

## WHAT PUTS "POP" IN POP CORN?

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"What puts the 'pop' in pop corn?" is a question which is often joked about and one which seems never to have been considered seriously enough to lead to any investigation. Some think the subject is, not worth study while others look upon it as one of the mysteries of nature which can never be unfolded and to them it is in the same class as the question, "Why is the grass green"? Pop corn has been a very popular food from very early times and is becoming more common as improved methods of preparation render it more and more appetizing.

*Theories of Popping.*

The writer formerly was led to think the cause and degree of popping was in proportion to the hygroscopic water contained in the corn when heated, but a little investigation convinces one that popping is quite independent of the water content except between very wide limits, besides other kinds of corn such as dent or sweet do not pop wide open at any moisture content. Some have thought the action to be similar to that of Professor Anderson's puffed corn or wheat, etc., in which the outer covering holds tenaciously enough to expand without breaking. This, however, is not the case with pop-corn as it is possible to drill holes in the grain or slit the sides of the hull with a sharp knife and still have the grain pop wide open on being heated in a proper way.

*Scope of Investigation.*

The study of this subject is still going on but the points investigated so far concern mainly the moisture and protein contents, percent of popping, time of heating for best popping, microscopical appearance of popped and unpopped corn and changes in composition after popping.

The 50 corn samples tested were secured from various sources. Many were from the farmers who grew the corn, some were obtained in grocery stores in different Indiana towns. They were mostly of the rice corn variety. Some of the samples are known as Australian Hulless, and some as California Golden. The percent of moisture, pop and protein content of the samples are given in the table which follows:

*Table 1 Showing Percent of Moisture, Pop, and Protein in Corn Samples*

Sample No.	Moisture	Pop	Protein
1	8.9	67.	....
3	8.15	90.5	....
4	8.21	95.0	....
5	8.41	86.	....
6	8.20	....	....
7	9.42	9.42	....
8	8.18	82.5	....
9	7.38	98.3	....
10	9.93	80.5	....
11	10.75	83.5	....
12	11.28	94.0	12.5
13	10.84	95.0	13.7
14	11.18	80.0	13.5
15	11.25	78.0	10.7
16	12.45	91.0	13.1
17	8.83	56.0	13.1
18	10.38	84.0	11.5
19	11.37	87.0	9.4
20	8.20	92.0	10.0
21	8.7	74.0	10.6
22	9.08	83.0	11.7
23	9.12	76.5	11.2
24	9.0	83.5	12.3
25	8.27	69.0	8.8
26	9.14	77.5	11.8
27	8.95	69.0	13.2
28	9.53	83.5	13.9
29	9.70	89.5	13.6
30	8.50	80.0	12.3
31	9.45	72.5	13.8
32	11.79	89.5	11.5
33	12.3	77.5	13.4
34	10.22	55.0	9.9
35	11.97	95.0	8.2
36	14.67	89.0	11.6
37	10.71	92.0	14.4
38	10.58	58.0	14.0
39	9.39	69.5	11.6
40	8.95	90.5	12.8
41	8.88	87.0	13.4
42	8.76	81.0	11.6
43	10.59	85.5	12.1
44	8.64	88.0	13.3
45	7.57	88.0	8.3
46	8.78	74.0	11.0
47	7.85	63.0	12.6
48	8.78	83.5	11.7
49	10.31	85.0	12.8
50	8.71	83.0	13.4
51	7.70	85.5	13.4
52	9.57	74.0	11.4

It was found that the time consumed in popping had much to do with the completeness to which any sample of corn could be popped. For this test a definite amount of corn (30 c c) in a sheet iron popper was always used and different heats of gas flame applied, the time varying from 1 to 9 minutes. It was found the best results were secured when the popping was finished in 2.5 to 3 minutes. This was obtained by measuring

the volume of the popped corn shown in Photograph 1 below. When popped in lard it was found that popping started at 340° F and proceeded rapidly when a temperature of 380° F had been reached. If less time than 3 minutes was consumed in popping the volume would be lessened because many kernels would be only partly popped while if a greater time was used the corn would be dried out too much and good popping made impossible.

*Effect of Moisture on Popping.*

An attempt was made to subject a series of samples of the same corn to extremes of moisture and dryness and then test their ability to pop. The results of these tests are given in the table below.

*Table 2 Showing the Relation of the Moisture to Popping of Corn*

Sample Duplicate	Percent Moisture	Percent Pop
1	11.34	93.0
2	16.23	87.0
3	18.92	85.0
4	24.3	84.0
5	21.4	60.5
6	20.84	25.0
7	4.15	4.0

It will be noted from Table 2 that the moisture content is not a prime factor in popping of corn except when extreme limits are reached.

There is a difference in the appearance after it is popped and the way of popping between high and low moisture corns. The former gives a muffled sound when popping whereas the latter pops with a loud sharp report and emits very little fragrance compared to the former. The photographs 2 and 3 will serve to show the moisture effect on popping and the appearance of the popped grains.

*Effect of High and Low Protein on Popping.*

It was surmised that the great differences noted in popping might be due somewhat to the horny protein layer surrounding the starch in some samples, hence the protein contents of the samples were obtained, but this clue was found false as shown in Graph I, in which the protein, moisture and percent of pop are graphically illustrated and no relation seems to be apparent between the percent of popping and the protein content.

*Microscopical and Chemical Studies.*

In order to study the changes going on within the cells it was thought worth while to make some photomicrographs of a cross section of the pop corn grains both before and after being popped. These differences are shown in photomicrograph 1, 2, 3 and 4. It will be noticed that the cell walls and the contents of the cells are very greatly expanded and more clearly defined in the popped corn than in the unpopped indicating extensive molecular rearrangement in the cellular structure.

The chemical analysis seems to indicate that the most pronounced change

due to popping corn is that which the starch undergoes forming soluble starch and dextrin. This is shown by the increase in blue color given by the iodine test for starch as well as by the increased solubility of starch and dextrin when extracted by cold water.

It was found also that there is considerable increase in the amount of fat extractable with ether after the corn is popped. This is probably due to the thorough disruption of the cellular structure making more complete extraction possible. It was noted too that there is a slight increase in the fiber content when corn is popped. The action of malt diastase on the popped corn shows that over half of the starch has been converted to a form capable of reducing Fehling's solution.

It is well known that a large amount of steam escapes when corn is popped but it is usually considered that this comes only from the moisture contained in the corn. This does not seem to be entirely the case. Since the loss in weight on popping is slightly greater than that of the moisture in the corn, and since there is no carbon dioxide gas produced, the excess water may come from a partial breaking down of the starch molecule to a less complex structure through the loss of water of constitution as shown in the table which follows:

*Table 3 Showing the Loss of Water of Constitution in Popped Corn*

Sample No.	Percent Moisture	Percent Loss on Popping	Percent of Water of Constitution
A	7.96	8.68	0.72
B	10.21	11.71	1.50
C	8.56	9.60	1.04
D	14.31	15.50	1.19
E	14.04	14.50	0.46

The change taking place seems to be one of hydrolysis due to the action of steam under a considerable pressure. The cellular starch wall is very elastic permitting of wide distention, and loss of some cell granules, without breaking. Other corn grains split open without much cell elasticity being shown.

#### *Summary.*

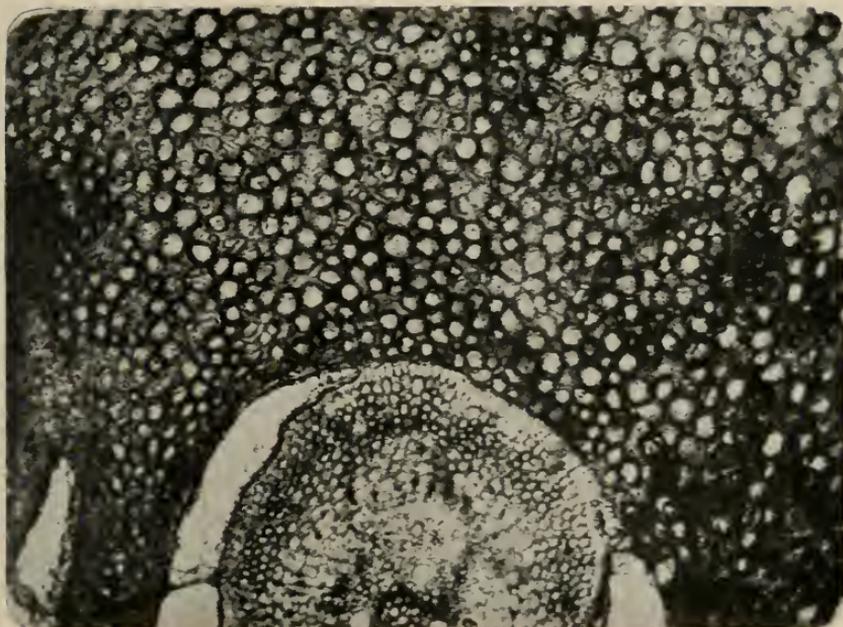
I. The amount of moisture is not the determining factor in popping of corn except in cases of extremes wet or dry samples.

II. The time consumed in popping corn is an important factor; when heating has been too rapid the corn does not have a chance to become dextrinized throughout the grain, when heating is too slow the moisture content becomes too low to explode the grain.

III. Photomicrographs of popped corn show the cells to be greatly enlarged and a considerable part of them disrupted releasing some starch granules which may be stained blue with iodine solution.

IV. Popping corn increases the ether soluble fat, also the soluble starch and dextrin and decreases the starch while the fiber is slightly increased.

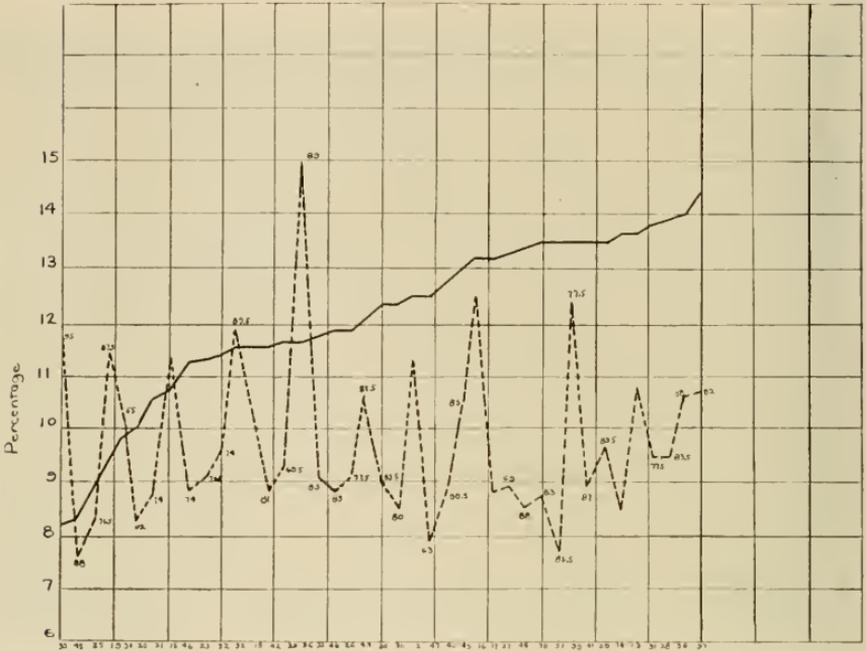
V. The popping of pop corn seems to be caused by the multiple cell explosion of steam derived from water of constitution and from hygroscopic moisture.



Photomicrograph I showing germ and nucleus also starch grains of the unpopped corn. X 50 by Dr. E. G. Mahin.



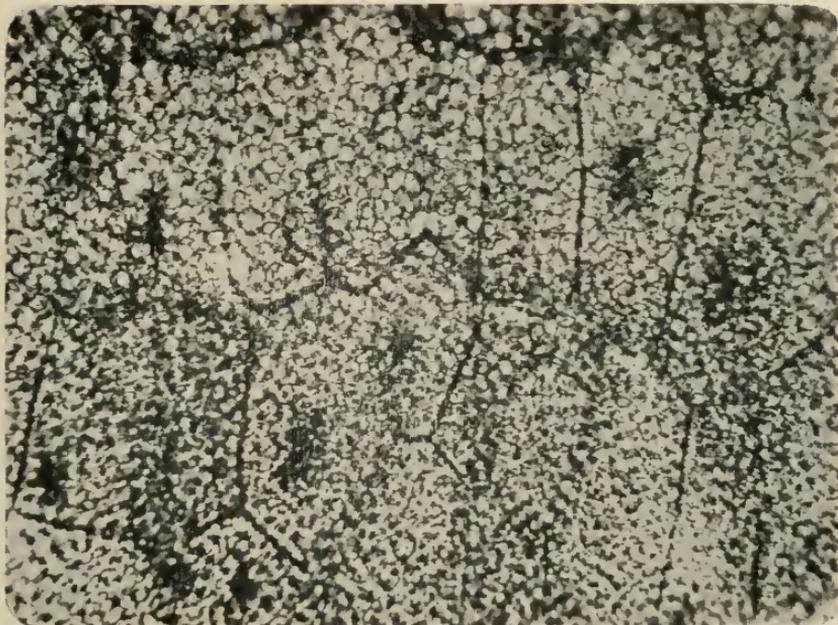
Photomicrograph 4.—Showing starch grains in unpopped corn, as white dots and the cell walls as black circles. X 100 by Dr. E. G. Mahin.



Sample Numbers

Graph showing relation of Moisture, Protein and Pop.

Protein % ———  
 Moisture % - - - - -  
 Pop Numerals



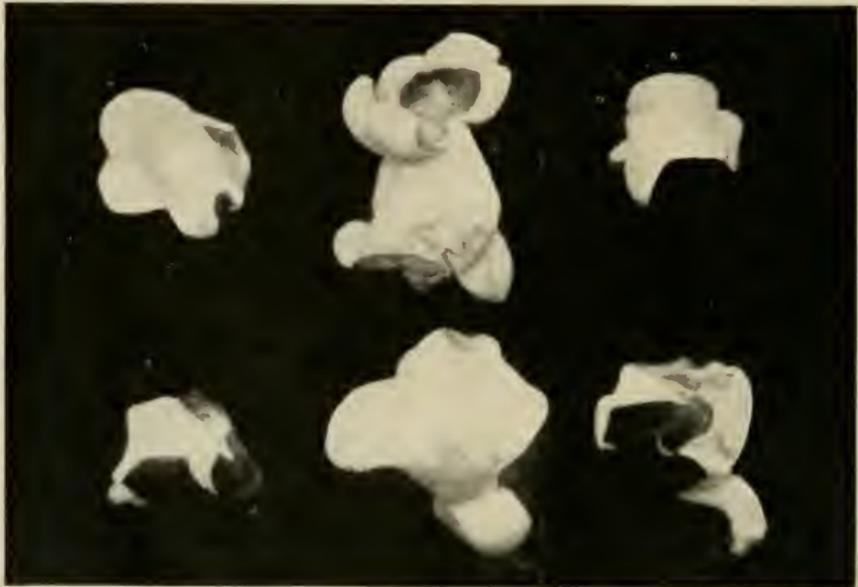
Photomicrograph 2.—Showing contents of the expanded starch cell due to popping of corn. The outline of cell wall can be distinguished by the black lines. X 50 by Dr. E. G. Mahin.



Photomicrograph 3.—Showing higher magnification than number 2. X 100 by Dr. E. G. Mahin.



Photograph I.—Showing volume of popped corn when 30 cc sample is popped at different time intervals.



Photograph II.—A group of typical low moisture kernels. Note large pieces peeled back, the unexpanded centers and smooth surfaces.



Photograph III.—A group of typical high moisture kernels. Note ragged edge, rough surfaces, fragmentary, flakey and irregular texture.

