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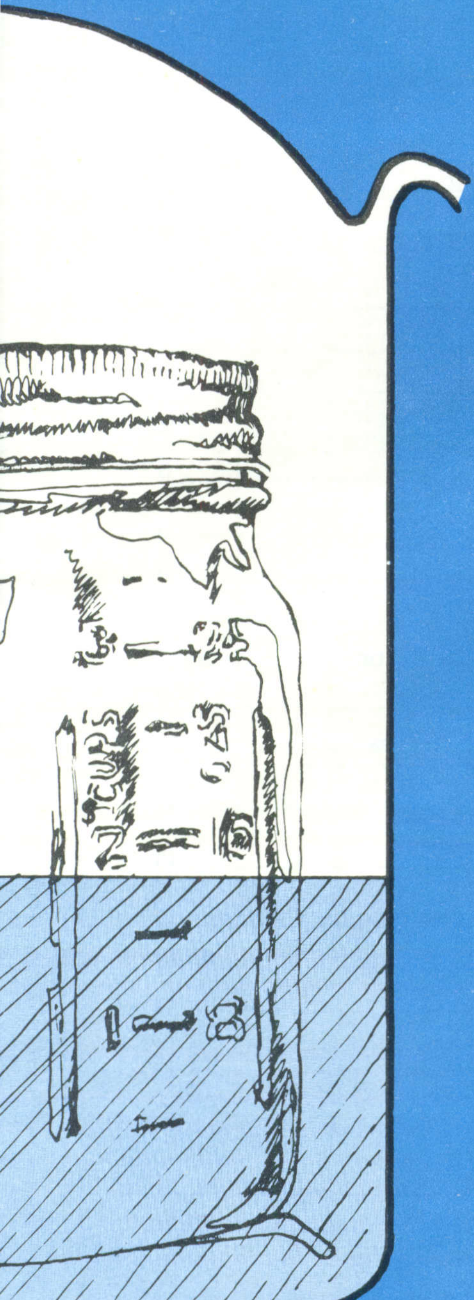

Use of Low Water Level in Boiling Water Bath Canning

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USE OF LOW WATER LEVEL IN BOILING WATER BATH CANNING

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INTRODUCTION

HOME CANNING OF FOOD is more popular than it has been in years. Reports in various publications *(6,12)* indicate that home growing and preserving of foods have reached the levels of World War II.

Employment of good processing technology is essential in home preservation of foods. Methods employed should (1) make efficient use of materials, time, and energy, (2) provide maximum protection from botulism and less serious types of food spoilage, and (3) produce tasty and nutritious products. A critical examination of present home food processing methods is needed and most timely.

A major concern of research reported in this publication is with the level of water to use in a boiling water bath (BWB) canning operation. Home canning publications generally recommend the use of enough water in the canning vessel to cover the tops of jars during the heating period *(1,3,4,5,8,9,10,11,14,15,16,17,18)*. Levels of water recommended range from 1 to 4 inches above top of jars. A canner with tight-fitting cover, boiling space above water, and rack in the bottom was also recommended. Ball *(8)*, Hertzberg *et al.* *(10)*, and U.S. Department of Agriculture *(15,16, 17,18)* reported that a pressure canner, with unfastened cover and open vent, could be used if deep enough to cover the jars with 1 to 4 inches of water.

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Data on thermodynamic properties of water and steam *(13)* indicate that products will heat as well with a low level of boiling water as with a high level, provided the canning vessel is equipped with a close fitting cover to hold saturated steam around and over the jars. Use of the low water level method would greatly reduce time and heat energy requirements for preheating canning vessels and water, reduce amount of heat liberated to kitchen, and provide a basis for a wider choice of vessels for BWB canning.

OBJECTIVES

Specific objectives of this study were:

1. To determine suitability and efficiency of available home processing equipment for BWB canning using different water levels in vessel.

2. To determine the effect of cover tightness of an atmospheric BWB canner on heating requirements and heat loss from exhaust steam.

3. To compare product heating rates and heating efficiencies resulting from use of different water levels in an atmospheric BWB canning operation.

METHODS AND MATERIALS

Available Home Canning Vessels

Retail stores in the Auburn-Opelika, Alabama, area were surveyed for available stocks of atmospheric and pressure vessels appropriate for home canning. Vessels on hand in the Horticulture Food Science Laboratory were also evaluated.

Heating Capacities and Efficiencies

Heat output of electric heaters was determined as follows: volts × amps × 3.415 = BTU per hour. Heat output of gas heaters was determined by metering the gas during a test period. A factor of 1,000 BTU per cubic foot of natural gas was used. Evaluations on measurable heat input in vessels were based on weight of water evaporated from vessel during 10-minute test periods (mean of three tests), calculated as follows: Pounds of water evaporated × 6 × 970 = BTU per hour. Measurable heat input in vessels was further evaluated as: (1) heat loss in exhaust steam from under vessel cover, determined with heater regulated to minimum output for maintenance of saturated steam in vessel; (2) maximum available heat, determined with heater regulated to maximum feasible heat output for vessel; and (3) net available heat or maximum available heat minus exhaust heat loss. Output from heater not accounted for by input heat to vessel was considered as heat liberated to area.

Heating Product in BWB Canning

Heating periods considered were: (1) preheating of the vessel and bath water to boiling temperature; (2) heat recovery or the period required for water and steam in the vessel to return to boiling temperature after adding the product; and (3) timed heat process period for a particular product and jar size.

Laboratory Experiments

Laboratory experiments were conducted on: (1) effects of cover tightness of an atmospheric canner on heat required to maintain saturated steam in the vessel; (2) comparison of heating rates and efficiencies in BWB canning of tomato juice with different canning vessels and levels of water; and (3) heating capacity and efficiency of different canners and heat sources.

RESULTS AND DISCUSSION

Canner Depth and Jar Load

Significance of water level in the canner in relation to canner depth, jar size, and jar load limit is illustrated in Figure 1. As illustrated, a canner at least 11¼ inches deep is required for one

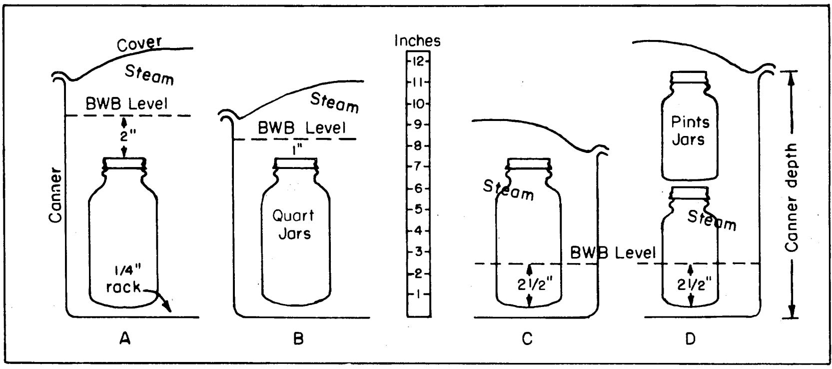

FIG. 1. Relation of BWB level to canner depth, jar size, and jar load. A and B, high levels; C and D, low level.

tier of quart Mason jars when allowance is made for 2 inches of water above jars and a 2-inch boiling space. In contrast, a canner only 7¼ inches deep is satisfactory for one tier of quart jars if a low water level method is used.

Survey of Vessels

Result of the survey of home canning vessels available in the Auburn-Opelika, Alabama, area are presented in Table 1. All of the regular canning vessels studied were suitable for BWB canning in standard quart or smaller Mason jars with low or medium water level. In contrast, none of the atmospheric vessels found in the stores visited and only two of the pressure vessels found were deep enough for quart jars with allowance for 2 inches of water and a 2-inch boiling space above jars. These two pressure vessels and two of the atmospheric vessels studied were deep enough for pint or smaller size jars with the 2-inch space each

TABLE 1. HOME CANNER VESSELS FOUND AVAILABLE IN SURVEY OF AUBURN-OPELIKA, ALABAMA, AREA[1]

Vessel type and material	Size			Potential load capacity[2]		Where found[1]	Approximate retail price
	Diameter	Depth	Liquid volume	Pint jars	Quart jars		
	In.	*In.*	*Qt.*	*No.*	*No.*		*Dol.*
BWB canners equipped with rack and recessed cover							
Polished aluminum	12.0	8.0	16.0	9	7	A	10
Porcelain enamel	13.0	9.5	21.5	11	7	A,C,F	4 to 9
Porcelain enamel	15.5	10.0	33.0	15,17	10,12	B,D	15
Polished aluminum	13.8	8.8	22.0	10	7	G	----
Aluminum stock pot	17.0	16.0	60.0	21[4]	14[5]	G	----
Pressure canners with rack and sealed cover							
Polished aluminum[3]	9.0	4.8	6.0	6[3]	none	A	29
Polished aluminum	12.0	11.0	22.0	10[5]	7	B	42
Aluminum, acrylic finish	12.0	7.0	12.0	9	7	D,E	40 to 50
Aluminum, acrylic finish	12.0	7.8	16.0	10	7	D	60
Aluminum, acrylic finish	12.5	10.5	21.0	9[5]	7	D	65
Polished aluminum	12.0	8.0	16.0	10	7	C	60
Polished aluminum (metal-to-metal seal)	12.5	12.0	24.0	9[5]	6,7	G	----

[1] Vessel location: A, B, and C, local hardware and houseware stores; D, national chain department store; E and F, local general merchandise stores; G, Horticulture Food Science Laboratory, Auburn University.

[2] See Figure 1 for limitation on load due to canner depth when high level BWB is used. Where two load capacities per tier of jars are shown, the higher is attainable by substituting a flat jar rack for the wire crate or divider type rack supplied with the canner.

[3] This is a conventional pressure cooker but deep enough for pint jars by low level BWB method if the 1-inch head space in cover is utilized.

[4] Vessel is deep enough for three tiers or a maximum load of 63 pint jars.

[5] With single tier of jars. Canner is deep enough for two tiers if low level BWB is used.

for water and boiling above jars. These four vessels were also deep enough for quart jars with 1-inch space each for water and boiling above jars. The only vessel included in the study that was deep enough for canning in quart jars with the maximum water level mentioned in the literature (4 inches above jars) was the 60-quart stock pot in the Horticulture Food Science Laboratory. This vessel would not normally be feasible for home canning on a kitchen stove because of its size and initial cost.

Effect of Vessel Cover Tightness on Heating

Atmospheric canning vessels are normally equipped with recessed covers. These are designed to maintain saturated steam in the vessel above the boiling water with minimum exhaust of steam to the atmosphere and to return condensate from the under surface of cover to the vessel. Four basic designs for these covers are illustrated in Figure 2.

The 33-quart, porcelain enamel, atmospheric canning vessel described in Table 1 was used in a study on effects of cover tightness. The vessel was tapped on one side at top and bottom for installation of thermometers extending horizontally into the vessel and for a vertical water column to indicate vessel pressure. One thermometer near the bottom measured temperature of the water (maintained at approximately 2-inch level) and another near the top measured temperature of the steam. A gas burner was used for heating, with both minimum and maximum heat levels tried, Table 2. This study was concerned with the relation of vessel cover tightness (closeness of contact with vessel

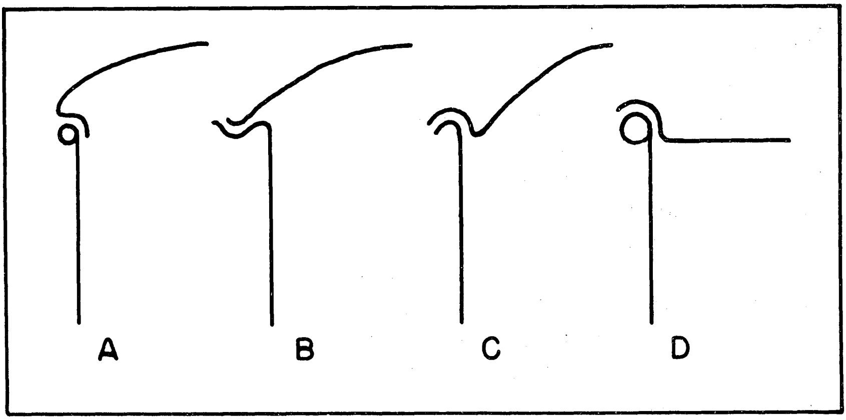

FIG. 2. Basic designs for tight fitting vessel cover.

TABLE 2. EFFECTS OF COVER TIGHTNESS AND HEATING RATE OF ATMOSPHERIC (BWB) CANNER ON THERMODYNAMICS OF OPERATION[1]

Heater adjustment and tightness of vessel cover[2]	Water pressure in vessel	Temperature (F) in vessel		Exhaust steam per hour	
		Water	Steam	Water evaporated	Heat loss in exhaust steam
	In.	*Deg.*	*Deg.*	*Lb.*	*BTU*
Minimum heat level[3]					
Weighted, 50 lb.	0.75	211.1	211.1	1.49	1,445
Weighted, 10 lb.	0.15	211.0	211.0	1.68	1,630
Clamped[4]	0.50	211.0	211.0	1.50	1,455
Unweighted[5]	0.12	210.9	210.9	1.89	1,830
Raised 1/16 in.	0.00	210.8	210.8	4.64	4,500
Raised 1/8 in.	0.00	210.7	210.7	8.31	8,060
Maximum feasible heat level[6]					
Weighted, 50 lb.	2.10	211.6	211.6	15.20	14,744
Unweighted	0.25	211.5	211.5	14.30	13,871
Cover off	0.00	210.0	----	13.20	12,804

[1] 33-quart, 15.5-inch diameter, porcelain enamel vessel with recessed cover, equipped with thermometers and water column pressure indicator. Tests made with approximately 2 inches of tap water in vessel.

[2] Special laboratory gas burner, 69,000 BTU per hour maximum heat output. This burner had a maximum heat input capacity of 24,100 BTU per hour when operated under a 17-inch diameter, covered aluminum stock pot with 6 inches of water. Rate was 23,000 BTU per hour with cover off. (Input capacities based on water evaporated.)

[3] Burner regulated to minimum heat output to maintain saturated steam and barely visible exhaust under vessel cover.

[4] Cover clamped with four note paper clamps, 1¼-inch leaf spring type.

[5] Essentially the same results were obtained when experiment was repeated using high level of tap water in vessel or when demineralized water was substituted for tap water with low water level.

[6] Maximum feasible heat output with flame confined under vessel.

rim) to pressure and temperature in vessel and heat loss in exhausted steam.

Based on altitude, the boiling temperature of water at Auburn, Alabama, should be approximately 210.9°F. This was the temperature of both the water and steam in the vessel with cover unweighted (held in place by its own weight only). Use of cover clamps or weights resulted in a slight increase in pressure and temperature, a decrease in heat required to maintain saturated steam, and a decrease in exhaust heat loss. Raising the cover 1/16 inch and 1/8 inch above vessel rim resulted in temperatures of 210.8° and 210.7°F, respectively, in both water and steam in vessel. To maintain these temperatures it was necessary to increase output of heater substantially with corresponding increases in exhaust heat loss.

These data demonstrate that it is feasible to maintain saturated steam in a covered BWB canner with low water level. Exhaust heat loss is affected by cover tightness. This loss is relatively low with cover unweighted, however, and is reduced further by use of cover weight or inexpensive clamps, Table 2. Heat loss from exhaust steam is essentially the same whether low or high level of water is used.

Use of Different Water Levels

A series of tests was made on BWB canning of tomato juice using four water levels, three canner vessels, three jar loads, and two heater output levels, Table 3. This study was concerned with the time and heat energy required in preheating the water bath and vessel, heat recovery period after placing product in canner, and product temperature after a timed heating period.

Tomato juice was used as the test product because of its uniform consistency and moderate rate of heating. A quantity of juice was prepared from ripe tomatoes by the hot break process using 0.060-inch screen for pulping and 0.033-inch screen for finishing. The juice was held at 0°F in 30-pound cans until used in the canning study. Standard quart Mason jars with modern two-piece covers were used as containers. Jars were filled to a level ½ inch from the top.

All heating tests were initiated with canning vessel and water preheated to boiling temperature and packaged juice equilibrated to 120°F. Heating periods lasted 20 minutes after adding product to canner. This included the heat recovery period for the water bath, which is not normally included in the timed process period in a canning operation. At termination of heating period, jars were quickly removed from canner, shaken briefly, and temperature readings taken at center of jar. In most of the tests, three jars were reserved unopened for vacuum readings after product cooled to approximately 80°F. Temperature readings were taken on all other jars. Detailed results are presented in the table.

Weight of bath water used and time and heat energy required for preheating varied widely depending on water level, canner vessel, and jar load. With a seven-jar load, for example, the weight of bath water was 3 pounds for the 1-inch water level in the 21.5-quart vessel, compared with 38 pounds for the 8-inch water level in the 33-quart vessel. In this same comparison the times required for preheating bath water and vessel were 5.8 and 52 minutes, respectively. Heat inputs in vessel and bath water during preheating were 517 and 5,538 BTU, respectively, and the

TABLE 3. EFFECT OF WATER LEVEL, VESSEL, JAR LOAD, AND HEATER OUTPUT ON BWB CANNING OF TOMATO JUICE IN STANDARD QUART FRUIT JARS[1]

Jar load, qt.	Water bath		Preheating water and vessel			Heating product		
	Wt.	Level[2]	Time	Heat in water and vessel[3]	Heat liberated to room[4]	Heat recovery period	Final temperature[5]	Vacuum, mean of 3 jars
	Lb.	*In.*	*Min.*	*BTU*	*BTU*	*Min.*	*Deg. F*	*In.*
21.5-quart porcelain enamel, cover clamped[6]								
7	3.0	1.0	5.8	517	730	6.0	179.5	20.1
7	5.0	2.5	8.0	799	921	6.5	180.3[7]	21.3
7	7.9	4.5	11.0	1,180	1,185	7.0	181.1	----
7	20.0	8.0	32.0	2,914	3,966	7.0	180.5	20.0
24-quart pressure canner, cover sealed, vent open[6]								
7	2.2	1.0	7.8	608	1,072	4.3	179.3	20.0
7	4.0	2.5	9.3	862	1,138	5.3	182.0	21.3
7	6.8	4.5	12.0	1,257	1,323	5.8	182.7	20.7
7	16.3	8.0	30.0	2,596	3,854	7.0	181.9	20.7
33-quart porcelain enamel, cover clamped[6]								
7	5.7	1.0	9.5	983	1,060	5.0	179.3	20.3
7	11.0	2.5	16.0	1,730	1,710	5.8	181.0	21.5
7	18.5	4.5	24.0	2,788	2,397	8.5	182.0	----
7	38.0	8.0	52.0	5,537	5,763	8.8	181.3	19.8
10	5.2	1.0	8.8	912	1,159	8.5	176.7	20.0
10	8.5	2.5	12.5	1,378	1,310	9.7	180.6	21.2
10	13.2	4.5	18.0	2,040	1,830	10.0	179.9	----
10	31.0	8.0	48.5	4,550	5,878	10.8	179.2	21.0
12	4.3	1.0	7.8	785	885	9.0	173.7	19.7
12	6.5	2.5	10.0	1,096	1,054	10.5	177.9	22.0
12	10.0	4.5	14.0	1,589	1,421	11.5	176.4	----
12	26.5	8.0	40.0	3,916	4,724	14.5	177.4	----
12[8]	4.3	1.0	5.3	785	999	5.5	176.8	19.0
12[8]	6.5	2.5	7.0	1,096	1,261	6.0	179.8	----
12[8]	10.0	4.5	10.5	1,589	1,941	6.0	178.9	20.5
12[8]	26.5	8.0	23.8	3,916	4,104	7.0	179.2	21.0
12[8]	5.4	1.8	6.0	940	1,080	5.5	179.5	----

[1] Except as otherwise noted, all tests were heated with the small laboratory gas burner adjusted to 12,900 BTU output. Initial product temperature, 120°F. Jars filled to ½ inch of top. Two-piece jar covers used.

[2] Water level above bottom of jars; 4.5-inch level came to shoulder of quart jars and 8-inch level came 1 inch above jar tops.

[3] Based on specific heat. Temperature increased from 70 to 211°F.

[4] Heat output from burner minus heat in water and vessel.

[5] 20-minute total heat period including heat recovery period. Mean of 4 to 10 jars.

[6] See Table 1 for canner vessel specifications.

[7] Test repeated with cover unweighted, mean temperature 180.7°F.

[8] Heater output increased to 20,200 BTU per hour by use of larger orifice and air intake.

heat units liberated to room during preheating were 730 and 7,763 BTU, respectively. Other similar comparisons may be drawn from the data.

Except for the 1-inch water level, rate of heating of the product was not significantly affected by water level or canner vessel.

Product temperatures at end of heating periods were essentially the same in each of the three vessels when the product load was seven jars, and 2.5-, 4.5-, or 8-inch water levels were used. Product temperature was slightly lower in each vessel when the 1-inch water level was used. Increasing the product load to 10 and to 12 jars in the 33-quart vessel also caused small decreases in final temperature of product. With this same vessel and the 12-jar product load, increasing the gas burner output from 12,900 to 20,200 BTU per hour substantially decreased heat recovery period but caused only a small increase in final temperature of product regardless of the water level used in the vessel. Also with the 33-quart vessel, 12-jar product load, and higher burner output, a 1.8-inch water level heated the product as fast as 2.5-, 4.5-, or 8-inch water levels; however, the 1-inch water level treatment resulted in slightly slower heating as in the other tests.

These experiments clearly demonstrate that packaged tomato juice processed in a covered BWB canner will heat as fast with the bath water at a level of 2.5 inches as it will with higher water levels, including a level 1 inch above jar tops (8-inch level). Use of the 2.5-inch water level reduced the time and heat required to preheat the water and heat units liberated to kitchen area during the preheat period to approximately one-fourth the quantities when the 8-inch water level was used. This study also substantiates other advantages mentioned earlier for the low water level method. Reason for slightly slower heating of product with 1 inch of water in the canner was not determined. This may have been due to less movement of jars in contact with the boiling water and, subsequently, less agitation of product. The 1.8-inch water level was used in one study and it heated the product as fast as higher levels.

While the experiments reported involved only the heating of tomato juice in quart jars, a low level boiling water bath canning method has been used extensively for more than a decade in the Horticulture Food Science Laboratory at Auburn University. Many acid foods have been processed by this method, using various sizes of jars and cans. Heating rates of products have always been satisfactory with approximately 2 inches of water in a covered BWB canner.

Evaluation of Canner Vessels and Heaters

Heating tests were made on five home canner vessels, each with five different heaters. The canner-heater combinations were evaluated for heating capacity and efficiency as BWB canning equipment, Table 4.

Data presented in tables 3 and 4 demonstrate that a pressure canner is an excellent vessel for atmospheric canning with a low water level as well as for pressure canning. When used as an atmospheric canner, the cover should be clamped on and the vent left open. Heat input should be regulated as needed to maintain saturated steam in the vessel.

TABLE 4. HEATING CAPACITY AND EFFICIENCY OF HOME CANNER VESSELS WITH DIFFERENT HEAT SOURCES[1]

	BTU/hr. heat input to vessels from heat sources[3]				
Vessel[1] and heat availability[2]	Kitchen stove, large surface unit at high heat			Laboratory gas burner	
	208 V. 8.2 A.	240 V. 9.8 A.	Gas burner	Small	Large
21½-qt. porcelain enamel (1,475 BTU/hr. exhaust heat)					
Maximum	4,015	4,715	5,295	7,740	13,190
Net	2,540	3,240	3,820	6,265	11,715
33-qt. porcelain enamel (1,830 BTU/hr. exhaust heat)					
Maximum	3,800	4,480	5,300	8,030	13,870
Net	1,970	2,650	3,470	6,200	12,040
22-qt. polished aluminum (1,740 BTU/hr. exhaust heat)					
Maximum	4,015	5,100	4,715	7,040	13,545
Net	2,275	3,360	2,975	5,300	11,805
24-qt. pressure canner (1,450 BTU/hr. exhaust heat)					
Maximum	4,750[4]	5,620	5,265	6,870	12,745
Net	3,300	4,170	3,815	5,420	11,295
60-qt. aluminum stock pot (1,220 BTU/hr. exhaust heat)					
Maximum	4,540	5,100	5,200	6,800	24,100
Net	3,320	3,880	3,980	5,580	23,000
Mean, 5 vessels					
Maximum	4,224	5,003	5,155	7,296	13,338[5]
Net	2,681	3,460	3,612	5,753	11,714[5]

[1] Approximately 2 inches of water in vessel, recessed cover unweighted. BTU ratings determined as follows: Pounds water evaporated during 10-minute test period (mean of three tests) × 6 × 970 = BTU per hour. See Table 1 for vessel description.

[2] Heating rate available for product varies essentially from maximum heat at beginning to net heat at end of heat recovery period. Maximum heat is based on evaporation with heater at maximum feasible level; exhaust heat is based on evaporation with heater at minimum level to maintain saturated steam and visible exhaust. Net heat is maximum minus exhaust heat.

[3] Maximum outputs on heaters (BTU per hour) were: 208 V, 5,850; 240 V, 8,050; kitchen stove gas burner, 12,900; small laboratory gas burner, 20,200; large laboratory gas burner, 69,000.

[4] 5,355 BTU per hour with foil reflector shell surrounding vessel, 1 inch away.

[5] Data on 60-quart stock pot heated with large laboratory burner are not included in mean.

SUMMARY

The widely recommended practice of a high water level in a covered BWB canner received critical examination in this study. Compared with a low water level, the high level was highly wasteful of heat energy and required excessive time for preheating. Furthermore, this method limits the choice of vessel for home canning and is cumbersome for the operator.

None of the atmospheric canning vessels found on sale in the Auburn-Opelika, Alabama, area was deep enough for canning in standard quart Mason jars with 2 or more inches of water above jar tops. Only two of those found were deep enough for canning with 1 inch of water over the jars.

In canning tests with tomato juice, the product heated as fast with a 2.5-inch water level in the canner as with higher levels up to 1 inch above jars. With the 2.5-inch level, time and heat energy required to preheat the water and amount of heat liberated to kitchen area were reduced to approximately one-fourth the quantities resulting from use of 1 inch of water above jar tops.

The conventional pressure canning vessel, operated with cover sealed and vent open, provides an excellent vessel for atmospheric canning with a low water level.

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APPENDIX 1—SOME FUNDAMENTALS IN QUALITY CANNING

Product Heating Rate

Correct heating of the product is of utmost importance in canning. Factors affecting heating rate should be understood. While this research has demonstrated that low water level in a covered BWB canner does not slow heating rate of the product, certain other factors do affect heating rate. Consistency of the food may affect heat conduction to some extent and heat convection to a great extent. These are the main thermal processes involved in movement of heat into the food. Conduction is the movement of heat energy from molecule to molecule through the jar and through relatively stationary portions of food. Convection is the movement of heat by flow of heated liquid from interior surface of jar to colder areas of the mass of packaged food. This results from decrease in density of liquid upon heating. Radiation, a third mode of heat transfer, usually is not greatly involved in BWB canning. Fast heating occurs when product consistency is favorable for relatively rapid convection in the jar. Heating rate decreases with decrease in convection and is slow when convection ceases and heat movement into product is mainly or solely by conduction.

Convection rate and subsequent heating rate are relatively high in clear liquids with low viscosity, such as unsweetened fruit juices. These rates may be substantially reduced by adding materials such as starch, sugar, pectin, or protein, which increase viscosity, or by the inclusion of insoluble pulpy material in the liquid serum as in the case of tomato juice. Relatively high levels of pulpy material result in products with puree consistency. Sweet potato and pumpkin pie stock are examples. In general, both convection and heating rate of purees are low, although these may vary somewhat with levels of food solids, starch, or other mucilaginous materials in the product.

In the case of solid foods packed in a liquid medium, convection and heating rate are affected by wholeness and firmness of pieces of food and by viscosity of liquid surrounding the pieces. Products with firm intact pieces surrounded with a low viscosity liquid, such as green beans covered with water, heat rapidly. Ragged ripe peaches packed in heavy syrup and ripe tomatoes packed in tomato juice heat slowly.

Filling, Closing, Exhausting

Final quality of the canned product may be affected substantially by methods and procedures used in filling and closing the container and exhausting air from the product. A general rule in filling is to pack the prepared food fairly firmly to within ½ inch of top of jar and cover with the liquid medium to same level. Variations from this rule are needed for best results with some foods. For example, peach and pear halves or slices processed by canning and whole peaches processed by pickling tend to give up juice on heating. This causes decrease in volume of fruit and increase in volume of cover syrup, and can result in an excess of cover syrup in proportion to fruit in the jar. To minimize this, preheat the prepared fruit before packing and/or pack it firmly to top of jars. Add cover syrup only to within 1 inch of top. An opposite situation may occur in the canning of southern peas, lima beans, and whole kernel corn. These foods tend to absorb liquid during canning, especially if in an advanced stage of maturity. To avoid low liquid level in these products, fill jars loosely to within approximately 1 inch of top and add cover liquid to within ¼ inch of top.

A spatula or knife blade should be used to dislodge air pockets from filled jars, and jar tops should be wiped free of product particles before applying the two-piece covers.

In the case of atmospheric canning, jar covers should be tightened firmly but not excessively. Jars closed in this manner with the two-piece covers will self-exhaust during heating. Further tightening after heating is not needed.

When pressure canning in jars with two-piece covers, liquid may be lost from jars when the canning vessel is depressurized. When this is a problem it is advisable to pre-exhaust the product before pressure processing. This can be accomplished by holding filled jars with covers on loosely for about 10 minutes in the pressure canner with vent open and steam escaping. Holding time will vary with consistency of product and its temperature when packaged. After exhausting, tighten covers firmly and pressure process for specified period. Remove vessel from heat and allow it to depressurize gradually to 0 gauge pressure before opening vent.

APPENDIX 2

Processing Time Table for Atmospheric Canning of Fruits and Acid Vegetables[1]

Fruit and cover liquid	Processing time with bath water boiling[2]			
	Hot pack—prepared fruit and cover liquid preheated to obtain closing temperature, center of jar, 160-170°F[3]		Raw pack—prepared fruit packed cold, cover liquid added at boiling temperature	
	Pints	Quarts	Pints	Quarts
	Min.	*Min.*	*Min.*	*Min.*
Apple slices, syrup	15	18	20	24
Apple sauce, none	15	18	----	----
Apricots, syrup	16	20	20	25
Blackberries, syrup	10	15	15	18
Cherries, syrup	12	16	18	22
Fruit juices, none	8	10	12	15
Peaches, firm ripe, syrup	17	20	22	27
Pimientos, none	25	----	40	----
Pears, firm, syrup	18	22	25	30
Plums, syrup	17	20	22	25
Sauerkraut, brine	20	25	25	30
Strawberries, syrup	12	15	15	18
Tomatoes, juice	17	20	35	45
Tomato juice, none	10	12	----	----

[1] Adapted from extensive canning studies in Auburn University Food Science Laboratory with consideration given to published recommendations *(8,9,10,11,14)*.

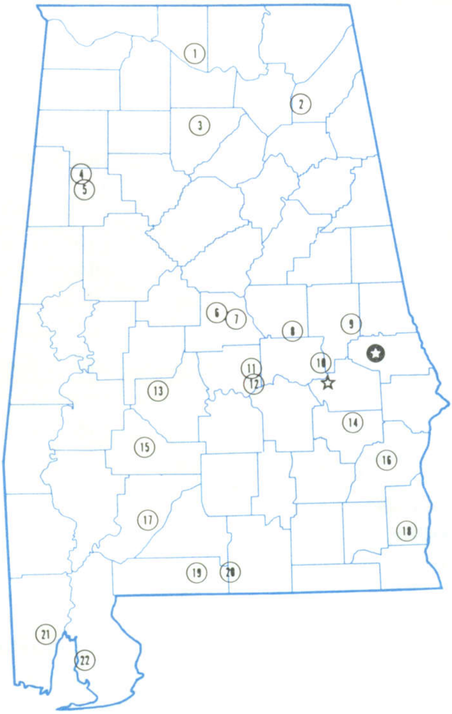
[2] Begin timing of process after water bath returns to boiling and air is exhausted from canning vessel. For altitudes of 1,000 feet or more above sea level, increase processing time by 5 percent for each 1,000 feet, or by the following formula:

Processing time $= M + .00005M$ Alt.
Where: $M =$ minutes processing time shown in table
Alt. $=$ altitude in feet above sea level.

[3] Product may be preheated in the syrup or other liquid to be used as cover medium. Usually 3 to 5 minutes in covered vessel with liquid boiling is sufficient to obtain specified temperature in closed jars.

Alabama's Agricultural Experiment Station System
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. The Turnipseed-Ikenberry Place, Union Springs.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Solon Dixon Forestry Education Center,
    Covington and Escambia counties.
21. Ornamental Horticulture Field Station, Spring Hill.
22. Gulf Coast Substation, Fairhope.