THE STEAM PRESSURE COOKER

By W. V. HALVERSEN*

The steam pressure method of canning has been adopted in homes and factories for the preservation of non-acid foods. The reasons for adopting this method are apparent: (1) it is less expensive because the period of processing is much shorter, and (2) certain heat-resistant bacteria, including the much-dreaded **Clos. botulinum,** can be killed with certainty at the high temperatures obtainable in the steam pressure cooker. The remarkable efficiency of this process for commercial canning is generally recognized. It must be admitted, however, that because of inferior equipment and less efficient operation, home canning by the steam pressure method is not as successful as could be expected. There is no question but that the principle is fundamentally sound, but there appears to be a definite need for research directed toward eliminating those factors which make home canning less efficient than commercial canning.

The pressure gauge is used on almost all makes of household steam pressure canning equipment as the sole means for regulating the processing. Since temperature and not pressure is the sterilizing agent, it appears obvious that a thermometer which gives a direct temperature reading would be more reliable as a guide for the processing of foods. The principal objections to a pressure gauge are: (1) It does not differentiate between steam pressure and air pressure (air may be present because of incomplete exhaust), 2) it may become inaccurate after a period of use, and (3) it is influenced also by altitude. Failure of the operator to recognize the importance of any of these three facts may result in the loss of the advantages of the steam pressure method.

Several writers on the subject of canning have pointed to the desirability of having household steam pressure cookers equipped with thermometers. For example, Stanley and Steinbarger (3) state, "It is desirable, also, to have a thermometer set in the top, so that the pressure can be checked against the temperature." They further state, "Pressure gauges may become inaccurate after a period of use." Tanner (4) writes, "However, good canning practice should provide for a reliable thermometer with which the actual temperature may be determined. This is necessary not only because the atmosphere in the cooker may contain considerable air but because gauges may become faulty by use year after year without inspection and adjustment." Baragar (1) concludes, "The test on fifty-two new and old gauges showed that many gauges being used on pres-

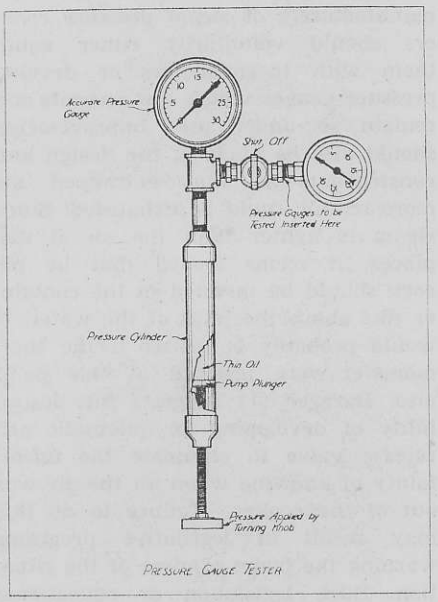

Figure 1.

The author acknowledges the fine work of Mr. Roy Kaylor, machinist at the University of Idaho shops, who made the pressure gauge tester pictured above.

*Bacteriologist Idaho Agri. Expt. Station, Moscow, Idaho. Published with the approval of the Director of the Idaho Agr. Expt. Station as Research Paper No. 181.

sure cookers are seriously off-calibration . . ."

It has been the author's observation that the manufacturers of household steam pressure cookers do not generally equip them with thermometers, and the foregoing references substantiate his claim that the pressure gauges supplied commonly become inaccurate after a period of use, which results in spoilage of canned food and exposes the home canner to the perils of botulism and the economic loss of food. It, therefore, appears logical that the manufacturers of steam pressure cookers should voluntarily either equip them with thermometers or develop pressure gauges which are accurate and remain so under use. Improvements should also be made in the design and construction so that entrapped air more readily could be exhausted. Since steam is lighter than the air it displaces, it seems logical that he pecock should be inserted in the container just above the level of the water. It would probably be better if the thermometer were inserted at this point also. Barager (1) suggests the desirability of developing an automatic air-release valve to eliminate the uncertainty of knowing when all the air was out of the cooker. Failure to do this may result in legislative programs warning the home canners of the situation. Such legislation or educational program would be undesirable be cause it would lessen confidence of the public in the steam pressure canner and retard the universal adoption of this type of equipment.

The degree of inaccuracy of pressure guages is portrayed by the data in Table 1.

For apparent reasons these steam pressure cookers are referred to by number. The names and addresses of the owners, the manufacturers of the pressure cookers and the manufacturers of the pressure gauges have been purposely omitted from the table. However, the group is representa'ive in that the common makes are represented. It is not uncommon to find the pointer on the pressure gauge to be fitted so loosely that it will move freely back and forth so as to vary from one to two pounds without any change in pressure. It is evident from these data that a large proportion of the steam pressure gauges used on household steam pressure cookers are inaccurate. Of thirty-eight representative gauges tested, 14 had an error of two or more pounds, five had an error of four or more pounds and one had an error of five pounds. It is unfortunate that a faulty gauge always indicates a steam pressure greater than that which actually exists within the cooker. This is serious because it follows that the temperature inside the cooker is not as high, and therefore not as effective for processing the food, as the gauge indicates.

Table 2 shows that the relationship of steam pressure gauge reading to temperature is influenced by altitude. The pressure gauge actually measures the difference between pressures inside the chamber and atmospheric pressure outside the chamber, which accounts for the fact that approximately one additional pound of steam pressure must be maintained inside the pressure cooker for each 200 feet of elevation above sea level, in order to maintain a temperature equal to that of steam pressure at sea level. Since all manufacturers of pressure gauges adjust them to read accurately at sea level, it is apparent that increases in altitude would require that the operator must either maintain a higher steam pressure or process the food longer in order to use for canning time tables which are based on sea level. Since the error due to altitude is in the same direction as the inaccuracy of the pressure gauge caused by use, it becomes apparent that the combined errors may become so great in mountain states, where steam pressure cookers are considered most urgent, as to defeat the purpose of the steam pressure method.

Table 2, page 16 shows the gauge pressure corresponding to specified process temperatures at various altitudes.

TABLE 1

Tests on Household Pressure Cooker Gauges

Number	Years cooker has been in use.	Elevation at which cooker is used.	Reading of pressure gauge compared to master gauge at:		
			5 lbs.	10 lbs.	15 lbs.
1	1	2650	5	10	15
2		2650	7	12	17
3	1	2650	6	12	17½
4	15-20	2650	5½-6	10½-12	16½-17
5	2	2650	5	10	15
6		2000	4-5	9-10	14-15
7		4450	5½	11	16
8	2	4450	8	13	18
9	20	4450	3½-5	9-10	14-15
10	18	4450	0-5	5-10	6-10
11	1	4450	5	10	15½
12	20	4450	6	11½	16½
13		4450	5	10	15
14		4450	0	6½	11
			At 20 lbs. pressure registers 16.		
15		4450	5-7½	10-12½	15-17½
16		5950	10	15	20
17		4450	5½-4½	10-11	15-16
18	5	4800	5-6	10-11	15-16
19	3	4800	6-7	11-12	16-17
20	5	5800	8	14	16-19
21	10	5200	6¼	12	17.5
22	1	4900	6	11	16
23	5	4900	6-8	12-14	17-19
24	2	5950	5	10	15
25	1	6000	5½	10½	15½
26	2	6000	6-7	11-12	16-17
27	2	6000	5	10	15
28	2	6000	5-	9	15
29	5	5950	5-6	10-11	15-16
30	1	6000	5-5½	9-10	14-15
31	4	5950	3-4½	8-9	13-14
32	2	5950	5	10-11	16-18
33	5	6000	6	11	16
34	25-30	6000	—	—	—
35	2	6000	6	12	17
36	2	6000	5	10	15
37	1	6000	5	10	15
38	17	1000	6	11	16

Considering that the elevations at which these cookers are used vary between 1000 and 6000 feet, it becomes apparent that one to three pounds' additional pressuure should be allowed, respectively. In the case of pressure cooker No. 20 it would be necessary to have a pressure gauge reading of 11 pounds of steam pressure in order to have a processing temperature equal to five pouunds of steam pressure at sea level and a gauge reading of 17 pounds to secure the equivalent of 10 pounds steam pressure at sea level. The same figures remain virtually true for No. 23.

Baragar (1) states: "Further since the temperatures indicated on pressure gauges are true only when the gauge calibration is correct and readings are being taken at sea level, the use of these temperatuures as a processing guide is misleading and the markings of temperature on pressure gauge dials should be taken with a reliable thermometer.

Testing the pressure gauge to determine its accuracy is a problem which

might naturally be assigned to a mechanical engineer rather than a housewife. The manufacturers of pressure gauges adjust them to read correctly at sea level. No satisfactory method for adjusting each gauge so as to compensate for the effect of altitude has been found. The simplest method for determining whether a certain steam pressure gauge is accurate is to take it off and send it back to the manufacturers. One of the principal manufacturers of pressure cookers makes the following offer: "Send your gauge to ....., regardless of the make of cooker you are using, with only 50 cents. If your gauge is found accurate, we will return it to you, postpaid, with a refund of 25 cents, charging you only 25 cents for handling, packing and postage." It would seem logical to educate users of pressure cookers to have their steam pressure gauges tested each year, and a statement of this type should be included with the directions supplied by the manufacturers of pressure cookers.

The most logical solution would be to equip the cooker with a thermometer so that the pressure gauge could be checked against the actual temperature. Under these conditions there would be little need for the pressure gauge. Time tables for processing would then be tabulated for given temperatures rather than steam pressure readings.

If a mechanical engineer were to test the gauge in the absence of a thermometer, he would probably mount the gauge along with a U-tube filled with mercury (manometer) and determine how high a given pressure reading would force the column of mercury. Such a test could best be made in a laboratory. This would necessitate that the pressure gauge be removed from the cooker and be sent to the testing laboratory. The service would be similar to that offered by the commercial company outlined above. In an elaborate experimental testing set Baragar (1) used a cooker equipped with (1) a mercury thermometer, (2) a copper-constantan thermocouple for measuring temperatures within the cooker (3) a safety valve, (4) an automatic air release valve, (5) a petcock for releasing steam, (6) an opening for the gauge to be tested and (7) a mercury manometer to be used as the standard for comparisons.

Another method which has been used extensively in the home is placing a

TABLE 2
Gauge Pressure Corresponding to Specified Process Temperatures at Various Altitudes

Temp.	Sea	Feet above sea level							Temp.
Deg. F	level	500	1000	2000	3000	4000	5000	6000	Deg. C.
200	——	——	——	——	——	——	——	——	93.3
205	——	——	——	——	——	——	0.5	0.9	96.1
210	——	——	——	0.4	0.9	1 4	1.8	2.3	98.9
212	0.0	0.2	0.5	1.0	1.5	2.0	2.4	2.9	100.0
215	0.9	1.1	1.4	1.9	2.4	2.9	3.3	3.8	101.7
220	2.5	2.7	3.0	3.4	3.9	4.4	4.9	5.3	104.4
225	4.2	4.5	4.7	5.2	5.7	6.2	6.6	7.1	107.2
230	6.1	6.3	6.6	7.1	7.6	8.0	8.5	9.0	110.0
235	8.1	8.3	8.6	9.1	9.6	10.0	10.5	11.0	112.8
240	10.3	10.5	10.8	11.3	11.7	12.2	12.7	13.1	115.6
242	11.2	11.4	11.7	12.2	12.7	13.1	13.6	14.1	116.7
245	12.6	12.9	13.1	13.6	14.1	14.6	15.0	15.5	118.3
248	14.1	14.3	14 6	15.1	15.6	16.0	16 5	17.0	120.0
250	15.1	15.4	15.6	16.1	16.6	17.1	17.5	18.0	121.1
252	16.2	16.4	16.7	17.2	17.7	18.1	18 6	19.1	122.2
255	17.8	18.1	18.3	18.8	19.3	19.8	20.2	20.7	123.7
260	20.7	21.0	21.2	21.7	22.2	22.7	23.1	23.6	126.7

Published by National Canners' Assoc. in Bulletin 26L, page 14, April 1939. Used by permission. (2)

maximum temperature thermometer inside the pressure cooker in a can of water and proceeding to heat the cooker just as one would begin to process canned food. Let the pressure rise to 10 pounds. If the pressure goes above 10 pounds, note the highest pressure reached. Remove the cooker from the heat and let it stand until the pressure registers zero, when it can be opened and the thermometer reading recorded. The mercury should be shaken down and the process repeated at 15 pounds' pressure. The following table shows the temperature in degrees Fahrenheit which correspond with the correct steam pressure at sea level.

TABLE 3

Temperature Corresponding to Gauge Reading in Pounds of Steam Pressure (at Sea Level)

Lbs. pressure per sq. inch	Temp. Degrees Fahrenheit
0	212.0
1	215.4
2	218.5
3	221.5
4	224.4
5	227.1
6	229.6
7	232.3
8	234.7
9	237.0
10	239.4
11	241.5
12	243.7
13	245.8
14	247.8
15	249.8
16	251.6
17	253.4
18	255.4
19	257.0
20	258.8

Observe the steam pressure shown in Table 3 corresponding to the temperature obtained on the maximum temperature thermometer. (Interpolate to obtain fractional pounds pressure), subtract this from the maximum steam pressure gauge reading maintained during the testing process. The difference represents the loss of sterilizing power due to inaccuracy of the gauge plus the altitude factor. For example, if this method showed an error of three pounds at 2000 feet elevation, it would be because of one pound for elevation and two pounds for inaccuracy of the gauge. If, however, a similar error of three pounds was encountered at 6000 feet elevation, it would indicate three pounds error due to elevation and the pressure gauge should be accurate at sea level. A thermometer especially suited to this purpose has been developped by one of the leading manufacturers of such equipment. The principal difficulty encountered in this method is that it requires a suitable source of heat and takes an hour or more to do the testing.

Figure 1 illustrates a simple portable device developed by the author for testing steam pressure gauges. The disadvantages encountered in using this device are (1) it is necessary to remove the pressure gauge from the cooker in order to perform the test, and (2) the master gauge, like the gauge on the cooker, is influenced by altitude. The advantages are that it works very fast and serves well for use in an educational campaign. Since all pressure gauges used on household pressure cookers have the same size threaded base it is

not necessary to have any complicated coupling connections.

The details of construction are so simple that they hardly need explanation. The tester is operated by turning the knurled knob which exerts a pressure on a pump plunger. This plunger is made air tight by a layer of lubricating oil, air pressure is transmitted equally to the master gauge and the gauge to be tested.

SUMMARY

The steam pressure gauge is used on almost all makes of household steam pressure cookers as the only means of indicating the temperature within the cooker. Tests have shown that most steam pressure gauges become inaccurate after they have been in use for several seasons. The inaccuracy is such that the gauge generally indicates a steam pressure greater than that which actually exists within the cooker.

Altitude also influences the relationship of pressure and gauge reading to temperature of the steam inside the pressure cooker. The pressure gauge actually measures the difference between pressures inside the chamber and atmospheric pressure outside the chamber, which accounts for the fact that approximately one additional pound of steam pressure must be maintained inside the pressure cooker for each 2000 feet elevation above sea level in order to maintain a temperature equal to a given steam pressure at sea level.

The error due to inaccuracy of the steam pressure gauge plus the added pressure to be allowed for elevation often combine to create such a large factor that it may entirely offset the advantages claimed for the steam pressure method of home canning.

Several methods for testing the accuracy of steam pressure gauges are outlined. The simplest is to remove the gauge and send it to the manufacturer. However, a simple testing device developed by the author is described.

Several modifications in design of steam pressure cookers are suggested to facilitate the removal of air and to give a true indication of the effective temperature inside.

This study indicates that the temperature control in the steam pressure method of home canning is a problem of such magnitude that manufacturers of this type of equipment should improve their utensils along the lines suggested here in order to guard against botulinus poisoning and to prevent unnecessary waste due to spoilage. Failure to do this must surely result in the adoption of educational or governmental control measures.

The seriousness of the condition of steam pressure cookers tested now in use can be judged by the following data: Of 146 pressure cookers tested 30 pressure gauges were accurate; on 63 gauges the dials were so loose that they would shake back and forth over a range of one pound or more without change in pressure: 31 fluctuated 2 pounds or more and 6 fluctuated 3 pounds or more; 87 were inaccurate to the extent that the dial also showed one pound or more pressure than they should; 42 showed an inaccuracy of 2 or more pounds; 23 showed an inaccuracy of 3 or more pounds; 13 showed an inaccuracy of 4 or more pounds; 3 showed an inaccuracy of 5 or more pounds.

REFERENCES

1. Bargar Arnold E., 1938. The Accuracy of Pressure Gauges Used on Household Steam Pressure Cookers, Research Bulletin No. 99. Nebraska Agr. Expt. Station.
2. National Canners' Association, 1937: Process for Non-Acid Canned Foods in Metal Containers. Bulletin 26L, p. 16.
3. Stanley, Louise,, and Steinbarger, Mabel C., 1936: Home Canning of Fruits, Vegetables and Meats. Farmers' Bulletin No. 1762.
4. Tanner, F. W., 1935: Home Canning and Public Health. Am. Jour. of Public Health, Vol. 25, No. 3, pp. 301-313.