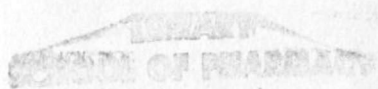


THE PRESERVATIVE ACTION OF SPICES

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Spices and condiments have been used since early civilization not only for their agreeable odor and taste but also for their preserving properties. In this connection, it might be interesting to study philologically the word condiment. It is derived from the Latin verb "deondire" meaning "to preserve."

Condiments are essentially seasoning agents in modern use, serving to awaken the appetite, to render the process of eating a pleasure and to aid in digestion of the food. They are not as a rule, foods in the sense of the term, for they are not capable of supplying the body to any great extent with tissue - building material. They may aptly be said, in the words of Gauthier, "To correspond to a sort of universal instinct which tends to associate sensations of an almost artistic order, with the coarse gratification of hunger."

The use of condiments has developed through a long period of time. In the times of "primative man," we are led to believe that the principal articles of diet were consumed in the raw state. In course of time, educated through necessity perhaps, methods for the preservation of their meats were devised in order to prepare for times of want. Thus the American Indians in the early days,

laid up a stock of ~~smoked~~ meat dried in the sun, for winter use. A further development in the preservation of meats, consisted of immersion in brine. Preservation by means of vinegar and like condiments were later steps in the process of evolution.

Condiments were thus originally used as preservatives. Their continued use, however, has cultivated an acquired taste for them which has entirely overshadowed their former use as preservatives. Their antiseptic value has been practically forgotten through their present use as necessities for flavoring foods.

Among the comparatively late substances introduced as condiments into European civilization are the spices. Although primarily used as condiments, scattered observations have led to the belief that spices are also of some value as preservative. It would be interesting to confirm these few observations and to ascertain more thoroughly by systematized work the extent to which the spices act as preservatives. Beyond the knowledge of their common use as condiments and as occasional medicaments, little is known of the universally used spices. This ignorance is excusable in that but little investigation has been carried on in regard to their properties. The scarcity of research work on so important a subject is astounding in view of the fact that spices have been

known and used for such a long time.

The habitat of the great majority of the spices including such important ones as cloves, cinnamon, nutmeg, allspice and pepper, was originally in the East Indies and the tropics of the Eastern Hemisphere. The only spices of importance in the West Indies were vanilla, ginger and capsicum. At present the cultivation of all spices is carried on throughout the tropics of both hemispheres.

The early commercial history of spices is closely associated with ^{that} all of exploration and conquest from the earliest periods of history. Spices were accepted by victorious nations as tribute. They have enriched nations as well as caused their downfall. They have served as international currency and incited wars. They are mentioned in biblical passages of the Mosaic writings, by the early Greek philosophers and also in the Chinese classics.

Spices were first brought to the attention of Europe by the Crusaders. They were imported by the returning knights of the faith from Arabia which for a long time was thought to be their source and, therefore, called the "land of spice." The rounding of southern Africa by the Portuguese at the commencement of the sixteenth century, gave a new impetus to the importation of spices

into Europe. In 1605, the Dutch obtained control of the spice monopoly by conquest. This monopoly was made secure by the destruction of spice trees in all but a few island possessions, and maintained for a long time until finally terminated by British domination of the seas.

Spices in ancient times were used largely in connection with religious rites such as incense for altars, embalming purposes and sacrifices. They were highly esteemed as perfumes and served often as presents to royalty. Not until some time after the opening of the East Indies by the British, did spices come into general use as condiments.

Therapeutically, the spices occupy no little place in medicine. In moderate amounts, nearly all spices exert an exhilarating effect on the system. They stimulate the secretion and flow of the digestive juices and thereby aid in the assimilation of food. They are also excellent carminatives and stomachics.

Over-indulgence in highly spiced foods however is to be guarded against, as irritating effects are produced both in the digestive tract and on the organs of secretion. Many physicians, therefore, forbid the use of heavily spiced articles during sickness and the period of convalescence. Even if this were not a common practice,

the interference with digestion on account of their preservative properties, would be inferred by our common knowledge of the chemistry of spices. Many of the so-called coal tar products which are of great antiseptic and disinfectant value, belong to what is known as the aromatic series of carbon compounds, that is, those compounds which derive their name from the aromatic substances as represented e.g. by the volatile oils obtained from spices and aromatics. The active constituents of the spices, especially ^{the oils} the oils of clove and cinnamon have, it is true, been used extensively for the preservation of library pastes, gums, soaps and commercial preparations for external medical use, and also considerably employed for application to carious teeth, but there appears to be little known about their specific antifermmentative action.

In order to secure specific data on this subject, a comparative study of the inhibitive effects of benzoic acid and spice chemicals on yeast was undertaken. Preliminary tests were made, in the ordinary fermentation tube, with eugenol as principal constituent of cloves, and with cinnamic aldehyde as principal constituent of cassia. A 5 p.c. emulsion was used in both instances.* As ferment

*Eugenol, or cinnamic aldehyde	10.0 g.
Powdered gum acacia	7.5 g.
Water, a sufficient amount to make	200.00 cc.

ordinary compressed yeast was taken and as medium for growth a 10 p.c. solution of glucose. The yeast was mixed with the sugar solution. Of this mixture a sufficient amount was taken to make 35 cc. with varying amounts of emulsion. The results are recorded in the following tables. In each series a blank test was made for the sake of control and comparison.

E U G E N O L.

No. of Exp.	Amt. of Emulsion	Amt. of yeast and Grape sugar	Amount of Eugenol	Results
1	1/2 cc.	34.5 cc.	0.071 p.c.	Complete fermentation in 6 hrs. but slow in starting.
2	1 cc.	34. cc.	0.142 p.c.	Only a partial fermentation, i.e. abt. 1/2 inch of CO ₂ formed.
3	2 cc.	33. cc.	0.284 p.c.	Slight traces of carbon dioxide.
4	3 cc.	32 cc.	0.426 p.c.	No fermentation.
5	5 cc.	30. cc.	0.710 p.c.	No trace of fermentation.
6		35. cc.	0.000 p.c.	Complete fermentation in three hours.

C I N N A M I C A L D E H Y D E .

No. of Exp.	Amt. of Emulsion	Amt. of 10 p.c. Glucose and yeast	Percent of Cin. Ald.	Results
1	1 cc.	34 cc.	0.142 p.c.	A little fermentation during the first 24 hours, i. e. about $\frac{5}{8}$ in. of CO ₂ .
2	2 cc.	33 cc.	0.284 p.c.	No appreciable fermentation. Traces of gas after 48 hours.
3	3 cc.	32 cc.	0.426 p.c.	No fermentation. Traces of gas after 48 hours.
4	4 cc.	31 cc.	0.568 p.c.	No fermentation. No gas after 48 hours.
5	5 cc.	30 cc.	0.710 p.c.	No fermentation. No gas after 48 hours.
6		35 cc.	0.000 p.c.	Complete fermentation in tube within 24 hours.

Inasmuch as the ordinary fermentation tubes fail to give quantitative results, except of the roughest kind, more accurate determinations were made in closed flasks, the gas being measured in the ordinary Lunge nitrometer. When the amount of carbon dioxide became too great for the nitrometer, e.g. during the night interval of about eight hours, the gas was collected in flasks and measured the next morning.

In order that the experiments between eugenol, cinnamic aldehyde and benzoic acid might be directly comparable, chemically equivalent amounts of these three substances were employed, and the four experiments - i.e., including the necessary blank - were made at the same time, with the same yeast and under like conditions.

After some preliminary experimentation which showed that even 1/20 percent of benzoic acid or equivalent amounts of eugenol or cinnamic aldehyde checked all fermentation, several series of experiments with 1/40 percent of benzoic acid and equivalent amounts of eugenol and cinnamic aldehyde were made. The results are recorded in the following tables.

A 10 p.c. solution of commercial glucose was employed. For the sake of more accurate measurements 1 p.c. emulsions of cinnamic aldehyde and of eugenol were used. Of benzoic acid a 0.2 p.c. solution was employed. To 75 cc. of the sugar solution the requisite amounts of preservative solution, respectively emulsion ^{were} was added, then enough water to make 100 cc. To the blank 25 cc. of water were added. As a result, the sugar solution represented a strength of 7.5 percent glucose. A like amount of fresh compressed yeast (1/8 of a small cake mixed with water and the mixture divided into four equal parts) was added to each flask and the flask connected with the nitro-

meter. The four flasks were placed in an asbestos-lined box gently warmed with an electric lamp in such a manner that a uniform temperature of 30 to 35° - barring accident - could be maintained.

T A B L E I I I.

Preservatives:-	Blank	Eugenol	Cinn. Ald.	Benz. Acid
Amt. of Emulsion:-	0.00 cc.	3.35 cc.	2.70 cc.	12.50 cc.
Amt. of Preservative:-	0.000 g.	0.0335 g.	0.027 g.	0.025 g.
Time	Number of cc. of gas produced.			
1/29/09				
8:00 A.M.	-----	-----	-----	-----
9:00 "	-----	1.00 cc.	-----	-----
10:00 "	1.00 cc.	3.80 "	-----	-----
10:30 "	6.40 "	7.40 "	0.80 cc.	-----
11:00 "	14.00 "	12.00 "	2.00 "	-----
11:30 "	21.80 "	19.90 "	3.20 "	-----
12:00 "	30.00 "	27.40 "	4.40 "	-----
12:30 P.M.	39.00 "	36.20 "	5.00 "	-----
1:00 "	52.30 "	50.40 "	6.20 "	-----
2:00 "	96.00 "	90.00 "	10.00 "	-----
3:00 "	130.00 "	126.00 "	15.80 "	-----
4:30 "	189.00 "	175.40 "	27.00 "	0.80
5:30 "	224.00 "	210.00 "	35.00 "	3.00
6:00 "	278.00 "	232.60 "	44.80 "	6.40
10:00 "	330.00 "	279.60 "	109.80 "	57.40

Feb. 3rd*.

*Transferred from nitrometer to graduated bottles on Friday after 6:00 o'clock. Light in incubator was extinguished during night because the wires were disturbed by snow storm. On Monday, the temperature rose to 40°C. Again decreased to 30°C. on Tuesday.

A second series of experiments gave similar results.

T A B L E I V.

Preservatives:-	Blank	Eugenol	Cinn. Ald.	Benz. Acid
Amt. of Mixt.:-	0.00 cc.	3.35 cc.	2.70 cc.	12.50 cc.
Amt. of Preservative:-	0.000 g.	0.0335 g.	0.027 g.	0.025 g.
Time of reading	Amount of Gas Generated.			

2/4/09

1:30 P.M.	-----	-----	-----	-----
2:00 "	0.50 cc.	0.80 cc.	-----	-----
2:30 "	1.60 "	3.00 "	-----	-----
3:00 "	2.80 "	7.20 "	-----	-----
3:30 "	5.00 "	12.00 "	-----	-----
4:00 "	6.80 "	15.60 "	-----	-----
4:30 "	8.40 "	21.20 "	-----	-----
6:00 "	13.40 "	33.00 "	-----	-----
9:30 "	43.00 "	116.00 "	-----	0.20 cc.

2/5/09

1:00 A.M.	73.00 "	210.40 "	1.60 cc.	0.40 "
10:00 "	102.00 "	276.40 "	35.00 "	1.80 "
11:00 "	109.00 "	290.80 "	39.40 "	1.90 "
12:00 "	115.40 "	313.40 "	44.80 "	2.20 "
2:30 P.M.	136.60 "	380.80 "	58.60 "	2.40 "
3:00 "	144.40 "	392.60 "	64.40 "	2.60 "
4:00 "	154.60 "	415.20 "	70.60 "	2.60 "
5:00 "	165.60 "	435.20 "	79.00 "	2.80 "

8:00 P.M.	193.40 cc.	496.80 cc.	98.20 cc.	3.40 cc.
2/6/09				
2:00 "				5.20 "
5:00 "				5.60 "
2/8/09				
2:30 "				12.60 "
2/9/09				
11:00 A.M.	245.40 cc.	526.80 cc.	142.20 cc.	15.20 "
2/11/09				
3:00 P.M.	271.40 "	526.80 "	325.20 "	15.20 "
2/13/09				
10:30 A.M.	292.80 "	526.80 "	337.20 "	15.20 "

24
3
16 2/3
105

The most striking feature of ^εthose two tables is this that eugenol, when used in amounts that represent the chemical equivalent of 1/40 percent of benzoic acid, appears to stimulate fermentation of this sort. In the first of these two tables, the data show that the blank test caught up after three hours and kept ahead of the eugenol experiment to the very end. From the second table, however, it becomes apparent that the eugenol experiment not only staid ahead of the blank but gained throughout. Additional experiments, therefore, seem necessary to study the behavior of eugenol on ordinary yeast.

This phenomenon, however, is not so very remarkable if interpreted in the light of the results obtained when more highly organized plants are subjected to the influence of poisonous salts such as copper sulphate etc. In the work done by True and Kahlenberg on the seedlings of the ordinary sow bean similar phenomena were observed. Substances that reveal poisonous effects when used in toxic doses, may have a stimulating effect when applied in smaller doses.

To replace the commercial glucose used in the preliminary experiments, and thereby obtain more reliable results, a solution of invert sugar of known strength, was prepared from cane sugar. A ten percent sugar

solution was inverted with the aid of oxalic acid (2g acid to 100g of the syrup) and the oxalic acid removed by heating the inverted syrup with an excess of calcium carbonate. The amount of invert sugar in the filtered syrup was determined by the Defren and Sullivan test which revealed that all of the cane sugar had been inverted.

The fermentation tests were made as in the previous series of experiments. However, fresh lots of cinnamic aldehyde (Fr. Bros.) and eugenol (Fr. Bros.) were obtained. This necessitated the making of fresh emulsions. In order to be able to measure more accurately the small amounts of emulsions necessary for a single experiment, these emulsions were made of half strength only, i.e. 1/2 p.c. strength instead of 1 p.c. strength as heretofore. As a result an error crept into the first and second series of experiments. The usual amount of emulsion was taken, but as this was only one-half the strength of the previous emulsions, the amounts of eugenol and cinnamic aldehyde were the equivalents of merely 1/80 of the amount of benzoic acid taken, not of 1/40. The data of the second and third columns are, therefore, not directly comparable with those of column four, that is in tables V and VI.

In a way, however, the results are very instructive. Eugenol and cinnamic aldehyde, when used in these dilu-

tions, evidently act as stimulants to the ferment organisms. Whatever the minor variations in the data of columns two and three, the totals of gas generated at the end of both series of experiments are way above those of the fourth (benzoic acid) column; and in table V even far ahead of the blank. The differences in the end results of the blank tests of tables V and VI again emphasize the necessity of guarding against the drawing of final conclusions from a single series of experiments.

-16-
T A B L E V.

Preservative:-	Blank	Eugenol (1/80)	Cinn. Ald. (1/80)	Benz. Acid. (1/40 p.c.)
Ant. of Sol.:-	-----	3.35 cc.	2.70 cc.	12.50 cc.
Ant. of preservative:-	-----	0.0167 g.	0.0135 g.	0.025 g.
Time	No. of cc. gas generated.			
2/15/09				
5:30 P.M.	-----	-----	-----	-----
9:00 "	35.80cc.	15.20cc.	8.60cc.	7.00cc.
2/16/09				
1:30 A.M.	141.80cc.	61.60 "	84.00 "	36.00 "
10:30 "	187.80 "	96.20 "	96.00 "	68.80 "
12:00 "	199.20 "	129.20 "	106.00 "	96.8 "
2:00 P.M.	222.40 "	136.00 "	134.6 "	116.2 "
3:30 "	244.00 "	158.4 "	164.2 "	131.8 "
4:30 "	254.80 "	168.2 "	186.2 "	140.6 "
8:30 "	279.20 "	212.2 "	265.8 "	163.0 "
2/17/09				
2:30 A.M.	292.0 "	261.2 "	352.0 "	186.2 "
12:30 P.M.	330.0 "	349.8 "	481.00 "	211.6 "
5:30 "	331.6 "	382.6 "	534.00 "	219.2 "
12:00 "	357.8 "	427.2 "	628.2 "	220.8 "
2/18/09				
10:00 A.M.	414.8 "	510.4 "	730.2 "	223.0 "
11:30 "	420.6 "	519.4 "	734.6 "	223.0 "

3:30 P.M. 443.4 cc. 543.2 cc. 754.0 cc. 223.0 cc.

6:00 " 451.0 " 555.0 " 763.0 " 223.0 "

2/19/09

1:00 A.M. 473.2 " 589.0 " 779.2 " 223.0 "

11:00 " 493.2 " 615.4 " 781.8 " 223.0 "

6:00 P.M. 494.4 " 617.8 " 782.0 " 223.0 "

24
4
96 1/2

T A B L E V I.

Preservative:-	Blank	Eugenol (1/80)	Cin. Ald. (1/80)	Benz. Acid (1/40)
Ant. of Emulsion:-	-----	3.35 cc.	2.70 cc.	12.5 cc.
Ant. of Preserv.:-	-----	0.0167 g.	0.0135 g.	0.025 g.
Time	No. of cc. gas generated.			
2/23/09				
4:30 P.M.	-----	-----	-----	-----
5:30 "	8.6 cc.	11.2 cc.	12.2 cc.	6.4 cc.
6:00 "	14.0 "	17.6 "	17.2 "	10.0 "
9:00 "	95.0 "	102.0 "	66.0 "	32.0 "
10:00 "	135.0 "	151.0 "	100.0 "	43.0 "
2/24/09				
12:30 A.M.	229.0 "	247.0 "	196.0 "	78.8 "
9:30 "	427.0 "	454.0 "	274.0 "	182.8 "
10:30 "	443.2 "	477.6 "	291.0 "	191.2 "
11:45 "	467.6 "	508.8 "	318.2 "	202.6 "
2:00 P.M.	526.6 "	577.8 "	379.8 "	224.6 "
3:30 "	544.6 "	623.0 "	422.2 "	237.6 "
6:00 "	590.6 "	680.0 "	476.0 "	257.0 "
9:15 "	673.0 "	777.0 "	570.0 "	278.0 "
10:00 "	686.0 "	793.4 "	582.0 "	282.0 "
2/25/09				
10:30 A.M.	768.0 "	829.0 "	747.0 "	305.0 "

12:15 P.M.	779.0 cc.	843.0 cc.	759.0 cc.	305.2cc.
2:00 "	817.4 "	883.6 "	798.0 "	305.8 "
5:00 "	859.0 "	925.0 "	841.0 "	306.0 "
8:30 "	899.0 "	969.0 "	886.0 "	306.0 "

2/26/09

8:00 A.M.	1005.0 "	1073.0 "	990.0 "	306.0 "
11:00 "	1014.0 "	1087.0 "	1004.0 "	306.0 "
2:30 P.M.	1022.0 "	1201.0 "	1018.0 "	306.0 "
5:00 "	1025.0 "	1208.0 "	1023.0 "	306.0 "
8:00 "	1029.0 "	1216.0 "	1032.0 "	306.0 "

2/27/09

9:00 A.M.	1030.0 "	1228.0 "	1040.0 "	306.0 "
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24
3
72
12
4 1/2
88 1/2

In the next two series the error made in V and VI was corrected, so that the amounts of eugenol and cinnamic aldehyde are the molecular equivalents of 1/40 percent of benzoic acid. The data in columns two, three and four are, therefore, directly comparable.

The most striking result is this that in both series eugenol and cinnamic aldehyde inhibit fermentation more than does benzoic acid. With commercial glucose, compare tables III and IV the results were the other way.

In both series the amount of gas given off in the benzoic acid experiment was almost as great as that given off in the blank test. In this particular, these results differ greatly from the finals in table VI, but somewhat less from the finals of columns one and four in table V.

These results are corroborated by those recorded in table IX, but the differences are less emphasized.

So much for the final results of these series. If we now compare the earlier results in each series, it becomes apparent that, on the whole, benzoic acid inhibits the initial steps of fermentation longer than do eugenol and cinnamic aldehyde. There is an exception to this in table VIII, where the benzoic acid experiment starts way ahead of the cinnamic aldehyde experiment.

As to the blank, this, as a rule, starts ahead of the others, but in experiment VII cinnamic aldehyde starts

ahead of the blank, in experiment VIII both eugenol and benzoic acid, the latter staying ahead until the end of the second day whereas the former drops behind ^{at the after} early the second day. *six hours.*

If the amounts of eugenol and cinnamic aldehyde used in ^{these} other experiments be compared with those supposed to be found in ^{a certain brand of} catsup, it will be seen that these substances might be expected to stimulate fermentation rather than inhibit it. This conclusion might justly be drawn if catsup contained but one of these inhibiting agents and not a considerable number thereof. The next ^{line} of experimentation will, therefore, be devoted to ascertaining what the influence of the total spices on fermentation is. In addition to that the action of vinegar and salt, not to mention sugar in this connection, will also have to be taken into account.

T A B L E V I I .

Preser- vatives:-	Blank	Eugenol (1/40)	Cinn. Ald. (1/40)	Benz. Acid (1/40)
Ant. of Mxt.:-	-----	6.7 cc.	5.4 cc.	12.5 cc.
Percent of preserva- tive:-	-----	0.0335p.c.	0.027 <i>p.c.</i>	0.025 <i>p.c.</i>
Time	No. of cc. gas generated.			
2/27/09				
10:30 A.M.	-----	-----	-----	-----
10:45 "	0.8 cc.	0.4 cc.	1.2 cc.	-----
11:00 "	4.0 "	1.6 "	3.8 "	-----
12:00 "	6.0 "	2.6 "	4.8 "	-----
12:45 P.M.	8.4 "	4.0 "	5.4 "	0.6 cc.
2:15 "	30.0 "	25.0 "	7.0 "	6.2 "
3:30 "	61.0 "	58.2 "	7.2 "	17.0 "
4:00 "	80.0 "	76.0 "	8.0 "	30.0 "
5:00 "	102.0 "	104.0 "	8.4 "	46.0 "
8:30 "	162.0 "	142.0 "	9.4 "	93.0 "
10:00 "	221.0 "	176.0 "	10.6 "	147.0 "
2/28/09				
2:00 A.M.	297.0 "	210.0 "	12.0 "	229.0 "
3/1/09				
9:30 "	303.0 "	235.0 "	33.0 "	256.0 "
5:00 <i>PM</i>	303.0 "	244.0 "	33.0 "	264.4 "
3/3/09				
9:00 <i>AM</i>	303.0 "	254.0 "	33.0 "	265.0 "

-23-
T A B L E V I I I.

Preservative:-	Blank	Eugenol (1/40)	Cin. Ald. (1/40)	Benz. Acid (1/40)
Ant. of Sol.:-	-----	6.7 cc.	5.4 cc.	12.5 cc.
Percent of Preservative:-	-----	0.0335p.c.	0.027 p.c.	0.025p.c.

Time No. of cc. gas generated.

3/3/09

9:45A.M.	-----	-----	-----	-----
10:00 "	-----	1.2 cc.	-----	-----
10:30 "	-----	2.8 "	-----	-----
11:00 "	-----	3.0 "	-----	-----
12:00 "	-----	3.4 "	-----	-----
12:45 P.M.	-----	4.2 "	-----	1.2 cc.
2:00 "	3.6 cc.	6.4 "	-----	8.2 "
2:30 "	5.8 "	7.4 "	-----	13.0 "
3:00 "	10.0 "	9.8 "	-----	22.0 "
4:00 "	21.6 "	12.4 "	-----	40.0 "
5:00 "	35.4 "	18.4 "	-----	61.0 "
7:15 "	72.4 "	42.4 "	-----	112.0 "
9:30 "	118.4 "	59.4 "	0.2 cc.	158.0 "

3/4/09

12:30 A.M.	178.0 "	86.4 "	2.0 "	223.0 "
11:00 "	215.0 "	111.4 "	13.0 "	234.0 "
12:00 "	221.4 "	116.8 "	14.0 "	302.0 "
5:00 P.M.	276.0 "	165.0 "	19.0 "	325.6 "

8:00 P.M.	300.0 cc.	186.0 cc.	21.0 cc.	335.6cc.
12:00 "	338.0 "	215.6 "	24.4 "	350.0 "

3/5/09

8:00 A.M.	417.0 "	256.6 "	25.0 "	390.4 "
11:00 "	435.4 "	260.4 "	25.0 "	395.0 "
3:00 P.M.	455.4 "	262.6 "	25.0 "	405.0 "
7:30 "	478.4 "	264.0 "	25.4 "	410.0 "

3/6/09

9:00 A.M.	512.8 "	264.0 "	25.4 "	422.0 "
5:00 P.M.	513.0 "	264.0 "	25.4 "	427.4 "

3/7/09

9:00 A.M.	513.0 "	264.0 "	25.4 "	429.0 "
Final	513.0 "	264.0 "	25.4 "	429.0 "

24
96

T A B L E I X.

Preservative:-	Blank	Eugenol	Cin. Ald.	Benz. Acid
Ant. of Mxt.:-	-----	6.7 cc.	5.4 cc.	12.5 cc.
Percent of preservative:-	-----	0.0335 p.c.	0.0270 p.c.	0.025 p.c.
Time	No. of cc. of gas generated.			
3/8/09				
3:00 P.M.	-----	-----	-----	-----
3:45 P.M.	1.4 cc.	1.0 cc.	0.4 cc.	0.2 cc.
4:15 "	2.6 "	1.8 "	1.2 "	0.4 "
5:00 "	4.4 "	2.6 "	1.4 "	0.8 "
6:00 "	11.0 "	4.8 "	1.6 "	2.0 "
10:00 "	96.0 "	55.0 "	4.0 "	58.0 "
3/9/09				
11:00 A.M.	151.0 "	91.0 "	24.0 "	151.0 "
12:00 "	158.0 "	92.8 "	49.6 "	153.2 "
2:00 P.M.	192.0 "	97.4 "	56.4 "	165.0 "
5:00 "	231.0 "	102.2 "	65.0 "	177.0 "
7:30 "	267.0 "	107.0 "	75.0 "	191.0 "
3/10/09				
1:00 A.M.	332.0 "	114.0 "	90.4 "	259.0 "
9:45 "	390.4 "	118.0 "	124.6 "	270.0 "
11:00 "	393.0 "	118.2 "	128.0 "	270.2 "
2:30 P.M.	396.0 "	118.8 "	131.6 "	271.0 "
5:00 "	397.0 "	119.0 "	132.6 "	271.8 "
3/11/09				

1:00 A.M.	397.0 cc.	119.0 cc.	133.6 cc.	275.8cc.
3/12/09				
10:00 "	397.0 "	119.0 "	134.0 "	289.0 "

24
3 1/2
12
72
84
7
91

REPORT ON INHIBITIVE ACTION OF MIXED SPICES.

In series X, XI and XII, mixtures of spices were used, the object being to get some idea of the inhibitive action of the total amounts of spices that might be expected to be in the finished catsup. In order to make these tests comparable in a measure to the factory experiments an emulsion of the modified spices or rather modified spice oils and oleoresins ^{was} were taken. The manner in which the amounts were computed becomes apparent from the "Tabulation of spice ingredients."

TABULATION OF SPICE INGREDIENTS OF CATSUP AND EQUIVALENT OILS.

Crude Drug	Amt. of crude drugs for one qt. of tomatoes or 500g. catsup	Amt. of crude drugs for two qts. or 1000g. of catsup	Percent oil or oleoresin obtainable from drugs	Equivalent amount of oil or oleoresin for 1000 g. of catsup	Percent of phenol or ald. constituents of oils.
Cinnamon	2.0 g.	4.020 g.	2.percent	0.0804 g.	75 p.c.
Cloves	0.39g.	0.857 g.	18. "	0.15626g.	90 "
Pimenta	0.39g.	0.857 g.	4. "	0.03428g.	65 "
Capsicum	0.25g.	0.520 g.	12. "	0.0624 g.	--
Pepper	0.21g.	0.467 g.	6.5 "	0.03036g.	--
<hr/>					
Total					

The mixture of phenols and oleo-resins were triturated with 15 g. of powdered gum acacia, to a smooth mass; 30 cc. of water were immediately added and the nucleus of the emulsion perfected. Then water was added to form a mixture of 500 cc. This emulsion is sufficient for 50000. g. catsup, or 1 cc. of the emulsion is the spice equivalent of or sufficient for 100 g. catsup. An amount of 50 cc. of this emulsion was diluted to make 500 cc. of emulsion, thus making an emulsion of 1/10 the strength. 10 cc. of the latter is required for 100 g. of catsup.

Aldehyde or phenol	Amt. of phenols of the oils, and the oleo-resins used for 1000g. catsup	Percent amount of phenols and oleoresins in the catsup.	Emulsion of ingredients 50 times the amount required for 1000 g. Catsup. 1 cc. of emulsion is the equivalent of spices in 100 g. catsup.
Cinnamic Ald.	0.0603g.	0.00603 p.c.	3.015 g.
Eugenol	0.14064g.	0.014064 "	7.032 g.
Eugenol	0.02228g.	0.00223 "	1.114 g.
-----	0.0624 g.	0.00624 "	3.120 g.
-----	0.03036g.	0.003036 "	1.518 g.
		0.02603 "	

$$\begin{array}{r} 4.26 \\ .50 \\ \hline 3.76 \end{array}$$

50% = 50000

T A B L E N O. X.

Preservative:-	Blank	Spices (Mxt.)	Cin. Ald.	Benz. Acid
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Ant. of Mxt:	-----	10.0 cc.	5.4 cc.	12.5 cc.
--------------	-------	----------	---------	----------

Percent of preservative:-	-----	0.0260p.c.	0.0270 p.c.	0.025 p.c.
---------------------------	-------	------------	-------------	------------

Time	No. of cc. gas generated.			
------	---------------------------	--	--	--

3/17/09

2:45 P.M.	-----	-----	-----	-----
3:15 "	0.8 cc.	-----	-----	-----
3:45 "	1.8 "	-----	-----	-----
4:15 "	3.0 "	-----	-----	-----
4:30 "	4.4 "	0.4 cc.	-----	1.8 cc.
5:00 "	7.2 "	2.2 "	-----	7.4 "
6:00 "	15.0 "	8.2 "	-----	26.4 "
10:30 "	128.0 "	108.0 "	3.0 cc.	145.4 "

3/18/09

8:00 A.M.	338.0 "	217.0 "	60.0 "	355.4 "
10:00 "	377.0 "	249.0 "	68.0 "	386.4 "
11:00 "	397.4 "	267.0 "	73.6 "	403.6 "
12:00 "	413.8 "	283.2 "	78.4 "	416.0 "
2:30 P.M.	446.0 "	313.4 "	88.0 "	439.6 "
3:30 "	469.0 "	337.0 "	96.4 "	457.0 "
6:00 "	510.6 "	379.0 "	120.6 "	468.0 "
8:45 "	568.0 "	433.0 "	153.0 "	531.0 "
12:00 "	613.0 "	479.0 "	182.0 "	567.0 "

3/19/09

-30-

9:00 A.M.	658.0 cc.	491.0 cc.	200.0 cc.	658.0cc
11:00 "	671.4 "	503.6 "	213.6 "	669.4 "
12:45 P.M.	687.4 "	518.6 "	229.6 "	683.0 "
3:00 "	706.6 "	537.2 "	249.4 "	698.6 "
5:00 P.M.	725.0 "	556.0 "	269.0 "	714.0 "
7:30 "	746.0 "	576.0 "	291.0 "	732.0 "

3/20/09

1:45 A.M.	787.0 "	612.0 "	337.0 "	758.0 "
10:30 "	839.0 "	652.0 "	397.0 "	771.0 "
12:30 P.M.	850.0 "	660.0 "	409.0 "	773.0 "
5:00 "	865.0 "	668.0 "	424.0 "	773.0 "

3/21/09

3:00 "	955.0 "	713.0 "	480.0 "	773.0 "
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3/22/09

9:00 A.M.	986.0 "	737.0 "	481.0 "	773.0 "
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$$\begin{array}{r}
 24 \\
 4\frac{1}{2} \\
 \hline
 12 \\
 96 \\
 108 \\
 6\frac{1}{4} \\
 \hline
 114\frac{1}{4}
 \end{array}$$

T A B L E N O. X I.

Preservative:-	Blank	Spices	Cin. Ald.	Benz. Acid
Amt. of Solution:-	-----	10.0 cc.	5.4 cc.	12.5 cc.
Percent of preservative:-	-----	0.0260 p.c.	0.0270 p.c.	0.0250 p.c.
Time	No. of cc. of CO ₂ produced.			
<u>3/22/09</u>				
10:00 A.M.	-----	-----	-----	-----
10:15 "	1.2 cc.	-----	-----	-----
10:30 "	2.2 "	0.4 cc.	0.8 cc.	-----
11:00 "	3.0 "	1.0 "	1.4 "	0.1 cc.
11:30 "	4.8 "	2.0 "	2.2 "	1.8 "
12:00 "	6.8 "	4.2 "	2.8 "	5.2 "
1:00 P.M.	13.8 "	10.0 "	6.0 "	14.8 "
2:15 "	26.6 "	23.6 "	11.4 "	36.0 "
3:00 "	40.0 "	38.6 "	15.0 "	55.4 "
4:00 "	60.0 "	63.6 "	20.8 "	88.0 "
5:00 "	83.0 "	93.0 "	28.8 "	104.0 "
6:00 "	99.2 "	118.0 "	38.2 "	122.4 "
7:00 "	129.0 "	155.0 "	55.0 "	152.0 "
10:00 "	194.0 "	225.0 "	88.0 "	195.0 "
10:30 "	209.0 "	240.0 "	99.0 "	204.0 "
<u>3/23/09</u>				
12:30 A.M.	252.0 "	284.0 "	140.0 "	238.0 "

		-52-			
9:45 A.M.	288.0 cc.	314.0 cc.	182.0 cc.	265.0cc	
10:45 "	302.8 "	332.2 "	192.8 "	276.0 "	
11:30 "	316.6 "	352.6 "	205.0 "	287.4 "	
12:00 "	322.0 "	362.0 "	210.0 "	293.0 "	
2:00 P.M.	359.0 "	418.4 "	247.2 "	325.8 "	
3:30 "	389.0 "	457.0 "	277.0 "	354.0 "	
5:00 "	410.4 "	487.0 "	302.0 "	376.0 "	
6:00 "	432.0 "	516.0 "	322.4 "	396.6 "	
7:15 "	445.0 "	550.0 "	349.0 "	421.0 "	
8:45 "	466.0 "	580.0 "	371.0 "	443.0 "	
11:00 "	505.0 "	632.0 "	410.0 "	477.0 "	
11:45 "	521.0 "	653.0 "	425.0 "	492.0 "	

3/24/09

8:00 A.M.	569.0 "	700.0 "	578.0 "	512.0 "	
9:00 "	585.6 "	718.0 "	593.4 "	519.0 "	
10:00 "	604.0 "	738.6 "	610.2 "	524.8 "	
11:00 "	623.0 "	761.0 "	628.0 "	530.0 "	
2:00 P.M.	677.0 "	820.4 "	681.0 "	542.4 "	
4:00 "	708.0 "	855.0 "	712.0 "	548.0 "	
6:00 "	738.0 "	888.0 "	742.0 "	552.0 "	
7:00 "	752.0 "	901.0 "	755.0 "	554.0 "	

3/25/09

1:00 A.M.	843.0 "	997.0 "	845.0 "	559.0 "	
11:00 "	908.0 "	1046.0 "	880.0 "	559.2 "	
12:00 "	916.0 "	1052.8 "	885.6 "	559.2 "	
4:00 P.M.	954.4 "	1082.0 "	910.0 "	559.2 "	

6:00 P.M.	973.0 cc.	-33- 1096.4 cc.	921.6 cc.	559.2 cc
7:30 "	989.0 "	1109.0 "	930.0 "	559.2 "

3/26/09

8:00 A.M.	1063.0 "	1167.6 "	976.0 "	559.2 "
11:00 "	1071.0 "	1176.0 "	984.0 "	559.2 "
5:00 P.M.	1077.8 "	1183.8 "	992.0 "	559.2 "

3/27/09

9:00 A.M.	1081.0 "	1192.0 "	1005.0 "	559.4 "
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24
120
119

TABLE NO. XII.

Preservative:-	Blank	Spices	Cin. Ald.	Benz. Acid.
Ant. of Solution:-	-----	10.0 cc.	5.4 cc.	12.5 cc.
Percent of Preservative:-	-----	0.0260p.c.	0.0270 p.c.	0.0250 p.c
Time	Amount of CO ₂ generated.			

3/29/09

10:00 A.M.	-----	-----	-----	-----
10:15 "	1.0 cc.	0.8 cc.	0.6 cc.	-----
10:45 "	2.0 "	1.8 "	1.4 "	-----
11:00 "	2.4 "	2.0 "	1.8 "	-----
12:00 "	4.6 "	3.6 "	2.4 "	4.6 cc.
12:30 P.M.	6.4 "	6.4 "	2.6 "	12.0 "
2:00 "	37.0 "	34.0 "	3.0 "	64.0 "
2:45 "	56.0 "	51.0 "	3.2 "	97.0 "
3:45 "	94.0 "	91.0 "	3.4 "	129.0 "
5:00 "	133.0 "	134.0 "	3.8 "	178.0 "
6:00 "	156.0 "	160.0 "	4.4 "	191.0 "
7:00 "	191.0 "	199.0 "	5.0 "	215.0 "
9:45 "	268.0 "	275.0 "	9.0 "	255.0 "

3/30/09

1:30 A.M.	369.0 "	377.0 "	22.0 "	307.0 "
4:00 "	414.0 "	431.0 "	31.0 "	336.0 "
7:00 "	472.0 "	498.0 "	43.0 "	376.0 "

9:15 A.M.	509.0 cc.	539.0 cc.	52.0 cc.	403.0 cc.
9:45 "	518.0 "	548.0 "	54.0 "	410.0 "
11:30 A.M.	547.0 "	581.0 "	63.0 "	431.0 "
2:30 P.M.	586.0 "	627.0 "	77.0 "	458.0 "
5:15 "	628.0 "	675.0 "	95.0 "	488.0 "
5:45 "	634.0 "	682.0 "	98.0 "	492.0 "
7:15 "	652.0	702.0 "	107.0 "	501.0 "
9:30 "	675.0 "	732.0 "	119.0 "	515.0 "

3/31/09

1:15 A.M.	715.0 "	781.0 "	143.0 "	535.0 "
7:30 "	774.0 "	857.0 "	183.0 "	555.0 "
11:00 "	800.0 "	888.0 "	201.0 "	561.0 "
4:00 <i>AM</i>	836.0 "	923.0 "	227.0 "	564.0 "
9:45 "	871.0 "	950.0 "	251.0 "	565.0 "

4/1/09

1:30 <i>AM</i>	898.0 "	965.0 "	266.0 "	565.0 "
11:30 "	984.0 "	994.0 "	303.0 "	565.0 "
6:00 P.M.	1023.0 "	1003.0 "	313.0 "	565.0 "

4/2/09

9:00 A.M.	1114.0 "	1016.0 "	330.0 "	565.0 "
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4/4/09

3:00 P.M.	1184.0 "	1022.0 "	338.0 "	565.0 "
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24
6
174
5

The amount of mixed spices taken for the three series of experiments is based on a catsup formula. The sugar-yeast mixture was spiced to the extent that catsup would have been spiced according to the Detroit formula.

In order to have comparable amounts of benzoic acid, the fortieth part of the gram molecule was taken, i.e. the same as in the experiments recorded in tables III to IX. Of cinnamic aldehyde the chemical equivalent was taken.

In both experiments XI and XII the tubes with mixed spices and cinnamic aldehyde gave off gas sooner than did the benzoic acid tube. The latter led from the beginning in Experiment X.

The most remarkable feature of all three series is this that after several hours the benzoic acid led not only the cinnamic aldehyde and mixed spices but even the blank. This would seem to imply that whereas benzoic acid inhibits in the very beginning more than the other antiseptics, after the organisms get acclimated to it, as it were, it stimulates their growth, i.e. when used in such dilutions as 0.025 percent.

This stimulation, however, does not necessarily keep up. In all three series it falls behind the blank at the end. In X and XII, i.e. in two out of the three

experiments, the cinnamic aldehyde has affected the greatest retardation in the end.

In a general way, it may be concluded, with reference to yeast, that the mixed spices are not as effective in the inhibition of fermentation as are corresponding amounts of cinnamic aldehyde or benzoic acid.

INHIBITIVE ACTION OF ACETIC ACID.

In the foregoing experiments the attempt was made to ascertain something about the inhibitive action of two of the principal spice constituents, viz. cinnamic aldehyde and eugenol as compared with benzoic acid. While the use of these spice constituents as antiferments is largely restricted by their strong aroma, that of acetic acid is limited only by its acid taste which in large part can be neutralized by sugar as is actually done in the manufacture of catsup. It became a matter of importance to compare the inhibitive action of acetic acid as compared with that of benzoic acid.

The experiments were made in the usual manner. In tables XIII and XIV will be found the results obtained by using the chemical equivalent of the amount of benzoic acid employed, also ten times this amount. The 0.01 p.c. acetic acid inhibited but very little. The 0.1 p.c. acetic acid inhibited during the first few hours more

than did the benzoic acid. In the end, however, about three times as much gas had been given off by the stronger acetic acid mixture as had been given off by the benzoic acid mixture.

T A B L E N O. X I I I.

Preservative:-	Blank	Act. Acid	Act. Acid	Benz. Acid
Amt. of Solution:-	-----	1.0 cc.	10.0 cc.	12.5 cc.
Percent Strength:-	-----	0.0123p.c.	0.123 p.c.	0.025 p.c.
Time	No. of cc. CO ₂ generated.			
<u>4/5/09</u>				
10:00 A.M.	-----	-----	-----	-----
10:15 "	1.2 cc.	0.6 cc.	-----	0.8 p.c.
10:30 "	2.4 "	1.4 "	0.2 p.c.	1.8 "
10:45 "	3.0 "	2.0 "	0.4 "	2.4 "
11:00 "	3.4 "	2.4 "	0.6 "	2.6 "
12:00 "	6.0 "	5.6 "	2.6 "	5.2 "
2:30 P.M.	50.0 "	79.0 "	22.0 "	29.0 "
2:50 "	64.0 "	96.0 "	26.0 "	36.0 "
3:30 "	82.0 "	123.0 "	34.0 "	43.0 "
4:00 "	96.0 "	144.0 "	41.0 "	48.0 "
5:00 "	132.0 "	186.0 "	58.0 "	63.0 "
5:30 "	142.0 "	196.0 "	62.0 "	66.0 "
7:15 "	197.0 "	262.0 "	86.0 "	82.0 "
10:00 "	277.0 "	358.0 "	126.0 "	107.0 "
<u>4/6/09</u>				
2:00 A.M.	367.0 "	448.0 "	176.0 "	131.0 "

7:00 A.M.	460.0 cc.	546.0 cc.	243.0 p.c.	167.0 p.c.
9:30 "	491.0 "	582.0 "	266.0 "	178.0 "
12:00 "	524.0 "	619.0 "	289.0 "	187.0 "
5:00 P.M.	591.0 "	696.0 "	344.0 "	196.0 "
9:45 "	647.0 "	755.0 "	388.0 "	205.0 "

4/7/09

2:45 A.M.	700.0 "	813.0 "	429.0 "	210.0 "
5:00 "	720.0 "	830.0 "	443.0 "	211.0 "
10:00 "	767.0 "	874.0 "	478.0 "	211.2 "
4:30 P.M.	816.0 "	921.0 "	519.0 "	211.4 "

4/8/09

12:30 A.M.	877.0 "	973.0 "	566.0 "	211.4 "
1:30 <i>PM</i>	979.0 "	1038.0 "	646.0 "	211.4 "
3:00 <i>PM</i>	990.0 "	1041.0 "	650.0 "	211.4 "

4/9/09

12:15 <i>AM</i>	1036.0 "	1064.0 "	683.0 "	211.4 "
12:30 P.M.	1102.0 "	1097.0 "	716.0 "	211.4 "
5:00 "	1124.0 "	1106.0 "	724.0 "	211.4 "

4/10/09

9:00 A.M.	1226.0 "	1145.0 "	740.0 "	211.4 "
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4/11/09

3:00 P.M.	1265.0 "	1154.0 "	740.0 "	211.4 "
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4/12/09

12:00 A.M.	1296.0 "	1160.0 "	740.0 "	211.4 "
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T A B L E N O. X I V.

Preservative:-	Blank	Act. Acid	Act. Acid Benz.	Acid.
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Ant. of Solution:-	-----	1.0 cc.	10.0cc.	12.5 cc.
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Percent Strength	-----	0.0123 p.c.	0.123p.c.	0.025p.c.
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Time	No. of cc. of gas collected.			
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4/16/09

10:00 A.M.	-----	-----	-----	-----
10:30 "	-----	-----	-----	-----
11:00 "	0.6 cc.	-----	-----	-----
12:00 "	7.0 "	3.0 cc.	-----	1.8 c.c.
1:00 P.M.	26.0 "	22.0 "	1.2 cc.	9.0 "
2:00 "	63.0 "	59.0 "	8.0 "	23.0 "
3:00 "	95.0 "	96.0 "	20.0 "	37.0 "
4:00 "	120.0 "	126.0 "	38.0 "	53.0 "
4:45 "	146.0 "	153.0 "	54.0 "	65.0 "
6:00 "	191.0 "	195.0 "	79.0 "	75.0 "
8:40 "	286.0 "	278.0 "	133.0 "	107.0 "
9:45 "	309.0 "	302.0 "	145.0 "	115.0 "

4/17/09

1:30 A.M.	389.0 "	382.0 "	199.0 "	143.0 "
4:30 "	435.0 "	430.0 "	238.0 "	161.0 "
8:00 "	483.0 "	477.0 "	275.0 "	179.0 "
9:30 "	502.0 "	495.0 "	291.0 "	186.0 "

10:00 A.M.	508.0 cc.	502.0 cc.	298.0 cc.	190.0 p.c.
12:30 P.M.	538.0 "	529.0 "	325.0 "	203.0 "
2:30 "	558.0 "	548.0 "	345.0 "	211.0 "
5:00 "	587.0 "	575.0 "	374.0 "	221.0 "
7:15 "	609.0 "	596.0 "	395.0 "	228.0 "

4/18/09

3:00 A.M.	686.0 "	672.0 "	469.0 "	243.0 "
11:15 "	740.0 "	733.0 "	522.0 "	247.0 "
8:00 P.M.	790.0 "	792.0 "	563.0 "	248.0 "

4/19/09

9:00 A.M.	872.0 "	883.0 "	596.0 "	248.0 "
2:00 P.M.	892.0 "	910.0 "	599.0 "	248.0 "
4:00 "	902.0 "	923.0 "	599.6 "	248.0 "
6:00 "	914.0 "	939.0 "	600.0 "	248.0 "
10:30 "	933.0 "	965.0 "	601.0 "	248.0 "

4/20/09

9:00 A.M.	983.0 "	1033.0 "	602.0 "	248.0 "
3:00 P.M.	1002.0 "	1062.0 "	602.0 "	248.0 "
6:00 "	1010.0 "	1076.0 "	602.0 "	248.0 "

4/21/09

9:00 A.M.	1052.0 "	1169.0 "	602.0 "	248.0 "
6:00 P.M.	1062.0 "	1201.0 "	602.0 "	248.0 "

4/22/09

10:30 A.M.	1068.0 "	1249.0 "	602.0 "	248.0 "
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4/23/09

10:00 "	1068.0 "	1275.0 "	602.0 "	248.0 "
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In the experiments, the results of which are recorded in tables XV and XVI, 0.5 percent and one percent of acetic acid respectively were used and compared with 0.1 percent of benzoic acid, the amount of the latter commonly allowed as preservative. It becomes apparent from the tables that whereas in one instance benzoic acid inhibited fermentation in the beginning somewhat more than did the acetic acid (table XV), more gas was generated in the end than in either the 0.5 p.c. or 1.0 p.c. acetic acid mixtures. In all instances but the blanks, the amounts of gas given off within several days was but very small indeed.

Finally, tests were made with 1.5 p.c. and 2 p.c. of acetic acid in ordinary fermentation tubes. In neither instances was any carbonic acid given off, even after standing for about two weeks.

T A B L E N O. X V.

Preservative:-	Blank	Act. Acid 0.5 p.c.	Act. Acid 1 p.c.	Benz. Acid.
Amt. of Solution:-	-----	10.0 cc.	20.0 cc.	0.1 g.
Percent Amount of Acid:-	-----	0.5 p.c.	1.0 p.c.	0.1 p.c.
Time	NO. of cc. of gas generated.			
4/26/09				
9:30 A.M.	-----	-----	-----	-----
10:00 "	1.0 cc.	0.4 cc.	-----	-----
10:30 "	2.0 "	0.8 "	-----	-----
11:00 "	3.4 "	1.0 "	0.2 cc.	-----
12:00 "	14.0 "	1.4 "	0.4 "	0.2 cc.
2:00 P.M.	96.0 "	2.0 "	1.0 "	1.2 "
3:00 "	132.0 "	2.2 "	1.8 "	1.8 "
4:00 "	166.0 "	2.4 "	1.8 "	2.0 "
5:45 "	224.0 "	2.4 "	2.4 "	2.6 "
8:15 "	316.0 "	2.8 "	2.8 "	3.8 "
10:00 "	375.0 "	3.0 "	3.4 "	4.8 "
12:00 "	412.0 "	3.2 "	3.8 "	5.2 "
4/27/09				
9:30 A.M.	516.0 "	3.4 "	4.0 "	6.2 "
12:00 "	540.0 "	3.4 "	4.4 "	6.4 "
2:30 P.M.	568.0 "	3.4 "	4.6 "	6.6 "
5:45 "	599.0 "	3.4 "	4.8 "	6.6 "
4/28/09				

12:30 A.M.	651.0 cc.	3.4 cc.	4.8 cc.	6.6 cc.
9:00 "	703.0 "	3.4 "	4.8 "	6.6 "
11:00 "	714.0 "	3.4 "	4.8 "	6.6 "
7:15 P.M.	754.0 "	3.4 "	4.8 "	6.6 "
4/29/09				
10:00 A.M.	*816.0 "	3.4 "	4.8 "	6.6 "

*Blank was still generating CO₂ when experiment was stopped.

24
3
22

TABLE NO. XVI.

Preser- vatives:-	Blank	Act. Acid	Act. Acid	Benz. Acid
Amt. of Preserv.:-	-----	10.0 cc.	20.0 cc.	0.1 g.
Percent Amount	-----	0.5 p.c.	1.0 p.c.	0.1 p.c.
Time	No. of cc. of gas generated.			
4/29/09				
10:30 A.M.	-----	-----	-----	-----
10:45 "	1.4 cc.	-----	-----	-----
11:00 "	2.2 "	-----	-----	-----
11:30 "	3.4 "	0.2 cc.	-----	0.2 cc.
12:00 "	5.0 "	0.6 "	0.2 cc.	0.8 "
1:00 P.M.	24.0 "	1.0 "	0.6 "	1.8 "
2:00 "	55.0 "	1.2 "	1.0 "	2.6 "
3:00 "	112.0 "	1.4 "	1.4 "	3.8 "
3:30 "	151.0 "	1.6 "	1.6 "	4.2 "
4:00 "	171.0 "	1.6 "	1.6 "	4.6 "
5:00 "	238.0 "	1.8 "	1.8 "	5.0 "
5:30 "	267.0 "	1.8 "	2.0 "	5.2 "
6:00 "	289.0 "	2.0 "	2.2 "	5.4 "
11:00 "	474.0 "	2.0 "	2.2 "	5.8 "
4/30/09				
8:00 A.M.	649.0 "	2.0 "	2.2 "	6.0 "
11:00 "	711.0 "	2.0 "	2.2 "	6.6 "
2:00 P.M.	787.0 "	2.0 "	2.2 "	7.2 "

6:00 P.M. 885.0 cc. $\frac{-47-}{2.2}$ cc. 2.4 cc. 7.4 cc.
5/1/09

9:00 A.M. 1089.0 " 2.4 " 4.0 " 9.2 "

5:00 P.M. 1122.0 " 5.6 " 4.0 " 9.8 "

5/3/09

9:00 A.M. 1159.0 " 6.0 " 4.8 " 10.8 "

3:00 P.M. 1159.0 " 6.0 " 4.8 " 10.8 "

$\frac{24}{3}$
 $\frac{72}{4\frac{1}{2}}$
 $\frac{70}{2}$

Before concluding the work on the antiferment action of spices on the one hand and of acetic acid on the other, it seemed desirable to learn something at least about the combined action of acetic acid and cinnamic aldehyde in moderate quantities. For this purpose three series of experiments were made (See Tables 17, 18 and 19).

From table 17 it will be learned that both 0.1 p.c. of benzoic acid and 0.5 p.c. of acetic acid completely inhibited fermentation in this case. It will also be noticed that in the blank test fermentation was slow to start although the usual amount of gas was liberated in the end. What is most remarkable, however, is that the addition of 0.027 p.c. of cinnamic aldehyde to 0.5 p.c. of acetic acid did not completely check the fermentation as did the acid alone. The amount of gas given off, however, is very small. Like in other series, this one shows once more that the unexpected may happen at any time and that it is not safe to draw conclusions from a single observation.

In Experiment 18, in which the yeast appears to have been in a more normal condition (120 cc. of gas being given off within the first 3-1/2 hours), gas was given off in all four tubes. Benzoic acid lead, followed by the acetic acid-cinnamic aldehyde mixture, finally by the acetic acid alone. Remarkable in this instance is

the fact that, at the end, acetic acid alone showed the smallest amount of gas, the mixture showed but a trifle more, the benzoic acid most. In no instance, however, is the amount of gas given off large.

In Experiment 19, benzoic acid leads in the beginning followed by acetic acid and then by the acetic acid - cinnamic aldehyde mixture, as one might expect. The remarkable feature of this series is the relatively large amount of gas given off in all the tubes as compared with experiments 18 and 17. The yeast again appears to have been good and may thus account for this phenomenon.

It becomes apparent from these experiments that 0.1 p.c. benzoic acid, 0.5 p.c. of acetic acid and a mixture of 0.5 p.c. acetic acid and 0.025 p.c. cinnamic aldehyde have about the same antiferment properties. Whether the antiferment properties of double the amount of cinnamic aldehyde with 0.5 p.c. of acetic acid would show up better, experiment alone can determine.

T A B L E N O. X V I I.

Preservative:-	Blank	Act. Acid +Cin.Ald.	Act. Acid	Benzoic Acid
Amt. of Solution:-	-----	Act. Acid 10.0 cc.Cin. Ald. 5.4 cc.	10.0 cc.	0.1 g.
Percent of Pre- servative:-	-----	Acetic Acid 0.5p.c. Cin. Ald. 0.027 p.c.	0.5 p.c.	0.1 p.c.
Time	No. of cc. of CO ₂ generated.			
5/18/09				
3:30 P.M.	-----	-----	-----	-----
4:00 "	2.0cc.	-----	-----	-----
5:00 "	8.0 "	-----	-----	-----
5:45 "	17.0 "	0.2 cc.	-----	-----
7:45 "	42.0 "	0.6 "	-----	-----
11:30 "	94.0 "	0.8 "	-----	-----
5/19/09				
1:00 A.M.	116.0 "	0.8 "	-----	-----
10:00 "	199.0 "	0.8 "	-----	-----
3:00 P.M.	264.0 "	0.8 "	-----	-----
4:00 "	285.0 "	0.8 "	-----	-----
5:30 "	304.0 "	0.8 "	-----	-----
11:00 "	388.0 "	0.8 "	-----	-----
5/20/09				
1:30 A.M.	424.0 "	0.8 "	-----	-----
12:00 "	558.0 "	0.8 "	-----	-----

3:00 P.M.	601.0 cc.	0.8 cc.	-----	-----
6:00 "	643.0 "	0.8 "	-----	-----
12:00 "	738.0 "	0.8 "	-----	-----
5/21/09				
9:00 A.M.	830.0 "	0.8 "	-----	-----
6:00 P.M.	917.0 "	0.8 "	-----	-----
11:00 "	962.0 "	0.8 "	-----	-----
5/22/09				
8:00 A.M.	1027.0 "	0.8 "	-----	-----
5:30 P.M.	1079.0 "	0.8 "	-----	-----
*12:00 "	1112.0 "	0.8 "	-----	-----

*Still running.

24
4
96
8 1/2
104 1/2

T A B L E N O. X V I I I.

Preservative:-	Blank	Act. Acid +Cin.Ald.	Act. Acid	Benzoic Acid
Ant. of Solution:-	-----	Acetic Acid 10.0 cc. Cin. Ald.5.4cc.	10.0 cc.	0.1 g.
Percent of Preserva- tive:-	-----	Act. Acid 0.5 p.c.Cin. Ald.0.027 p.c.	0.5 p.c.	0.1 p.c.
Time	No. of cc. of CO ₂ generated.			
5/24/09				
10:00 A.M.	-----	-----	-----	-----
10:45 "	4.0 cc.	0.1 cc.	-----	0.6 cc.
11:00 "	8.0 "	0.2 "	-----	0.8 "
12:00 "	27.0 "	0.6 "	0.1 cc.	1.2 "
1:30 P.M.	120.0 "	0.8 "	0.3 "	1.4 "
3:00 "	198.0 "	0.8 "	0.5 "	1.6 "
4:00 "	240.0 "	0.8 "	0.5 "	1.6 "
5:30 "	296.0 "	0.8 "	0.5 "	1.6 "
7:00 "	337.0 "	0.8 "	0.5 "	1.8 "
10:00 "	436.0 "	0.8 "	0.6 "	2.0 "
5/25/09				
1:00 A.M.	508.0 "	0.8 "	0.6 "	2.0 "
8:30 "	615.0 "	0.8 "	0.6 "	2.2 "
12:00 "	665.0 "	0.8 "	0.6 "	2.2 "
6:00 P.M.	758.0 "	0.8 "	0.6 "	2.2 "

5/26/09

9:30 A.M. 890.0 cc. 0.8 cc. 0.6 cc. 2.2 cc.

5/27/09

*9:00 " 981.0 " 0.8 " 0.6 " 2.2 "

*Still running.

$$\begin{array}{r} 24 \\ 3 \\ \hline 72 \\ 1 \\ \hline 73 \end{array}$$

T A B L E N O. X I X.

Preservative:-	Blank	Act. Acid. ^Σ +Cin. Ald.	Act. Acid	Benzoic Acid
Amt. of Solution:-	-----	Act. Acid 10.0 cc. Cin. Ald. 5.4 cc.	10.0 cc.	0.1 g.
Percent of Preservative:-	-----	Act. Acid 0.5 p.c. Cin. Ald. 0.027 p.c.	0.5 p.c.	0.1 p.c.

Time No. of cc. of CO₂ generated.

5/31/09

2:00 P.M.	-----	-----	-----	-----
2:15 "	1.2 cc.	-----	-----	-----
3:00 "	4.0 "	-----	0.1 cc.	0.2 cc.
4:30 "	24.0 "	0.4 cc.	0.8 "	0.6 "
5:00 "	43.0 "	0.6 "	1.0 "	0.8 "
5:30 "	72.0 "	0.8 "	1.3 "	0.8 "
6:30 "	135.0 "	1.4 "	2.0 "	1.1 "
8:30 "	253.0 "	2.6 "	4.0 "	1.6 "
10:00 "	349.0 "	3.8 "	6.2 "	2.0 "
11:00 "	384.0 "	4.2 "	7.0 "	2.2 "

6/1/09

1:30 A.M.	516.0 "	5.6 "	10.0 "	3.0 "
9:30 "	812.0 "	7.0 "	16.2 "	3.8 "
11:00 "	847.0 "	7.2 "	17.4 "	4.0 "
12:30 P.M.	878.0 "	7.4 "	18.0 "	4.0 "

2:30 P.M.	934.0 cc.	7.8 cc.	19.2 cc.	4.1 cc.
4:00 "	978.0 "	8.0 "	20.0 "	4.1 "
5:00 "	997.0 "	8.0 "	20.2 "	4.2 "
9:00 "	1085.0 "	8.4 "	21.6 "	4.2 "
11:00 "	1118.0 "	8.6 "	22.2 "	4.2 "

6/2/09

8:00 A.M.	1187.0 "	9.4 "	24.4 "	4.4 "
5:30 P.M.	1270.0 "	9.4 "	24.4 "	4.4 "

6/3/09

10:00 A.M.	1348.0 "	9.4 "	24.4 "	4.4 "
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24
2 1/2

12
68

8
68

APPROVED: Edmund Kemmer

DATED, June 1909.