
17	Dec. 6	12.47	12.35	124	81.89	0.0	5.51	12.60	0.0	2 - 20	12.98	405	418	1250.0	1292.0
18	Dec. 6	12.22		130						2 - 20	12.62	430		1333.0	
19	Dec. 16	12.31	12.39	130	82.56	0.0	7.75	9.69	0.0	1 - 45	13.31	390	398	1200.0	1225.0
20	Dec. 16	12.46		128						1 - 45	13.05	405		1250.0	
21	Dec. 31	11.74	11.71	128	75.76	0.76	7.42	16.02	0.0	2 - 0	12.11	345	350	1050.0	1067.0
22	Dec. 31	11.68		128						2 - 0	12.39	355		1083.0	
23	Jan. 10	11.41	11.37	129	74.61	1.5	13.08	11.15	0.0	2 - 25	11.42	350	333	1067.0	1009.0
24	Jan. 10	11.32		131						2 - 25	11.52	315		950.0	

Age and moisture as affecting pop-ability

Table III continued

Sample number	Date of popping	Percent moisture	Average percent moisture	Kernels number total	Average percent fully popped	Average percent not cracked	Average percent partially popped
25	Jan.20	10.25	1D.35	129	64.59	0.0	20;62
26	Jan.20	10.45		128			
27	Jan.30	9.78	9.63	128	60.84	0.38	23.95
28	Jan.30	9.48		135			
29	Feb. 9	11.04	11.36	133	51.50	2.26	45.30
30	Feb. 9	11.67		133			
31	Feb.19	11.36	11.80	133	64.43	1.15	19.54
32	Feb.19	12.04		128			
33	Mar.13	8.85	8.77	133	39.23	2.32	49.26
34	Mar.13	8.68		129			
35	Mar.13	7.79	7.69	131	7.24	10.65	60.07
36	Mar.13	7.59		132			
37	Mar.13	6.00	6.00	130	0.0	44.57	26.96
38	Mar.13	6.00		133			
39	Mar.13	4.00	3.95	130	0.0	91.58	0.0
40	Mar.13	3.89		131			
41	Mar.13	2.11	2.00	131	0.0	100.00	0.0
42	Mar.13	1.88		134			
43	Apr. 7	12.95	12.95	130	55.55	0.77	24.90
44	Apr. 7	12.95		131			
45	Apr. 7	12.35	12.35	134	60.00	0.38	18.84
46	Apr. 7	12.35		131			
47 Ck. not	Apr. 7	11.36	11.36	134	41.65	0.76	44.33
48 soaked	" 7	11.36		130			
49	Apr. 7	10.35	10.35	134	60.18	1.51	23.09
50	Apr. 7	10.35		130			

Sample number	Average percent cracked longitudinally	Average percent cracked crosswise	Popping time min. sec.	Percent weight loss in popping	Total vol. CC	Average vol. CC	Vol. percent increase	Average vol. percent increase
25	14.79	0.0	1 - 40	10.86	255	263	750.0	775.0
26			1 - 40	10.88	270		800.0	
27	14.83	0.0	2 - 0	10.37	255	263	750.0	775.0
28			2 - 0	10.35	270		800.0	
29	12.03	0.0	2 - 25	10.55	260	260	767.0	767.0
30			2 - 25	10.11	260		767.0	
31	11.88	0.0	1 - 45	10.31	250	243	733.0	708.0
32			1 - 45	10.31	235		683.0	
33	9.21	0.0	1 - 55	8.36	205	200	720.0	700.0
34			1 - 55	8.36	195		680.0	
35	19.00	3.04	1 - 50	7.52	120	110	380.0	340.0
36			1 - 50	7.55	100		300.0	
37	23.93	4.55	1 - 50	6.01	46	52	84.0	108.0
38			1 - 50	6.07	58		132.0	
39	8.43	0.0	1 - 55	4.12	35	35	40.0	40.0
40			1 - 55	4.40	35		40.0	
41	0.0	0.0	1 - 50	?	25	25	0.0	0.0
42			1 - 50		25		0.0	
43	18.79	0.0	2 - 0	11.21	235	248	68?.0	725.0
44			2 - 0	11.44	260		767.0	
45	20.69	0.0	2 - 0	11.16	250	273	733.0	808.0
46			2 - 0	11.49	295		883.0	
47 Ck. not	13.28	0.0	2 - 0	10.07	260	253	767.0	742.0
48 soaked			2 - 0	10.07	245		717.0	
49	15.24	0.0	2 - 0	9.43	280	270	833.0	800.0
50			2 - 0	9.43	260		767.0	

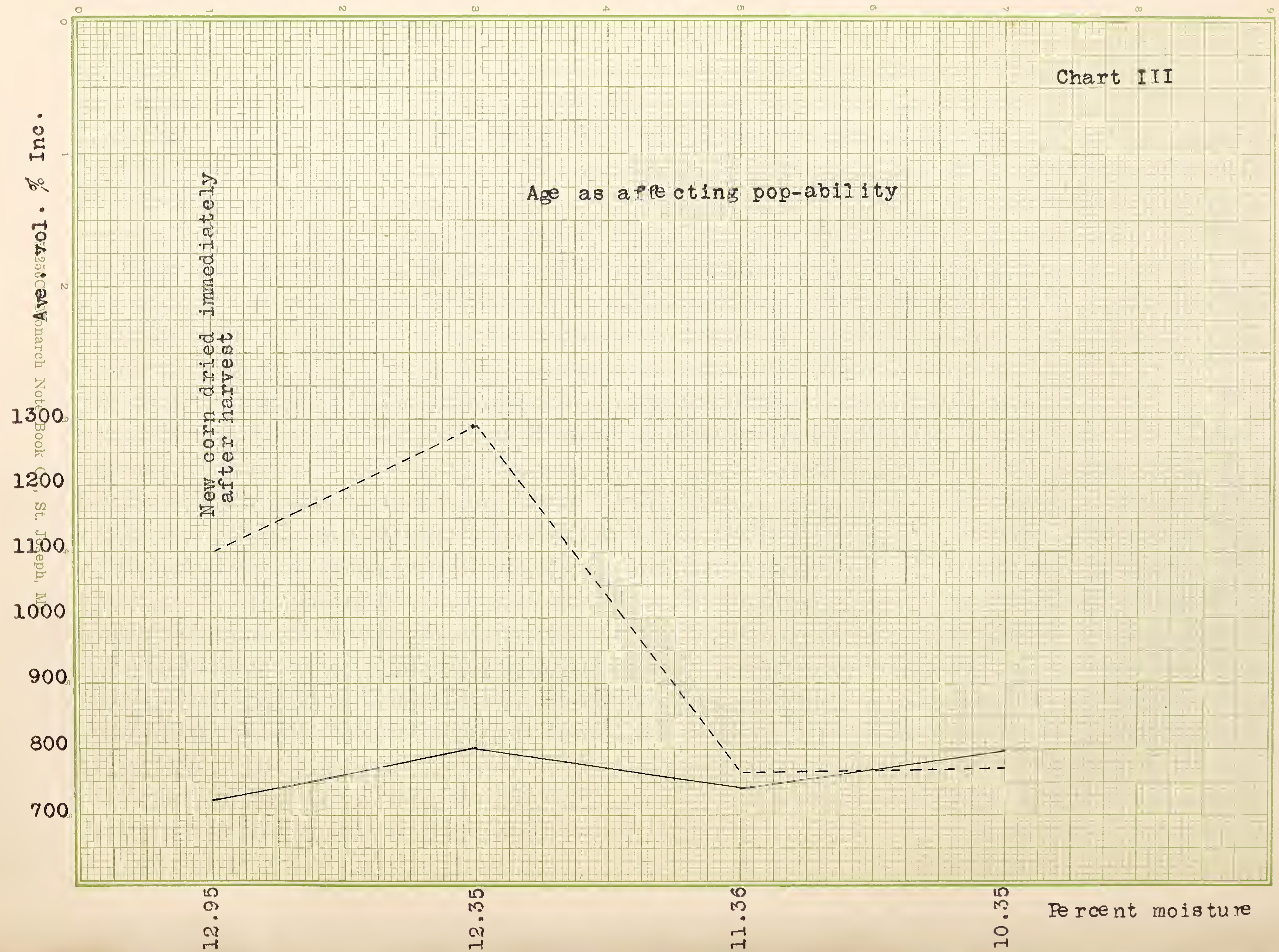


Chart III
Age as affecting pop-ability
New corn dried immediately after harvest
Ave. vol. % Inc.
1300
1200
1100
1000
900
800
700
12.95
12.35
11.36
10.35
Percent moisture

Maturity as affecting pop-ability

Table IV

Sample number	Stage of development	Moisture percent	Average moisture percent	Kernels number total	Average percent fully popped	Average percent not cracked	Average percent partially popped	Average percent cracked longitudinally	Average percent cracked cross-wise	Popping time min.sec.	Percent weight loss in popping	Total vol. CC	Average vol. CC	Vol. percent increase	Average vol. percent increase
1	Fully matured	11.36	11.33	106	69.34	0	25.00	5.66	0	1 - 50	10.07	240	222.5	700	641.5
2	Fully matured	11.30		106						1 - 50	9.95	205		583	
3	Dough stage	12.54	12.58	124	77.91	1.60	14.46	6.02	0	1 - 50	10.68	260	257.5	767	758.5
4	Dough stage	12.61		125						1 - 50	10.68	255		750	
5	Early dough	11.96	11.72	148	82.35	3.11	11.42	3.11	0	1 - 50	10.68	275	275.0	817	817.0
6	Early dough	11.48		141						1 - 50	10.80	275		817	
7	Medium milk	12.28	12.26	179	60.39	12.47	18.28	8.86	0	1 - 50	10.99	220	225.0	633	650.0
8	Medium milk	12.23		182						1 - 50	10.99	230		667	


Maturity as affecting pop-ability
Ave. vol. % Inc.
900
800
700
600
Fully Matured
Dough
Early Dough
Medium Milk

stored under ideal conditions after harvested or otherwise possibly might have been injured due to unfavorable storage conditions. Whether it would be advisable to advocate harvesting before fully matured is questionable. If not stored under ideal conditions it may be injured.

Experiment V

Kernel Treatment as Affecting Pop-ability

In this work kernels of the same size and number were used, all being selected from a composite sample.

Table V gives the treatments and results as follows:

1. A check, that is, no treatment of kernel, was run for a comparison in volume to the other kernel treatments. In no case did the treated kernels equal the volume of the check.

2. The kernels cut in halves lengthwise made no noise upon being heated but almost

Kernel treatments as affecting pop-ability

Table V

Sample number	Treatment	Size (width) inches	Volume before popping CC	Kernels number total	Portions of kernel	Volume after popping	Remarks
1 Check	None	0.229	5	25	Whole	35.6	Normal popping
2	Cut in halves lengthwise	0.229	5	25	Both halves	9.5	No noise. Only puffed
3 (a)	Cut in two crosswise (width way)	0.229	5	25	Cob ends	2.8	No noise.
3 (b)		0.229			Outer ends	15.6	A slight noise in popping
4 (a)	Cut in ¼ parts	0.229	5	25	Cob ends	3.0	No noise, only puffed
4 (b)					Outer ends	7.4	
5	Filed through skin longitudionally	0.229	5	25	Whole	10.2	Slight noise on popping
6	Filed through skin crosswise	0.229	5	25	Whole	10.8	Slight noise on popping
7	Skin removed	0.229	5	25	Whole	5.8	No noise. Just a swelling took place giving kernels appearance of puffed wheat
8	Germ removed	0.229	5	25	Whole	15.0	Very slight noise in popping

doubled in volume due to a puffing of the kernel.

3. The kernels cut in two crosswise gave very little swelling in case of the cob ends and no noise (3 a), upon being heated, while the outer ends (3 b) gave a slight noise and increased in volume almost six times greater than the cob ends.

4. Where the kernels were cut in one quarter parts the portions from the outer ends (4 b) gave about twice the volume as those from the cob ends (4 a), there being a greater puffing in case of the outer or densest portion of the kernel.

5. The whole kernels filed through the skin longitudinally increased in volume to less than one third that of the check.

6. Whole kernels filed through the skin crosswise gave a very slight increase in volume over that of kernels filed longitudinally.

7. The whole kernels with skin removed only puffed, giving a slight increase in volume. There was no noise in puffing.

8. Where the germs were removed the kernels increased in volume less than one half that of the check. As seen from above this decrease is probably

due to a breaking of the seed coat or skin.

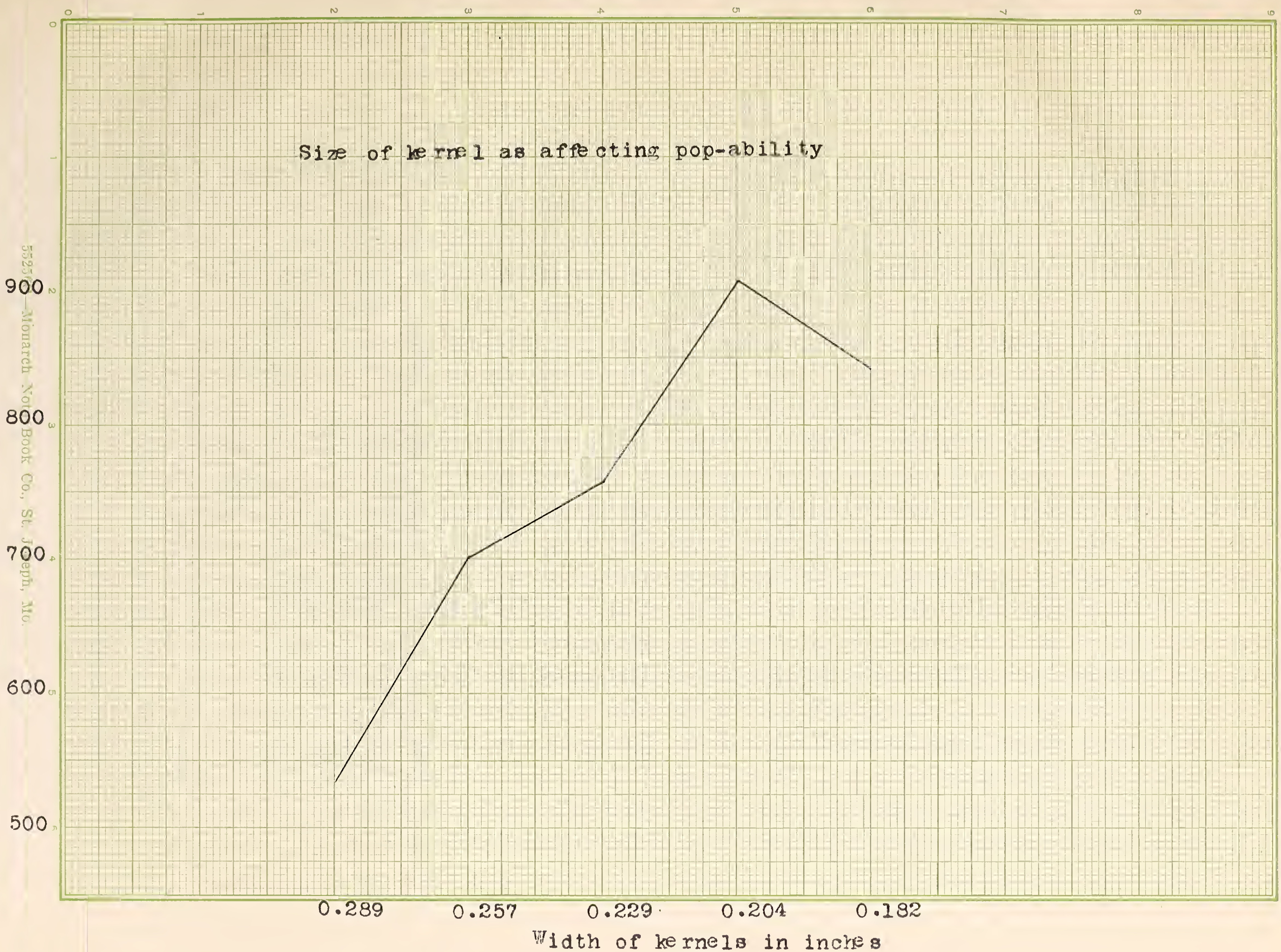
These results are illustrated in Plate VIII.

From the above work, it is plain, that the skin of the grain exerts a very decided influence on pop-ability. Storer (8) conducted some similar experiments and his conclusions seem to be confirmed by this work. He states: "It is plain that the skin of the grain exerts a very decided influence on the act of popping. It would appear, that both the structure of the individual starch grains in the kernel and the toughness of the restraining skin which envelops them all, act to control or modify the manner in which the moisture in the starch grains when suddenly heated is converted into steam of such high tension that the explosive act of popping results, whereby both the skin of the seed itself and the envelopes of most of the starch grains in the seed are ruptured."

Experiment VI

Size of Kernels as Affecting
Pop-ability

From a composite sample of corn 100 kernels for each sample were selected and graded. For deter-



Size of kernel as affecting pop-ability
900
800
700
600
500
0.289
0.257
0.229
0.204
0.182
Width of kernels in inches

mining the size a wire gauge containing the sizes as given in Table VI was used, each kernel being graded separately the broad or width way of kernel.

As shown in the table the corn was popped at the same moisture content with the same number of kernels for each sample. Due to the fact that an equal number of kernels were used the volume is smallest for the smallest size kernels, this makes the volume percentage increase appear large for the small kernels. However, as seen by the table the average percentage fully popped was greatest for the same sample as the maximum volume percentage increase. Therefore the data indicate that exceptionally large kernels do not pop very well while the highest percentage of pop-ability is associated with kernels of medium to a slightly smaller size. In other cases it was noted that exceptionally large kernels only partially popped or frequently only cracked.

The results obtained confirm that data from the New Jersey Station Report (7), but corn of a pure variety was used in this experiment

Size of kernels as affecting pop-ability

Table VI

Sample number	Size (width) inches	Vol. CC before popping	Weight unpopped corn.gms.	Average percent moisture	Kernels number total	Average percent fully popped	Average percent not cracked	Average percent partially popped	Average percent cracked longitudinally	Average percent cracked crosswise	Popping time min.sec.	Percent weight loss in popping	Total vol. CC	Average vol. CC	Vol. per-cent increase	Average vol. per-cent increase
1	0.289	26.0	20.158	9.92	100	35.5	1.5	43.0	14.5	5.5	1 - 50	9.94	160	165.0	515	534.5
2	0.289	26.0	19.696	9.92	100						1 - 50	9.49	170		554	
3	0.257	23.0	17.564	9.92	100	60.5	2.0	21.5	14.0	2.0	1 - 40	8.32	180	184.0	683	700.0
4	0.257	23.0	17.611	9.92	100						1 - 40	8.03	188		717	
5	0.229	21.0	15.775	9.92	100	57.5	1.0	22.5	19.0	0.0	1 - 40	7.34	170	177.5	710	756.0
6	0.229	20.5	14.950	9.92	100						1 - 40	7.14	185		802	
7	0.204	16.0	11.944	9.92	100	66.0	0.5	22.0	11.5	0.0	1 - 30	5.90	158	161.5	887	909.0
8	0.204	16.0	11.460	9.92	100						1 - 40	5.83	165		931	
9	0.182	12.5	9.200	9.92	100	57.0	0.5	25.5	17.0	0.0	1 - 30	5.66	120	120.0	860	841.5
10	0.182	13.0	9.477	9.92	100						1 - 30	4.82	120		825	

whereas in the New Jersey work cross-bred seed was used. Their work showed that large kernels from cross-bred seed would not pop fully while in the majority of cases the corn only parched. On the other hand small size kernels popped fairly well. Probably the factor of large size would have a greater bearing where cross-bred seed is used, due to a difference in structure.

See Chart V and Plate IX.

Experiment VII

Pop-ability as Affected by Freezing (0° F) with Different Moisture Contents

The samples were selected from a composite lot of corn and all but the check subjected to a temperature of 0° F. for sixteen hours in pill boxes placed in a can immersed in brine. Samples three and four were not soaked while all the other samples except the check were soaked for two and one half hours in water at 18° - 20° C., prior to being frozen. After soaking the samples were slowly dried to the desired percentages of moisture before being frozen. Exactly twenty grams was used for each sample and all popped at the same moisture content.

From Table VII and Chart VI it may be seen that the corn not soaked but frozen, even at a low moisture content, gave an increased volume over the check. Where soaked and frozen at higher moisture contents than the check there was a marked increase in volume in every case. See Plate X. Also the frozen corn not only popped better but it had a better appearance, was of a fine quality and very tender. In preliminary work where four samples of corn were soaked for two and a half hours and exposed at freezing temperature out of doors, the same results were obtained.

A microscopic examination of soaked and frozen kernels seemed to indicate a mechanical rupture of the cells of the endosperm, which was not shown in those not so treated.

General Observations from the Work as a Whole

Time Necessary for Popping

Good corn should pop in 1½ to 1¾ minutes, however it may require 3 minutes with high percentages of moisture. In the latter case the corn probably dries out to about the proper per

Effect on pop-ability of freezing (0°F) at different moisture contents (1)

Table VII

Sample number	Moisture per cent at time of freezing	Kernels number total	Per cent fully popped	Per cent not cracked	Per cent partially popped	Per cent cracked longitudinally	Per cent cracked crosswise	Popping time min. sec.	Per cent weight loss in popping	Total volume CC	Volume per cent increase
1	Not froze or	129	32.56	0.78	48.06	18.60	0.0	1 - 40	9.84	220	633
2	scaled 10.59	135	28.88	0.0	51.11	18.52	1.48	1 - 40	9.84	220	633
3	Not scaled	132	32.58	0.0	50.76	16.67	0.0	1 - 40	9.84	239	667
4	but froze 10.59	132	40.15	1.52	44.70	13.64	0.0	1 - 40	9.84	225	650
5	11.81	133	66.92	1.50	22.56	9.02	0.0	1 - 40	10.62	315	950
6	12.63	129	58.14	0.78	24.03	17.05	0.0	1 - 40	10.84	285	850
7	13.57	130	59.23	2.31	26.90	11.54	0.0	1 - 40	10.67	295	883
8	14.96	131	57.25	3.82	23.66	15.27	0.0	1 - 40	10.67	285	850
9	16.34	132	47.73	0.76	41.67	9.85	0.0	1 - 40	10.67	280	833
10	18.22	126	57.14	1.59	26.19	15.08	0.0	1 - 40	10.62	285	850
11	19.55	132	69.70	2.27	17.42	10.61	0.0	1 - 40	11.06	335	1017
12	20.21	134	49.25	0.75	37.31	12.69	0.0	1 - 40	10.51	285	850
13	21.21	129	67.44	4.65	13.18	14.73	0.0	1 - 40	11.06	365	1117
14	23.31	128	64.84	1.56	21.88	11.72	0.0	1 - 40	10.95	335	1017
15	24.80	132	57.58	2.27	21.97	18.18	0.0	1 - 40	10.51	300	900
16	25.19	133	54.89	2.26	30.83	12.03	0.0	1 - 40	10.78	300	900
17	26.07	134	50.75	2.24	29.85	17.16	0.0	1 - 40	10.78	290	867
18	27.40	129	59.69	2.33	22.48	15.50	0.0	1 - 40	10.84	310	933
19	27.41	127	39.37	0.79	33.86	25.98	0.0	1 - 40	10.28	265	783
20	28.28	130	44.62	3.85	27.69	23.85	0.0	1 - 40	10.84	280	833

(1) All popped with 10.59% moisture

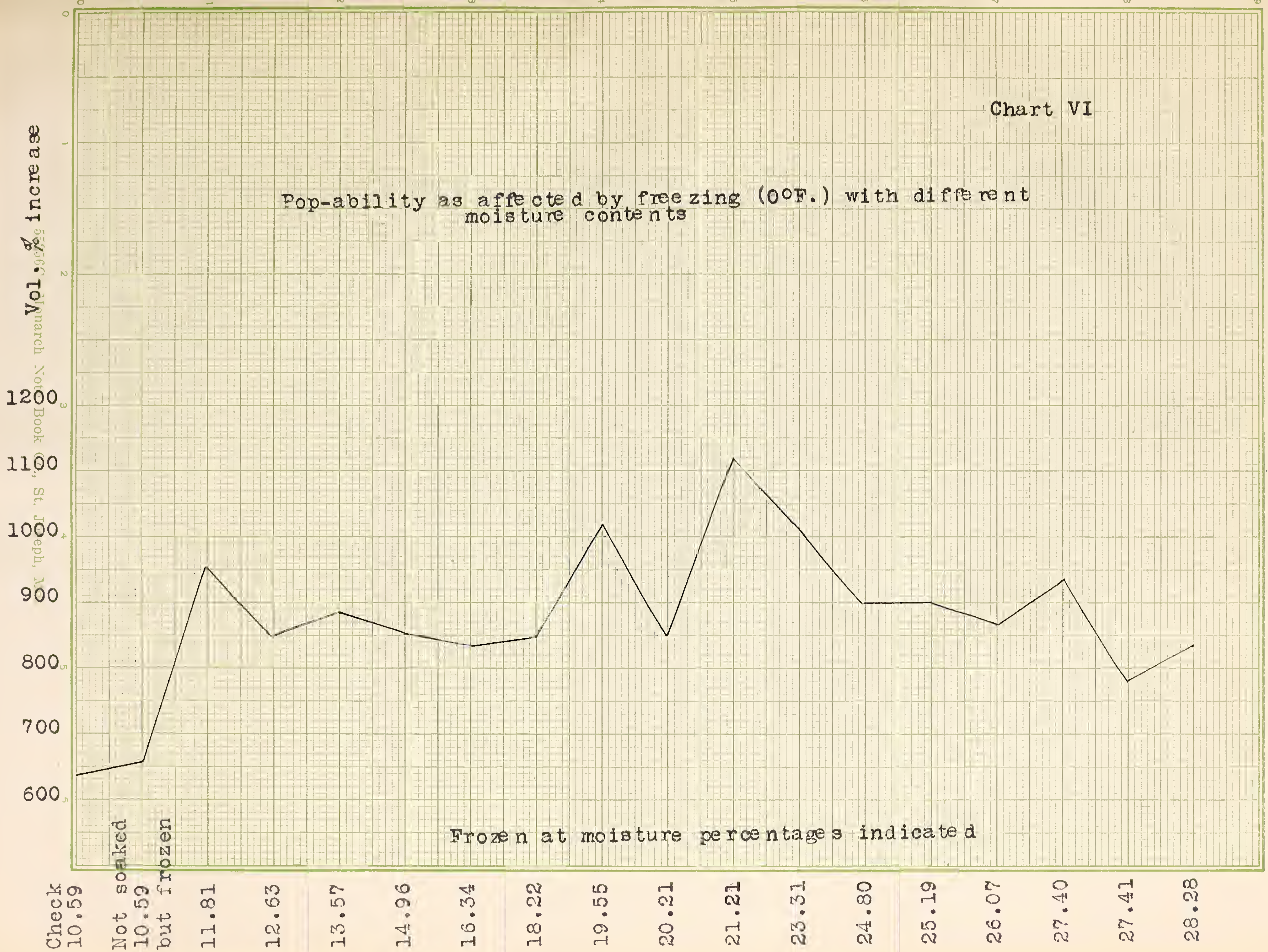


Chart VI
Pop-ability as affected by freezing (0°F.) with different moisture contents
Vol. % increase
1200
1100
1000
900
800
700
600
Frozen at moisture percentages indicated
Check 10.59
Not soaked 10.59 but frozen
11.81
12.63
13.57
14.96
16.34
18.22
19.55
20.21
21.21
23.31
24.80
25.19
26.07
27.40
27.41
28.28

cent for normal popping before it will pop or crack.

Loss in Weight in Popping

The loss of weight in popping is greater where the corn contains a high percentage of moisture. Below the optimum percentage for the best popping the loss in weight is very commonly greater than the moisture content of the corn, probably due to a charring.

Temperature

An idea of the extreme high temperature required for popping was obtained while conducting moisture determinations by the Brown - Duval method. It was noted that the corn immersed under the oil bath popped at a temperature between 165° - 180° C.

PLATE I

METHOD OF POPPING

PLATE II

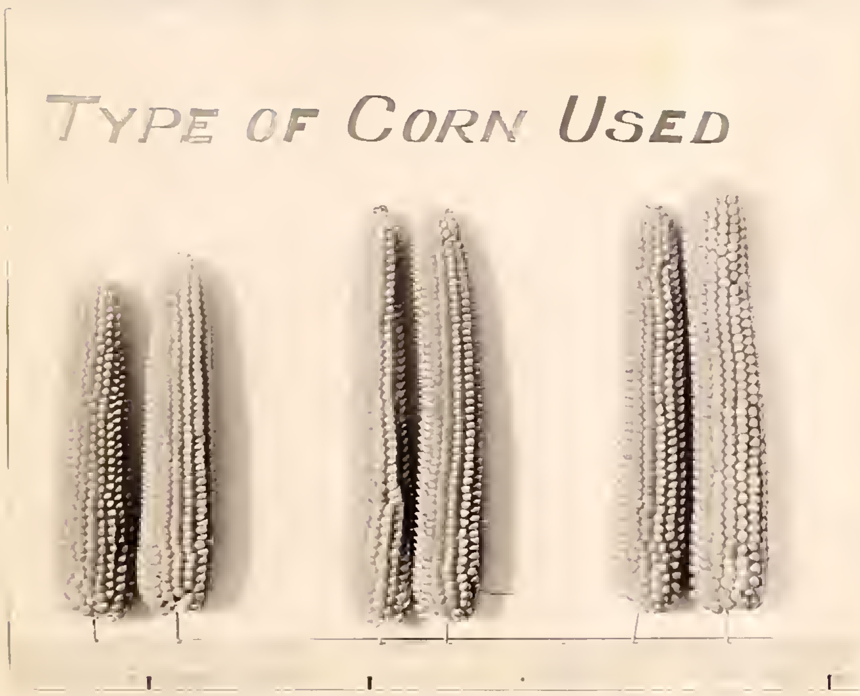
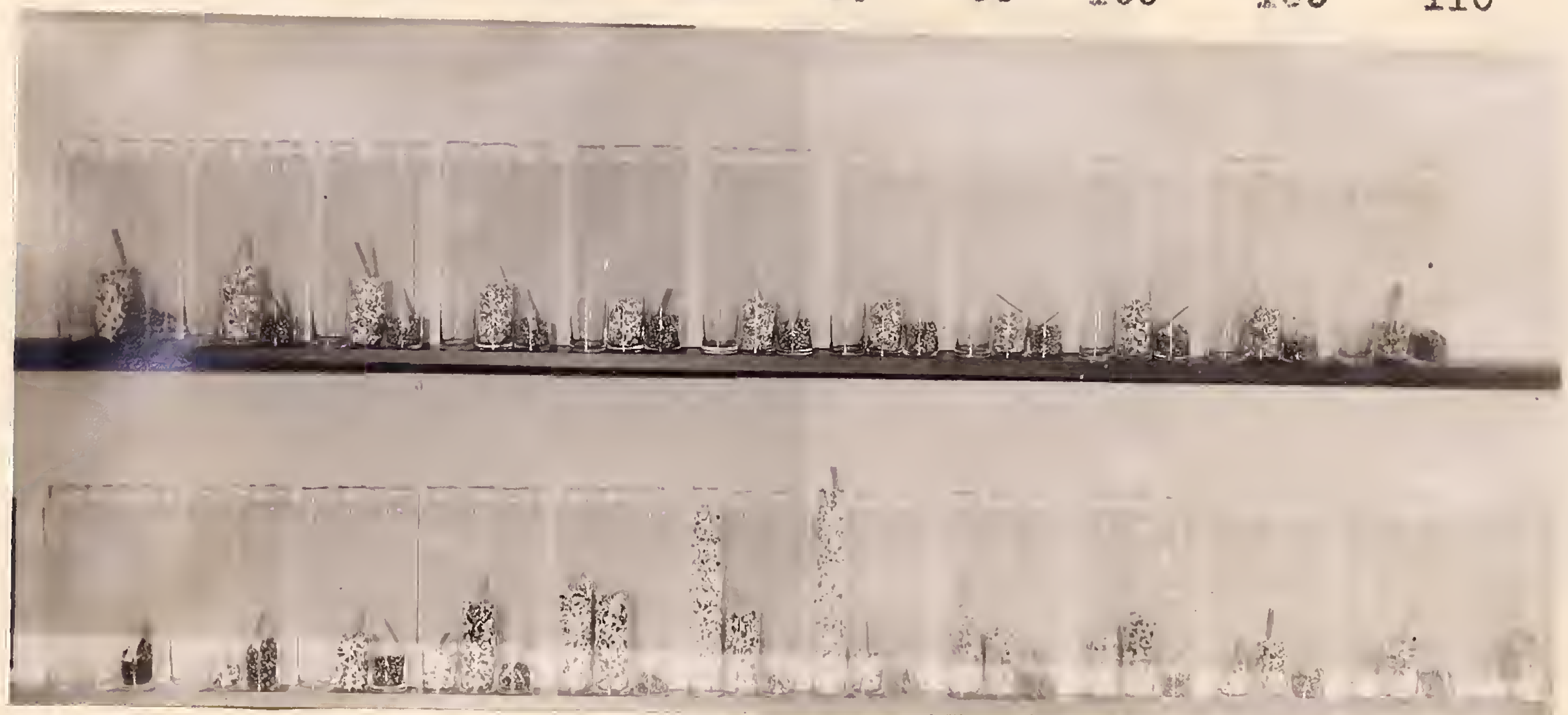


PLATE III

MOISTURE AS AFFECTING POP-ABILITY

Sample No. 60-65 | 65-70 | 70-75 | 75-80 | 80-85 | 85-90 | 90-95 | 95-100 | 100-105 | 105-110 | 110-115



Sample No. 1-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-35 | 35-40 | 40-45 | 45-50 | 50-55 | 55-60

Each set of three bottles from left to right represent volume, fully popped, partially popped and cracked only.
See Table I for moisture percentages

PLATE III-a

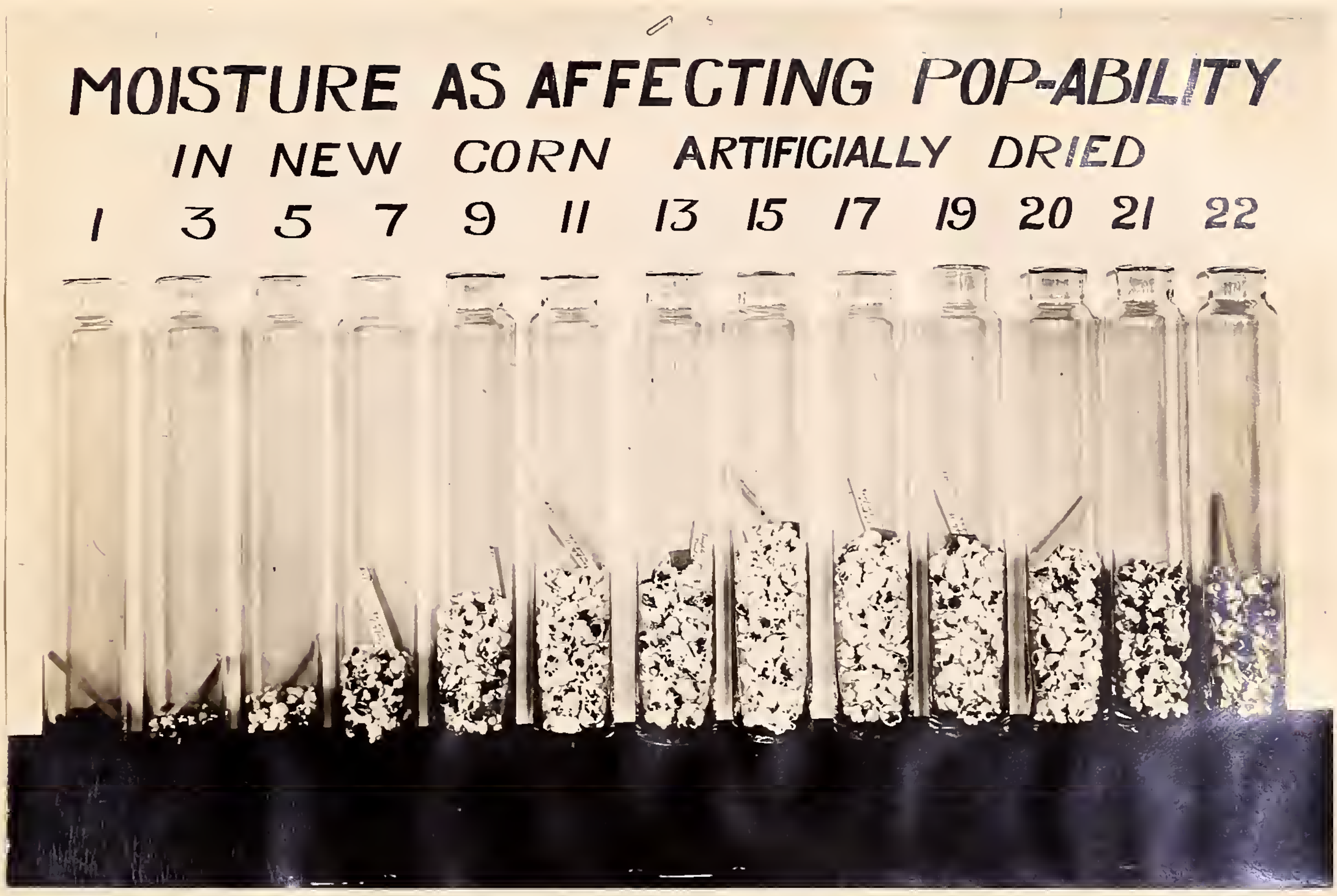
MOISTURE AS AFFECTING POP-ABILITY

1-5 16-20 26-30 36-40 56-60 111-115

See Table I for moisture percentages

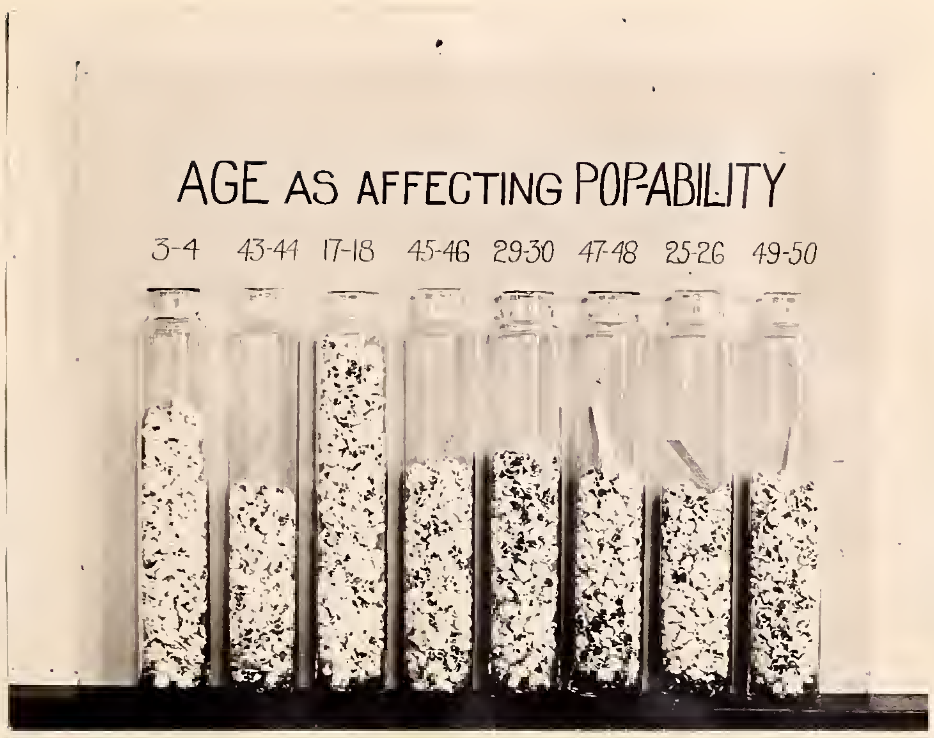
Each set of three bottles from left to right represent volume, fully popped, partially popped and cracked only.

PLATE IV



See Table II for moisture percentages

PLATE V



See Table III for age

PLATE VI

MATURITY AS AFFECTING POP-ABILITY

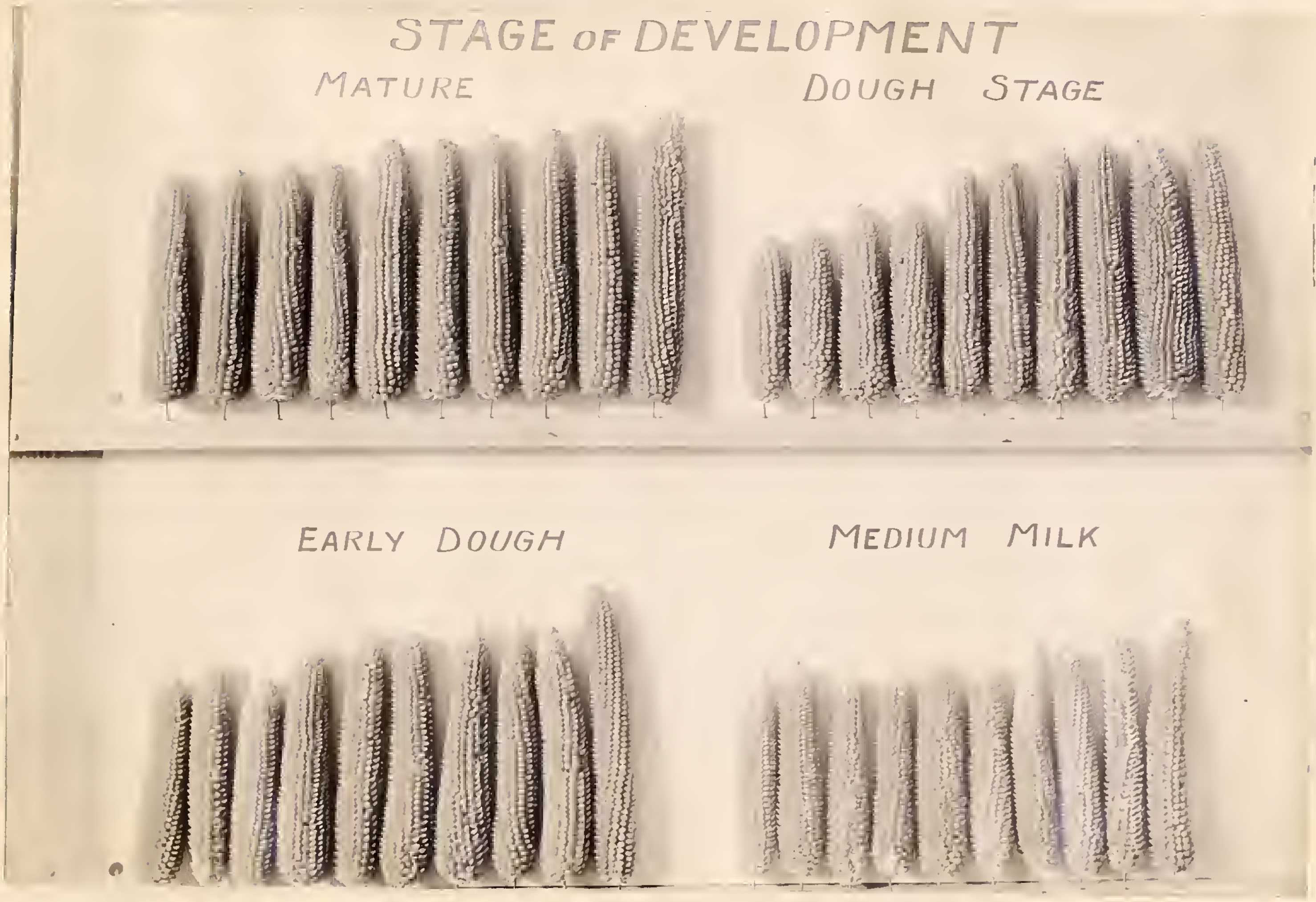


PLATE VII

MATURITY AS AFFECTING POP-ABILITY

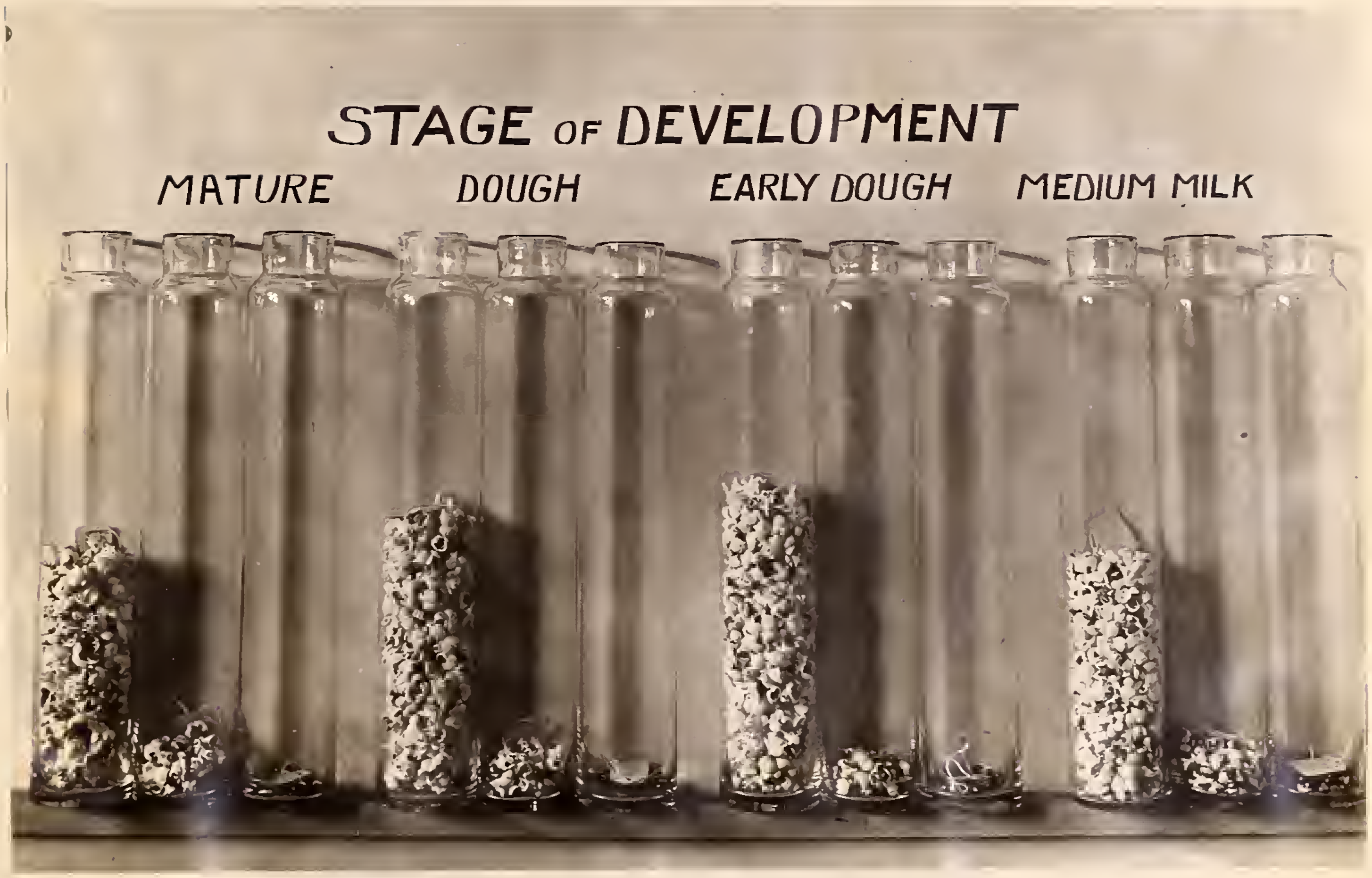
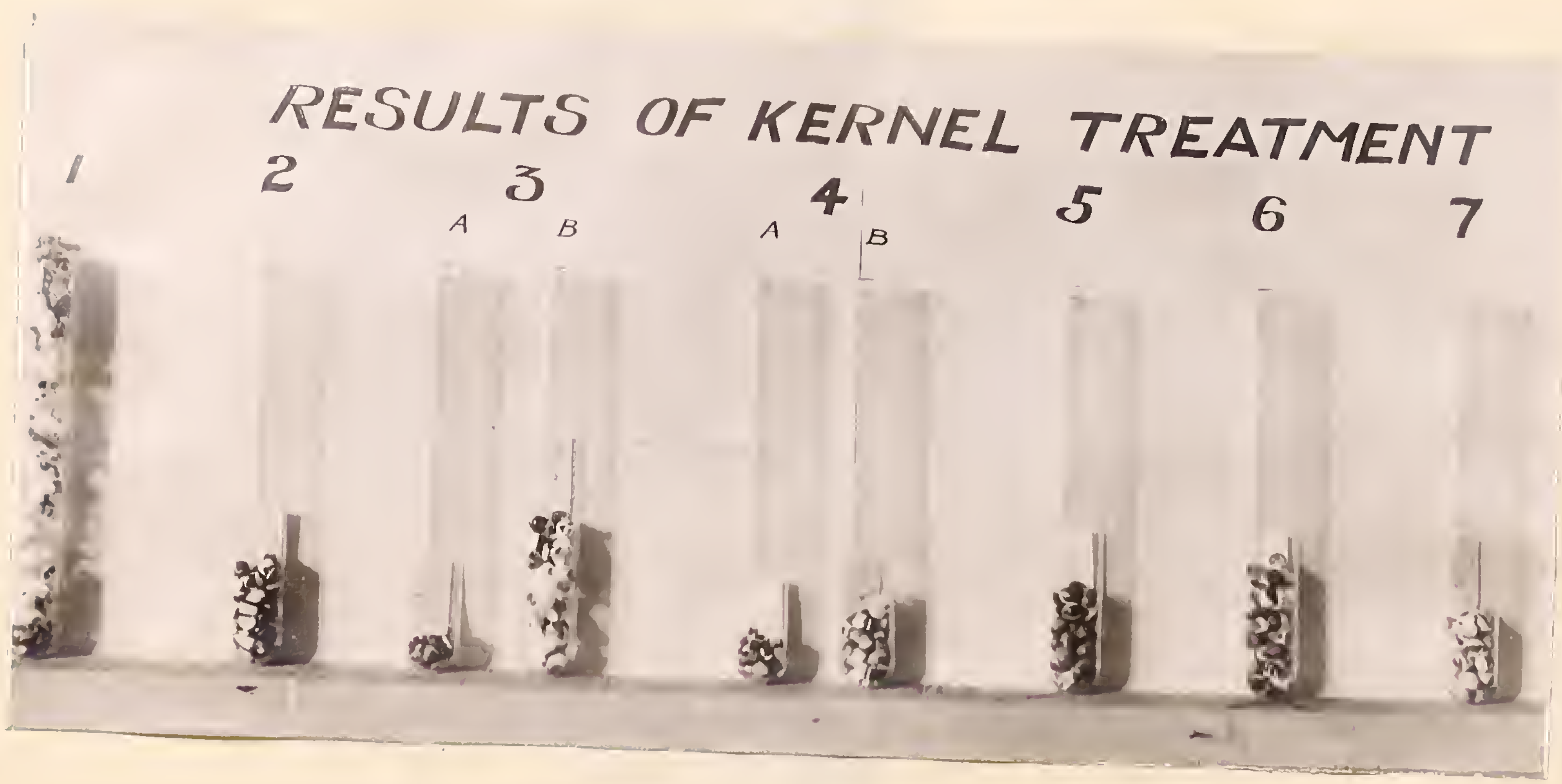


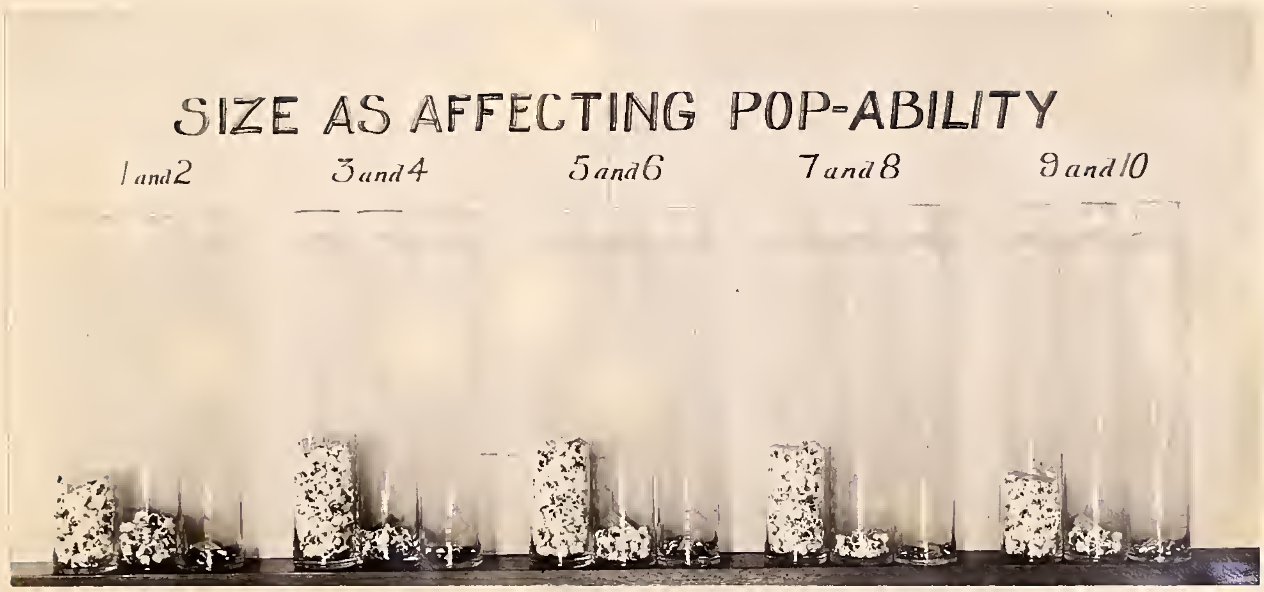
PLATE VIII

KERNEL TREATMENTS AS AFFECTING POP-ABILITY



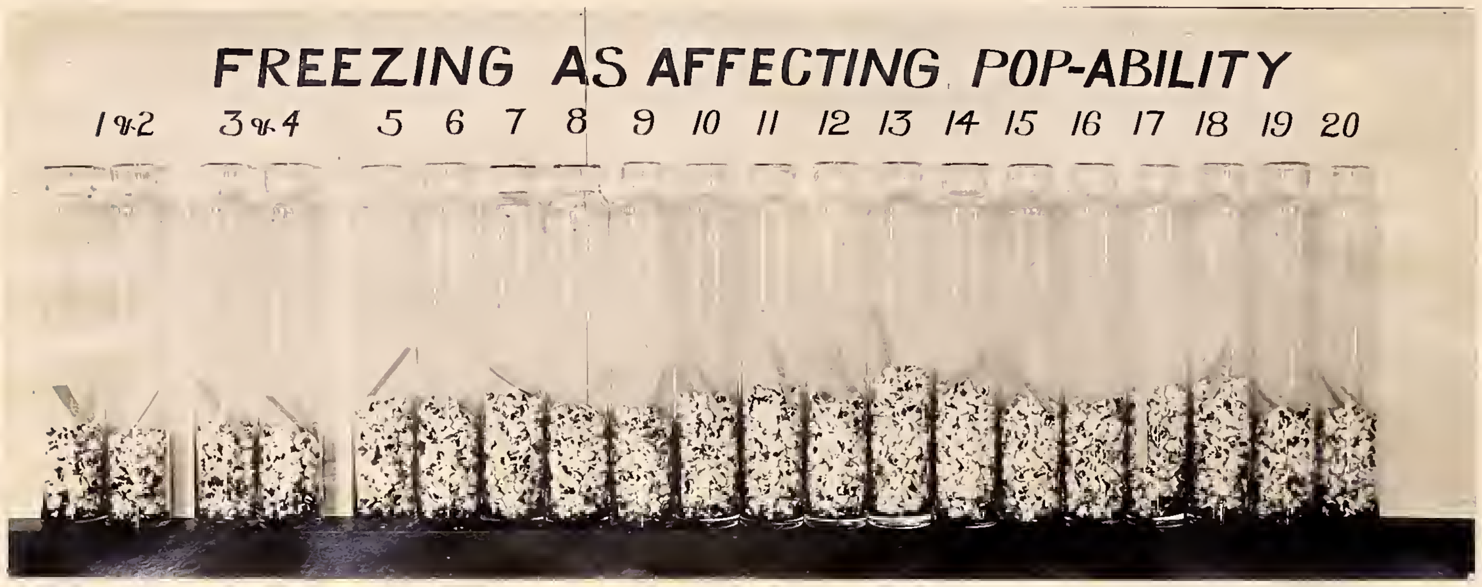
For treatments see Table V

PLATE IX



For size see Table VI

PLATE X



See Table VII

SUMMARY AND CONCLUSIONS

That many factors may affect the pop-ability of pop corn is shown by this work and results obtained by previous workers.

The economic value or necessity of controlling the factors which affect the pop-ability may be realized by the following conclusions:

1. Moisture: That pop corn pops best at about twelve per cent of moisture was shown in this work by extensive experiments. The right percentage of moisture is a very essential factor for the best pop-ability due to the fact that the optimum moisture for popping varies within a few per cent from twelve. In case of newly harvested corn artificially dried the indications were that moisture is the chief factor affecting the pop-ability of new corn.

2. Age: Experiments conducted to determine the effect of age on pop-ability indicated that there may be a slight beneficial

change conducive to pop-ability during the first two months after harvest. After this period it seems that pop-ability decreases with age.

3. Maturity: Indications were that if the corn reaches the early dough or dough-stage the pop-ability is even better than where fully matured. Possibly there is a beneficial change in immature corn after harvesting. Whether it would be advisable to advocate harvesting be-fore fully matured is questionable. If not stored under ideal conditions it may be injured.

4. Kernel treatments: The skin of the grain exerts a very decided influence on pop-ability as shown by any injury or rupture of the seed coat. It seems that both the structure of the individual starch grains in the kernel and the toughness of the restraining skin, act to control the manner in which the moisture in the starch grains, when suddenly heated is converted into steam of such high tension that the explosive act of popping results.

5. Size: Exceptionally large kernels do not pop well while the highest percentage of

pop-ability seems to be associated with kernels of medium to a slightly smaller size.

6. Freezing: Indications in all cases pointed to the fadt that freezing was beneficial, giving an increase in volume as well as better appearance, and very tender. A microscopic examination of soaked and frozen kernels seemed to indicate a mechanical rupture of the cells of the endosperm, which was not shown in those not so treated. Whether the mechanical rupture of the cell-walls decreases the resistance in the interior of the kernel, thereby causing more of the cells to rupture and improve the pop-ability, or whether there are other factors is a subject for further investigation.

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