RESULTS AND DISCUSSION

1- Effect of Processing Step on the Chemical Composition of Vegetables :

a)- Effect of Blanching Times :

The effect of blanching time on the chemical composition of green beans, peas and okra were shown in **Tables (1, 2 and 3).** It is clear from the data that, moisture content showed a general increase after blanching for 1, 3 and 5 minutes gradually. The increment reached 90.45, 81.29 and 89.71% in case of green beans, peas and okra after blanching for 5 min. The fat content tended to decrease slightly also after blanching. This trend was also observed for protein content. It is clear that, total protein in green peas is higher than that in green beans or green okra. Blanching of green beans, peas and okra decreased the ash content. It is more clear in the case of green beans. However, a considerable reduction in ash content was observed in all treatments. This reduction is in according with **Akpapunam (1985),** who mentioned that, blanching of lima bean had decreased its ash content. As for fiber and carbohydrate content their figures flactuated with decrease trend for fiber, but there is increase in carbohydrate.

The data recorded in **Table (1)** also show that, carbohydrate is higher in green beans than green peas or okra. Data in **Table (2)** show that, the effect of blanching time on the pH-values is not clear. On the contrary, ascorbic acid was considerably affected by blanching at the different times. The reduction in ascorbic acid as a result of blanching was also observed by **Feaster, (1960); Odland and Eheart, (1975) and Muftugul, (1986).** The data also show that, the reduction in ascorbic acid was more clear in the case of green beans than green peas or green okra. The reduction in ascorbic acid was increased by increasing blanching times.

The effect of blanching time on the mineral composition of vegetables under investigation is shown in **Table (2).** The general trend showed that, blanched materials contained less minerals than raw vegetables. Such reduction was more clear for potassium (K) and sodium (Na) than calcium (Ca). This could be attributed to the complete solubility of the salts of the former minerals in plant tissues. It is also clear from the data that, the reduction in minerals was increased by increasing blanching times such results were in agreements with **Bengtsson, (1969)** and **Wedler, (1971).**

Data in **Table (3)** show the effect of blanching time on the chlorophyll contents. Increasing blanching time increased the changes occurred to the both total and chlorophyll fractions. It seemed that, chlorophyll (b) is more susceptible to change than chlorophyll (a). It is also clear that, blanching time for 3min. in green beans, peas and okra was the best time for preserving plant chlorophyll. It seems that, the high reduction in chlorophyll content at 5 min. blanching time compared with blanching for 1 and 3 min. is due to the intensive change of chlorophyll to

Table (1): Effect of blanching time by boiling water 95°C on major constituent of green beans, peas and okra (calculated on dry matter basis).

Blanching Time	Moisture content* (%)	Fat (%)	Protein (%)	Ash (%)	Fiber (%)	Carbohydrate ** (%)
Green beans						
-Raw	88.28	1.67	16.25	6.26	9.30	66.52
-Blanched for						
1 min.	89.80	1.49	16.05	5.20	9.16	68.10
3 min.	90.11	1.26	15.80	4.96	9.12	68.86
5 min.	90.45	1.21	15.60	4.90	9.08	69.21
Green peas						
-Raw	78.69	2.52	27.69	6.80	9.65	53.34
-Blanched for						
1 min.	78.91	2.42	26.94	6.30	9.50	54.84
3 min.	80.57	2.41	26.57	6.22	9.43	55.37
5 min.	81.29	2.27	26.40	6.05	9.36	55.92
Green okra						
-Raw	86.21	2.88	24.23	8.86	11.30	52.73
-Blanched for						
1 min.	87.69	2.53	23.76	8.60	11.12	53.99
3 min.	88.55	2.34	23.32	8.43	11.06	54.85
5 min.	89.71	2.25	23.09	8.25	10.95	55.46

* Calculated on wet basis

** Total carbohydrates by differences

Table (2): Effect of blanching time by boiling water 95°C on pH-value, ascorbic acid and mineral content of green beans, peas and okra (calculated on dry matter basis).

Blanching Time	pH value	Ascorbic acid mg/100g	Mineral content mg/g				
			Ca	K	Na	P	Fe
Green beans							
-Raw	6.23	191.09	7.53	20.42	0.59	3.72	0.069
-Blanched for							
1 min.	6.21	107.70	7.19	18.49	0.45	3.64	0.069
3 min.	6.20	96.31	7.05	17.64	0.33	3.54	0.057
5 min.	6.19	76.09	7.01	15.88	0.31	3.45	0.055
Green peas							
-Raw	7.08	130.00	2.74	15.72	0.857	5.41	0.077
-Blanched for							
1 min.	7.12	98.08	2.70	14.77	0.741	5.37	0.069
3 min.	7.15	75.28	2.65	13.41	0.630	4.95	0.061
5 min.	7.17	69.07	2.60	11.67	0.585	4.66	0.057
Green okra							
-Raw	5.90	159.73	11.83	18.12	1.30	3.69	0.057
-Blanched for							
1 min.	6.01	110.00	11.54	16.59	1.12	3.65	0.056
3 min.	6.02	99.67	11.24	15.35	1.08	3.66	0.054
5 min.	6.08	88.03	11.09	14.78	1.01	3.32	0.052

Table (3): Effect of blanching time by boiling water 95°C on chlorophyll content of green beans, peas and okra (calculated on dry matter basis).

Blanching Time	Total chlorophyll		Chlorophyll a		Chlorophyll b	
	mg/100g	Reduction (%)	mg/100g	Reduction (%)	mg/100g	Reduction (%)
Green beans						
-Raw	66.01	---	46.25	---	19.76	---
-Blanched for						
1 min.	60.15	8.98	41.84	9.54	18.31	7.34
3 min.	59.50	9.86	41.15	11.02	18.35	6.98
5 min.	57.04	13.95	40.51	12.41	16.53	16.35
Green peas						
-Raw	62.65	---	34.58	---	28.07	---
-Blanched for						
1 min.	55.26	11.80	29.35	15.12	25.91	7.70
3 min.	54.20	13.48	28.92	16.37	25.28	9.93
5 min.	51.89	17.17	27.15	21.49	24.74	11.86
Green okra						
-Raw	89.19	---	56.09	---	33.10	---
-Blanched for						
1 min.	78.73	11.73	50.09	10.70	28.64	13.47
3 min.	76.49	14.24	48.50	13.54	27.99	15.44
5 min.	70.33	21.15	44.68	20.34	25.65	22.51

pheophytin in the former treatment. Such high intensity of chlorophyll change during 5 min. of blanching time for plants could be due to the long exposure to heat treatment and to the higher heat transfer coefficient of condensing heating (**Belitz, 1985**).

Results of the organoleptic properties of blanched green beans, peas and okra are shown in **Table (4).** Significant differences could be observed between blanched periods (minutes) in colour, texture ($P<0.05$). Differences between 1 and 5 min. were only not significant in case of colour for blanched okra ($P>0.05$). From the same data, it is also clear to show that, the best sensory attributes were observed in vegetable samples that blanched for 3 minutes.

b)- Effect of Thermal Process :

The effect of thermal process on the chemical constituents of green beans, peas and okra blanched for 3 min. and canned in brine solution or tomato sauce is shown in **Tables (5 and 6).** Data indicated that, moisture content was further increased so as to reach 91.88%, 82.72% and 91.08% as average values in canned green beans, peas and okra canned in brine solution. However, in case of filling vegetables in tomato sauce a slight increase in moisture content of blanched samples before canning was observed so as to reach 90.89%, 80.83% and 89.82% as average values in canned green beans, peas and okra in tomato sauce, respectively.

Table (5): Effect of thermal processing on major constituents of canned green beans, peas and okra previously blanched for 3 min. (canned in brine solution) calculated on dry matter basis.

Canned Product	Thermal Processing at	Moisture content * (%)	Fat (%)	Protein (%)	Ash (%)	Fiber (%)	Carbohydrate ** (%)
I- Green beans		90.11	1.26	15.80	4.96	9.12	68.86
	120.2/15	91.90	1.26	14.50	5.84	9.05	70.57
	116.0/25	91.77	1.25	14.29	6.02	9.01	70.13
	112.1/35	91.98	1.19	14.20	6.05	8.95	70.92
II- Green peas		80.57	2.41	26.57	6.22	9.43	55.37
	119.9/15	82.29	2.36	25.42	7.23	9.05	55.94
	116.0/25	83.20	2.39	25.87	7.38	9.06	55.30
	112.1/35	82.67	2.29	25.35	7.21	8.98	56.17
III- Green okra		88.55	2.34	23.32	8.43	11.06	54.85
	120.2/15	91.17	2.25	21.49	9.09	10.89	56.58
	116.0/25	90.91	2.30	21.86	9.20	10.84	56.10
	112.1/35	91.17	2.20	21.45	8.81	10.81	57.03

* Calculated on wet basis

** Total carbohydrate by differences.

Table (6): Effect of thermal processing on major constituents of canned green beans, peas and okra previously blanched for 3 min. (canned in tomato sauce) calculated on dry matter basis.

Canned Product	Thermal Processing at	Moisture content * (%)	Fat (%)	Protein (%)	Ash (%)	Fiber (%)	Carbohydrate ** (%)
I- Green beans		90.11	1.26	15.80	4.96	9.12	68.86
	120.2/35	90.92	1.20	15.28	6.92	9.12	67.48
	116.0/50	90.78	1.21	15.53	7.11	9.17	66.98
	112.1/65	90.98	1.24	15.17	6.95	9.14	66.50
II- Green peas		80.57	2.41	26.57	6.22	9.43	55.37
	119.9/30	80.69	2.36	26.20	7.26	9.22	54.96
	116.0/45	80.85	2.34	26.11	7.39	9.23	54.93
	112.1/60	80.95	2.36	26.15	7.27	9.16	55.06
III- Green okra		88.55	2.34	23.32	8.43	11.06	54.85
	120.2/30	89.82	2.28	22.93	9.32	11.17	54.20
	116.0/45	89.62	2.19	22.45	9.54	11.13	54.39
	112.1/60	90.03	2.13	22.09	9.28	11.34	55.16

* Calculated on wet basis
** Total carbohydrate by differences.

On the other hand, fat content of canned green beans, peas and okra did not show considerable variation in fat than the blanched sample either in brine solution or tomato sauce. As for total protein content, a decremental trend was observed in the canned vegetable samples. The average reduction ranged between 8.22 - 10.13%, 1.73 - 4.59% and 5.27 - 8.02% for canned green beans, peas and okra either in brine solution or tomato sauce, respectively. Also total fiber and carbohydrate content were decreased as a result of heat processing. On the contrary, canned vegetables were found to contain higher amount of ash and this may be due to the presence of tomato or the penetration of some sodium chloride from the brine solution to the vegetables. **Abdel-Kader, (1980)** found that, ash content was increased in canned green beans, peas and okra more than within the raw or blanched samples. Canning process had no effect on the total content of fiber in all vegetables samples under investigation.

Data in **Tables (7)** and **(8)** show that, addition of citric acid had decreased the pH-value in all samples at different thermal processing treatments. The highest decrease of pH was observed in canned samples in tomato sauce compared with that canned in brine solution. This results agrees with the finding of **Giannone and Porretta, (1966),** who reported that, pH-value decreased from 5.9 to 4.0 in green beans canned in brine solution.

Regarding to the total ascorbic acid, considerable drop in its values was observed in all canned samples either in brine solution or tomato sauce. The percentage loss in ascorbic acid was found to be 67.95 - 72.69%, 57.43 -60.0% for canned green beans in brine and tomato sauce, respectively. 67.39 - 69.38% and 35.00 - 38.42% for canned green peas in brine solution and tomato sauce, respectively, and 67.20 - 69.94% and 47.44 - 49.48% for canned green okra in brine solution and tomato sauce, respectively. It could be noticed that, vegetables canned in tomato sauce contained higher level of ascorbic acid than that canned in brine solution. Also it could be noticed that, the lower reduction of ascorbic acid was in all vegetables thermaly processed at 116°C for 25 and 45 min. either in brine solution or tomato sauce. **Lee *et al.*, (1982)** mentioned that, ascorbic acid was decreased after canning of peas by 31.03%.

Concerning the effect of canning process on the mineral content of blanched vegetables, the results indicated that, canning had a considerable effect on certain mineral content. Potassium element is more affected by leaching during thermal processing. Thus, approximately 27.43 - 32.82%, 13.87 - 16.40% and 19.74 - 21.24% of potassium content were lost during the thermal process of the blanched green beans, peas and okra in brine solution, respectively, and 8.73 - 10.15%, 3.88 - 7.68% and 7.43 - 8.99% were lost in tomato sauce, respectively. On the other hand, the other elements showed a percentages loss of 7.92 - 20.0% for calcium and 7.07 - 14.75% for phosphorus in canned green peas in brine solution. These results are comparable to values reported by

Table (7): Effect of thermal processing on pH-value, ascorbic acid and mineral content of canned green beans, peas and okra previously blanched for 3 min. (canned in brine solution) calculated on dry matter basis.

Canned Product	Thermal Process at	pH Value	Ascorbic acid mg/100g	Mineral content (mg/g)				
				Ca	K	Na	P	Fe
I- Green beans		6.20	96.31	7.05	17.64	0.33	3.54	0.057
	120.2/15	5.36	30.60	6.33	12.80	22.66	3.16	0.049
	116.0/25	5.30	30.87	6.12	12.15	24.54	3.10	0.051
	112.1/35	5.35	26.30	6.02	11.85	25.64	3.12	0.049
II- Green peas		7.15	75.28	2.65	13.41	0.630	4.95	0.061
	119.9/15	6.12	24.25	2.44	11.55	16.25	4.26	0.060
	116.0/25	6.14	24.55	2.19	11.30	16.71	4.60	0.060
	112.1/35	6.13	23.05	2.12	11.21	17.19	4.22	0.058
III- Green okra		6.02	99.67	11.24	15.35	1.08	3.66	0.054
	120.2/15	5.35	28.87	10.48	12.32	40.25	3.31	0.049
	116.0/25	5.37	28.67	10.34	12.27	40.35	3.42	0.052
	112.1/35	5.38	26.90	10.12	12.09	40.20	3.30	0.055

Table (8): Effect of thermal processing on pH-value, ascorbic acid and mineral content of canned green beans, peas and okra previously blanched for 3 min. (canned in tomato sauce) calculated on dry matter basis.

Canned Product	Thermal Process at	pH Value	Ascorbic acid mg/100g	Mineral content (mg/g)				
				Ca	K	Na	P	Fe
I- Green beans		6.20	96.31	7.05	17.64	0.33	3.54	0.057
	120.2/35	4.98	39.60	6.34	16.10	25.59	3.17	0.057
	116.0/50	5.03	41.00	6.40	16.02	25.89	3.20	0.055
	112.1/65	5.06	38.56	6.18	15.85	25.95	3.19	0.056
II- Green peas		7.15	75.28	2.65	13.41	0.630	4.95	0.061
	119.9/30	5.48	47.79	2.75	12.50	17.93	4.47	0.056
	116.0/45	5.45	48.66	2.82	12.89	18.32	4.62	0.048
	112.1/60	5.63	46.36	2.76	12.38	18.80	4.59	0.046
III- Green okra		6.02	99.67	11.24	15.35	1.08	3.66	0.054
	120.2/30	4.82	44.88	9.13	14.21	39.59	3.32	0.046
	116.0/45	4.86	46.27	9.16	13.97	41.58	3.45	0.045
	112.1/60	4.93	44.47	9.19	13.99	41.90	3.36	0.045

Elkins, (1979); Lopez and Williams (1985) and Lopez *et al.*, (1986). As for iron slight decrement trend was observed in its concentration after the thermal process of all vegetables either in brine solution or tomato sauce. This could be attributed to lower solubility of salts of these metals. Generally, the reduction of most minerals was more pronounced in green beans than green peas and okra.

The presence of sodium chloride as a brine solution in canned vegetables reflected the considerable increase of sodium content in canned products.

Both canned green beans, peas and okra samples showed lower phosphorus content with retention values of 87.58 - 89.26%, 85.25 - 92.93% and 90.16 - 93.44% for canned green beans, peas and okra in brine solution, respectively. Similar findings were noticed by **Lopez and Williams (1985)**, who mentioned that, retention value of phosphorus of canned green beans in brine solution was 88.00%.

Data in **Tables (9)** and **(10)** show that, the effect of thermal processing of vegetables in the brine solution reduced the total chlorophyll content by 45.88 - 51.13%, 54.56 - 56.88% and 39.14 - 39.63% for green beans, peas and okra, respectively. Other trend was found in vegetable samples in tomato sauce the chlorophyll content was reduced 57.19 - 57.49%, 69.04 - 71.12% and 45.28 - 53.85% for green beans, peas and okra, respectively, according to the different thermal processing used in canning process. Similar

Table (9): Effect of thermal processing on chlorophyll content of canned green beans, peas and okra previously blanched for 3 min. (canned in brine solution) calculated on dry matter basis.

Canned Product	Thermal Process at	Total chlorophyll		Chlorophyll a		Chlorophyll b	
		mg/100g	Reduction (%)	mg/100g	Reduction (%)	mg/100g	Reduction (%)
I- Green beans		59.50	---	41.15	---	18.35	---
	120.2/15	29.08	51.13	14.78	64.08	14.33	21.91
	116.0/25	32.20	45.88	15.50	62.33	16.60	9.54
	112.1/35	30.83	48.18	14.26	65.34	16.57	9.70
II- Green peas		54.20	---	28.92	---	25.28	---
	119.9/15	23.37	56.88	16.33	43.53	7.04	72.15
	116.0/25	24.63	54.56	16.27	43.74	8.36	66.93
	112.1/35	23.42	56.80	16.29	43.37	7.13	71.80
III- Green okra		76.49	---	48.50	---	27.99	---
	120.2/15	46.28	39.49	28.73	40.76	17.55	37.30
	116.0/25	46.55	39.14	28.87	40.47	17.68	36.83
	112.1/35	46.18	39.63	28.71	40.80	17.47	37.58

Table (10): Effect of thermal processing on chlorophyll content of canned green beans, peas and okra previously blanched for 3 min. (canned in tomato sauce) calculated on dry matter basis.

Canned Product	Thermal Process at	Total chlorophyll		Chlorophyll a		Chlorophyll b	
		mg/100g	Reduction (%)	mg/100g	Reduction (%)	mg/100g	Reduction (%)
I- Green beans		59.50	---	41.15	---	18.35	---
	120.2/35	25.43	57.29	18.18	55.82	7.25	60.49
	116.0/50	25.47	57.19	18.84	54.21	6.63	63.90
	112.1/65	25.29	57.49	18.31	55.50	6.98	61.69
II- Green peas		54.20	---	28.92	---	25.28	---
	119.9/30	15.65	71.12	12.33	57.36	3.32	86.87
	116.0/45	16.78	69.04	12.76	55.88	4.02	84.10
	112.1/60	15.70	71.03	12.52	56.70	3.18	87.42
III- Green okra		76.49	---	48.50	---	27.99	---
	120.2/30	40.29	47.32	27.23	43.85	13.06	53.34
	116.0/45	41.85	45.28	30.27	37.58	11.58	58.63
	112.1/60	35.30	53.85	27.27	43.77	8.03	73.13

behaviour could be observed for the reduction rate of both chlorophyll (a) and (b). The reason for the considerable reduction of chlorophyll at the end of thermal process of the vegetables in brine solution may be due to the following reasons : **(1)-** The thermal process higher than 100°C encourages the further change of this component from the olive green colour to brown which has serious effect on the visual appearance of the canned product. **(2)-** The used of salt for the preparation of the canned brine solutions is a commercial salt which still containing Fe^{++} ions which replace the Mg^{++} ions and change the colour and **(3)-** The reduction in pH-value after canning affects the chlorophyll pigments. The pH-value decreased from 6.20 to 4.98 (green beans), from 7.15 to 5.45 (green peas) and from 6.02 to 4.82 (green okra) as shown in **Tables (7) and (8),** this change in pH leads to the removal of Mg^{++} from the chlorophyll and the colour will be darker. Further more, the chlorophyll changes by increasing the acidity to pheophytin, which is changed by heat treatment from olive green to dark green.

The general trend showed that, vegetables canned in tomato sauce resulted in a higher loss in chlorophyll content compared with the similar treatments canned in brine solution.

Results of the organoleptic evaluation of canned green beans, peas and okra in brine solution at different thermal processing are shown in **Table (11)** significant differences could be observed between thermal processing (temp./time) in colour, texture and overall acceptability for canned green beans, peas and okra

Table (11): Organoleptic evaluation of canned green beans, peas and okra in brine solution (blanched for 3 min) at different thermal process times .

Sensory attributes	Canned green beans				Canned green peas				Canned green okra			
	120.2/15	116.0/25	112.1/35	L.S.D. at 0.05	119.9/15	116.0/25	112.1/35	L.S.D. at 0.05	120.2/15	116.0/25	112.1/35	L.S.D. at 0.05
Colour	7.0	7.3	6.1	0.1810	7.4	7.7	6.7	0.179	7.2a	7.5	7.1a	0.128
Texture	6.1	6.6	6.3	0.1850	6.5	7.3	6.8	0.235	6.5	7.2	6.8	0.160
Odour	6.6b	6.9a	6.7a,b	0.2080	6.7	7.0	6.9	0.160	6.3	6.6a	6.5a	0.179
Taste	6.8	7.1a	7.0a	0.1810	7.3	7.4	7.3	0.156	6.1b	6.3a	6.2a,b	0.128
Overall acceptability	26.5	27.9	26.1	0.9238	27.9	29.4	27.7	1.198	26.1	27.6	26.6	0.6133

a, b : there is no significant differences between any two means within the same attribute.

Table (12): Organoleptic evaluation of canned green beans, peas and okra in tomato sauce (blanched for 3 min) at different thermal process times .

Sensory attributes	Canned green beans				Canned green peas				Canned green okra			
	120.2/35	116.0/50	112.1/65	L.S.D. at 0.05	119.9/30	116.0/45	112.1/60	L.S.D. at 0.05	120.2/30	116.0/45	112.1/60	L.S.D. at 0.05
Colour	7.0	7.5	6.7	0.208	7.0a	7.5	6.9a	0.177	7.1	7.4	7.0	0.211
Texture	6.2	6.5	6.3a	0.150	6.6	6.9	6.4	0.129	6.6	6.9	6.5	0.117
Odour	6.7	6.9	6.5	0.143	6.5a,b	6.7a	6.3b	0.165	6.3	6.4	6.1	0.136
Taste	6.6	7.0a	6.9a	0.160	7.2	7.4	7.0	0.143	6.3a	6.4a	6.4a	0.123
Overall acceptability	26.5	27.9	25.7	1.1734	27.3	28.5	26.6	1.0773	26.3	27.1	26.0	0.8556

a, b : there is no significant differences between any two means within the same attribute.

(P<0.05) and not significant in case of colour at 120.2°C/15min. and 112.1°C/35min. for canned green okra (P>0.05).

Results of the organoleptic evaluation of canned green beans, peas and okra in tomato sauce at different thermal processing are shown in **Table (12)** significant differences could be observed between thermal processing (temp./time) in colour, texture and overall acceptability for canned green beans, peas and okra (P<0.05) and not significant in case of colour in canned green peas, texture in canned green beans, overall acceptability for canned green peas and okra.

From the same data it is also clear to show that, the best sensory attributes were observed in vegetable samples that processed at 116°C for 25, 25 and 25 minutes, for 50, 45 and 45 minutes for canned green beans, peas and okra in brine solution and tomato sauce, respectively. **Teixeira, *et al.*, (1975)** stated that, generally high temperature-short time commercial sterilization processes result in greater retention of nutrient and sensory quality factors than low temperature-long time for conduction heating of food processed in containers. He also, stated that processes with steam-temperature around 250°F (121.11°C) result in greater with steam retention of thiamin than processing at higher or lower temperature.

2- Microbial Evaluation of Canned Vegetables :

A- Microbiological analysis of green beans, peas and okra :

The microbiological analysis were taken as criteria for sanitary condition and a load of spore-forming bacteria. These analysis include total plate count, aerobic mesophilic and thermophilic spore-forming bacteria (**Saleh and El-Sherbeiny, (1994).**

1- Effect of pretreatment and blanching :

Data in **Table (13)** show that, the average initial load on raw green beans, peas and okra was 4.43×10^5, 2.8×10^5 and 3.9×10^5 colony/g, respectively. This results are similar to that obtained by **Splittstoesser, (1970) and Webb and Mundt (1978).** The low microbial load of peas compared with green beans and okra were expected, since seeds of the former were protected by pods from contamination in the field. These results are in agreement with **ICMSF, (1980)** who reported that, there were basical differences between the microbial counts on protected (e.g. peas) and unprotected vegetables (e.g. beans and okra).

The aerobic mesophilic and thermophilic spore-forming bacteria were also slightly higher in green beans and okra than peas. The total mesophilic spore-forming bacterial count was 31, 16 and 23 colony/25 g for raw green beans, peas and okra, respectively. On the other hand, the total thermophilic spore-forming bacterial count was 8, 6 and 10 colony/25 g for raw green beans, peas and okra, respectively. The total aerobic mesophilic and thermophilic spore-forming bacteria/25 g were (24), (12) and (25) colony/25 g for blanched green beans, peas and okra for 3min., respectively.

Regarding the effect of blanching time process on the microbial densities on the vegetables under investigation. Data obtained show that, the average reduction of microbial count were 90-95.71%, 90.36 - 96.43% and 90.01 - 95.90% for green beans, peas and okra, respectively. These results are coincide with the finding of **Abd El-Latif, (1991)** who found that, blanching process tends to decrease the total number of viable count by high percentage. On the other hand, the effect of blanching time process on the total aerobic spore-forming bacteria per 25 g. Data obtained showed the average reduction for mesophilic spore-forming bacteria were 32.3 - 42.0%, 31.3 - 56.0% and 13.0 - 26.1% for blanched green beans, peas and okra, respectively, but the average reduction for thermophilic spore-forming bacteria were about 25%, 33.3 - 50% and 20 - 30% for blanched green beans, peas and okra, respectively.

The effect of blanching for different times on the microflora load and aerobic spore-forming bacteria was considered. It is clear from the data that blanching process effectively reduced the total count, mesophilic and thermophilic spore-forming bacteria to over 90% for microbial plate count and between 20 - 56% for aerobic mesophilic and thermophilic spore-forming bacteria. This reduction was detected as a result of heat destruction effect. Different

Table (13): Effect of pretreatment on the total bacterial count of green beans, peas and okra.

Treatment	Microbial plate count per gram fresh weight	Reduction %	Average count of Aerobic spore-forming bacteria per 25 g fresh weight			
			Mesophilic	Reduction %	Thermophilic	Reduction %
Green beans						
Raw	4.43×10^5	---	31	---	8	---
Blanched by boiling water 95°C for						
1 min.	4.43×10^4	90.00	21	32.3	8	---
3 min.	2.56×10^4	94.22	18	42.0	6	25
5 min.	1.90×10^4	95.71	18	42.0	6	25
Green peas						
Raw	2.8×10^5	---	16	---	6	---
Blanched by boiling water 95°C for						
1 min.	2.7×10^4	90.36	11	31.3	4	33.3
3 min.	1.6×10^4	94.29	8	50.0	4	33.3
5 min.	1.0×10^4	96.43	7	56.0	3	50.0
Green okra						
Raw	3.90×10^5	---	23	---	10	---
Blanched by boiling water 95°C for						
1 min.	3.85×10^4	90.01	20	13.0	10	---
3 min.	2.60×10^4	93.33	17	26.1	8	20
5 min.	1.60×10^4	95.90	17	26.1	7	30

Table (14): The average bacterial count (aerobic spore-forming Bacteria) of canned green beans, peas and okra (in brine solution-tomato sauce) subjected to blanching time 3 min at 95°C.

Canned Product	Thermal processing at °C/min.	Canned in brine solution				Thermal processing at °C/min.	Canned in tomato sauce			
		Average count of aerobic spore-forming /25g					Average count of aerobic spore-forming /25g			
		Meso.	Red. %	Thermo.	Red. %		Meso.	Red. %	Thermo.	Red. %
I- Green beans		18	---	6	---		18	---	6	---
	120.2/15	2	88	1	83	120.2/35	1	94	1	83
	116.0/25	2	88	1	83	116.0/50	1	94	---	100
	112.1/35	4	78	2	66	112.1/65	2	88	2	66
II- Green peas		8	---	4	---		8	---	4	---
	119.9/15	1	88	1	75	119.9/30	---	100	---	100
	116.0/25	1	88	---	100	116.0/45	---	100	---	100
	112.1/35	2	75	2	50	112.1/60	1	85	1	75
III- Green okra		17	---	8	---		17	---	8	---
	120.2/15	3	82	2	75	120.2/30	1	94	1	88
	116.0/25	2	88	1	88	116.0/45	1	94	1	88
	112.1/35	5	70	2	75	112.1/60	2	88	2	75

investigators stated that, the principle purpose of blanching is to inactivate plant enzymes and beside sterilizing the product during preservation, however, there are another benefit due to heat effect, which reduces the microbial load by 98% of the initial counts **(Splittstoesser, 1970 and El-Samkary, 1971). El-Fiky, (1996)** reported that, the reduction of microbial load reached 99.31%.

2- Effect of thermal process on the aerobic spore-forming bacteria of canned vegetables :

The microbial evaluation of canned green beans, peas and okra blanched by 3 min. only was carried out. Data in **Table (14)** showed that, the average count of mesophilic spore-forming reached 2, 2 and 4 spores/25 g, 1, 1 and 2 spores/25 g, and 3, 2 and 5 spores/25 g for canned green beans, peas and okra in brine solution at different thermal processing, respectively. Vegetables canned in tomato sauce showed lower total mesophilic spore-forming count in all the respective samples. The average count of thermophilic spore forming reached 1, 1 and 2 spores/25 g, 1, 0 and 2 spores/25 g and 2, 1 and 2 spores/25 g for canned green beans, peas and okra in brine solution at different thermal processing, respectively. Canned vegetables in tomato sauce showed lower total thermophilic spore-forming count in all the respective samples.

3- Isolation and Identification of the predominant spore-forming bacteria (Bacillus):

Bacillus species are considered of special importance, since they are spore-forming bacteria which able to produce protective materials against environmental condition around their cells. This type of bacteria were found highly contaminating vegetables. Accordingly the occurrence and classification of such type of bacteria in raw vegetables as well as during processing is considered of great value.

In this respect, results in **Tables (15)** and **(16)** show that, the total number of isolated *Bacillus* from raw vegetables under investigation were 32, 22 and 33 out of 40 colony of each, for green beans, peas and okra, respectively. While, after exhausting, the total number was decreased to reach 19, 12 and 19 colony, 20, 12 and 20 colony for canned green beans, peas and okra in brine and tomato sauce, respectively.

The incidence of such species isolated and identified from vegetables (green beans, peas and okra) out of 240 colonies either from raw or exhausted vegetables (green beans, peas and okra). In brine solution could be arranged in descending order as 7, 4 and 9; 5, 2 and 6, 6, 4, and 4; 6, 6, and 5; 7, 4 and 3 colony of *B. subtilis, B. coagulans, B. stearothermophilus, B. cereus* and *B. licheniformis* , respectively. While, from raw or exhausted vegetables (green beans- peas and okra), in tomato sauce could be arranged in descending order as 7, 5 and 10; 5, 2, and 6; 6, 3, and

Table (15): Effect of exhausting treatment on the number of different *Bacillus* spp. isolated and identified from green beans, peas and okra (in brine solution).

Isolated *Bacillus* spp.	Number of isolated colonies of *Bacillus* spp. from 40 colonies					
	Green beans		Green peas		Green okra	
	Raw	After exhausting	Raw	After exhausting	Raw	After exhausting
B. subtilis	5	2	3	1	6	3
B. cereus	3	3	4	2	3	2
B. licheniformis	5	2	3	1	2	1
B. polymixa	3	1	—	—	5	3
B. coagulans	3	2	1	1	4	2
B. brives	4	2	2	2	6	3
B. stearothermophilus	3	3	2	2	2	2
B. megaterium	2	2	4	2	—	—
B. macerans	4	2	3	1	5	3
Total positive	32	19	22	12	33	19
N. I. C.*	40	40	40	40	40	40

* Number of isolated colony.

Table (16): Effect of exhausting treatment on the number of different *Bacillus* spp. isolated and identified from green beans, peas and okra (in tomato sauce).

Isolated *Bacillus* spp.	Number of isolated colonies of *Bacillus* spp. from 40 colonies					
	Green beans		Green peas		Green okra	
	Raw	After exhausting	Raw	After exhausting	Raw	After exhausting
B. subtilis	5	2	3	2	6	4
B. cereus	3	2	4	2	3	2
B. licheniformis	5	2	3	2	2	2
B. polymixa	3	2	—	—	5	2
B. coagulans	3	2	1	1	4	2
B. brives	4	3	2	1	6	2
B. stearothermophilus	3	3	2	1	2	3
B. megaterium	2	2	4	2	—	—
B. macerans	4	2	3	1	5	3
Total positive	32	20	22	12	33	20
N. I. C.*	40	40	40	40	40	40

* Number of isolated colony.

5; 5, 6 and 5; 7, 5 and 4 colony of the same previously micro-organisms, respectively. These results are in agreement with results obtained by **El-Mansy, (1975), Khalaf, (1977) and Saleh and El-Sherbeiny, (1994).**

4- Measurement of Heat-Resistance Parameters of *Bacillus* spp.:

a)- Measurement of D-values :

Spores are differed in their resistance to heat and this resistance can vary according to its species, and suspending media. This would definitely affect the calculation of optimal thermal process time. Accordingly, it is necessary to find out the heat resistance parameters of the type of spores contaminating the processing line of vegetables under investigation.

This will lead to develop a system makes it possible to compare the heat resistance of different strains at the same temperature and/or the heat resistance of one strain at different temperatures.

The heat resistance of spores of *Bacillus* species which has been isolated from either green beans, peas and okra before thermal processing was carried out.

Consequently, logarithms of survivors were plotted against heating times of *B. subtilis, B. coagulans, B. stearothermophilus, B. cereus* and *B. licheniformis*, heated in phosphate buffer (pH 7.0) and extract of vegetables and (brine - sauce) **(Fig., 1, 2, 3, 4 and 5).**

From these curves, D-values for the different species of *Bacillus* were obtained. Which in turn, were plotted to determine Z-values (**Fig., 6, 7, 8, 9 and 10**). The obtained D and Z-values for *B. subtilis, B. coagulans, B. stearothermophilus, B. cereus* and *B. licheniformis* , are tabulated in **Table (17).**

Results in this Table indicated that, *B. licheniformis* had the least D-value at different heating temperatures. While, *B. stearothermophilus* had the highest values at the same heating temperatures. While, the values of "D" for *B. subtilis, B. coagulans,* and *B. cereus* appeared in between.

It can be noticed from **Table (17)** that, $D_{100°C}$ in minutes for *B. subtilis, B. coagulans, B. stearothermophilus, B. cereus* and *B. licheniformis* , suspended in phosphate buffer at pH= 7.0 were 2.8, 2.1, 250, 3.0 and 2.0 minutes, respectively. While the corresponding values were 1.05, 0.85, 34.00, 1.05 and 0.85 minutes at 110°C, 0.42, 0.35, 4.26, 0.40 and 0.35 minutes at 120°C, and 0.39, 0.33, 3.68, 0.37 and 0.32 minutes at 121.11°C, respectively. On the other hand, these spores of *Bacillus* which were suspended in extract of vegetables and (brine-sauce) at pH 4.8 - 5.60 had D-values 2.5, 1.8, 230, 2.5 and 1.6 minutes at 100°C; 0.95, 0.75, 28, 0.88 and 0.66 min. at 110°C; 0.33, 0.31, 2.65, 0.33 and 0.28 min. at 120°C, and 0.29, 0.29, 2.00, 0.29 and 0.26 min. at 121.11°C, respectively.

Results in this Table indicated that, the $D_{120°C}$ for spores of *B. subtilis* were 0.42, 0.33 min. in phosphate buffer and extract of

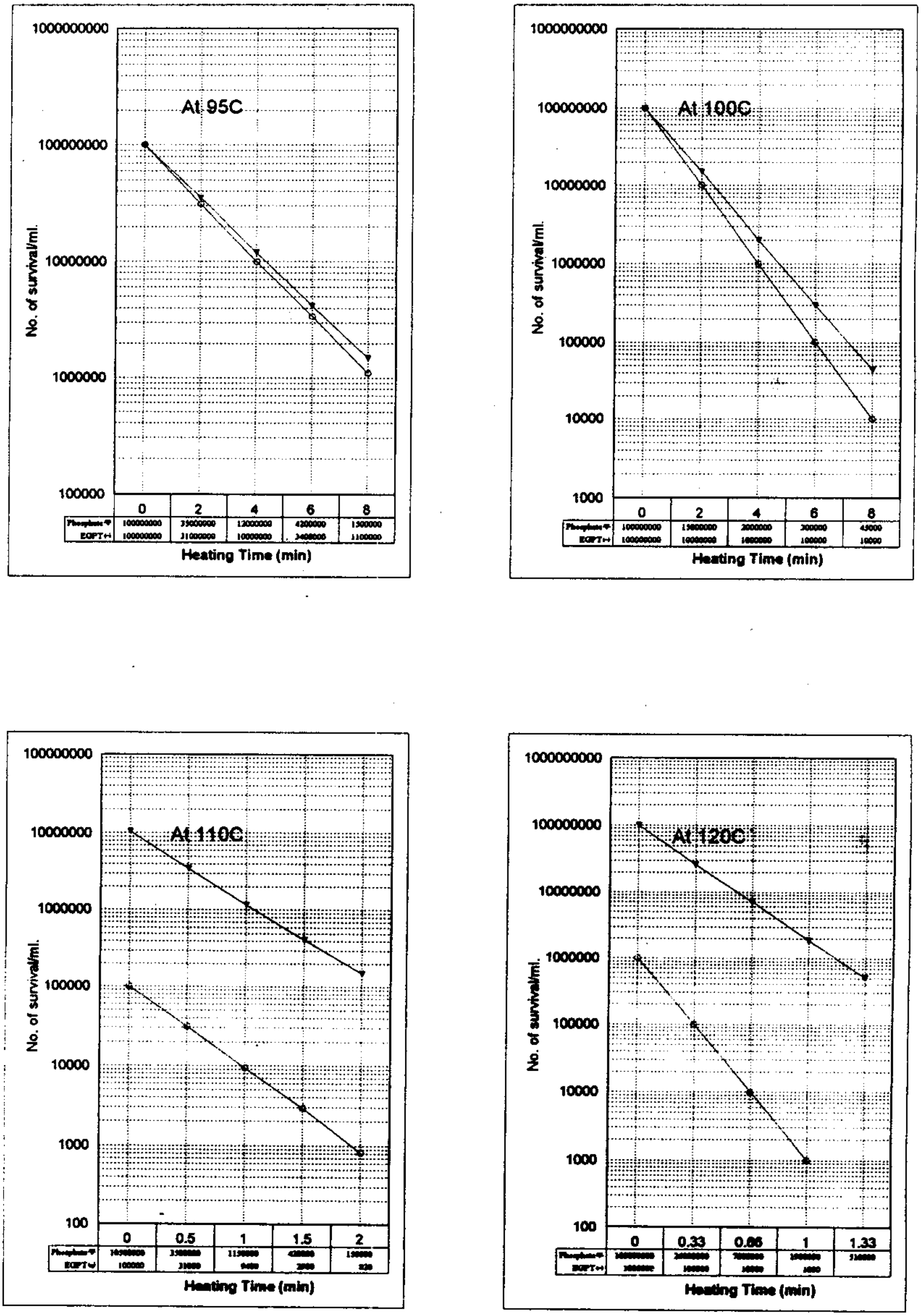

Fig. (1): Survivor curve for spores of *B. subtilis* at different heating temperature.

—▲— suspended in phosphate buffer pH = 7.0

—○— suspended in extract of green peas in tomato sauce (EGPT), pH = 5.6

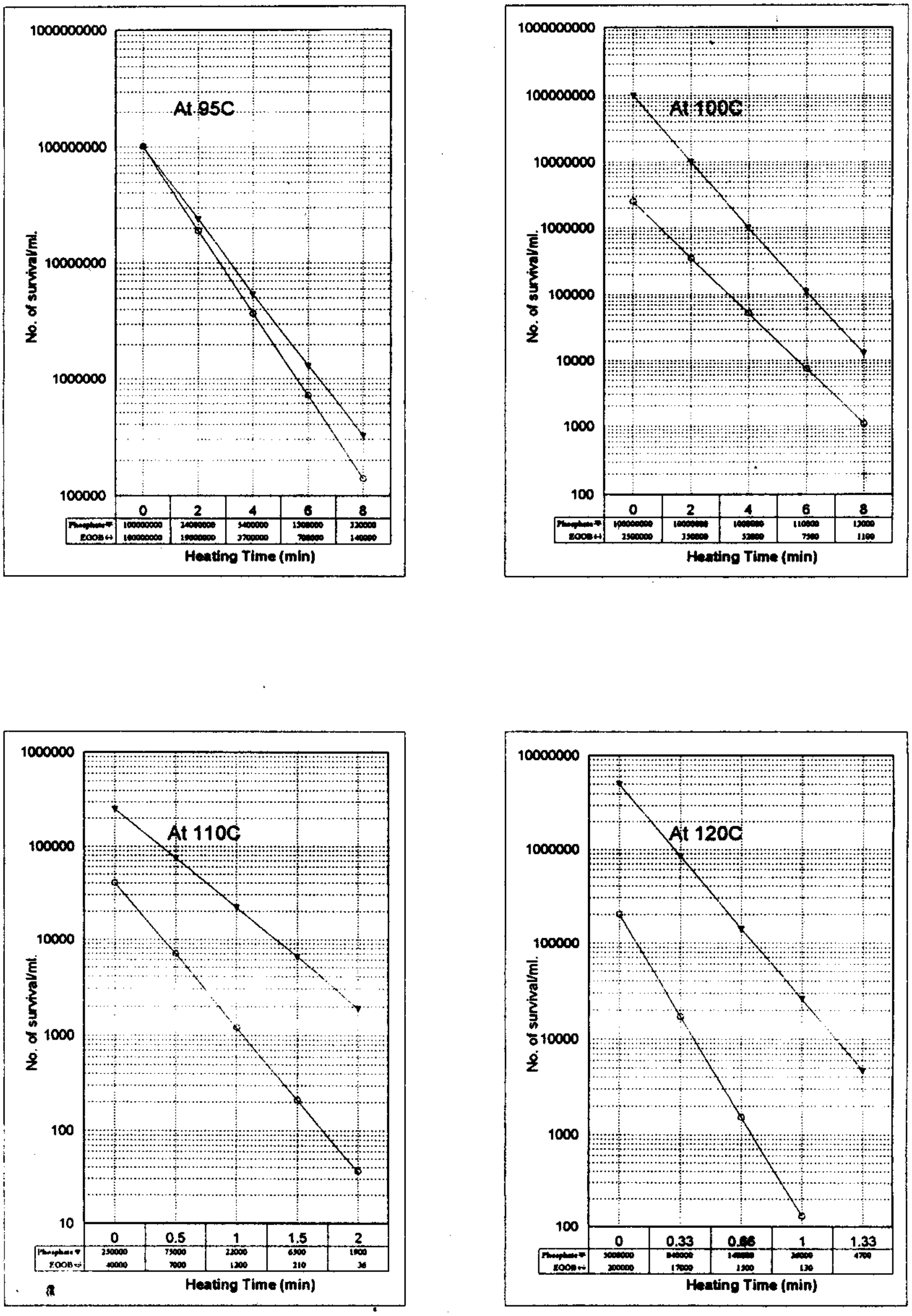

Fig. (2): Survivor curve for spores of *B. coagulans* at different heating temperature.

—▲— **suspended in phosphate buffer pH = 7.0**

—O— **suspended in extract of green okra and brine solution (EGOB), pH = 4.8**

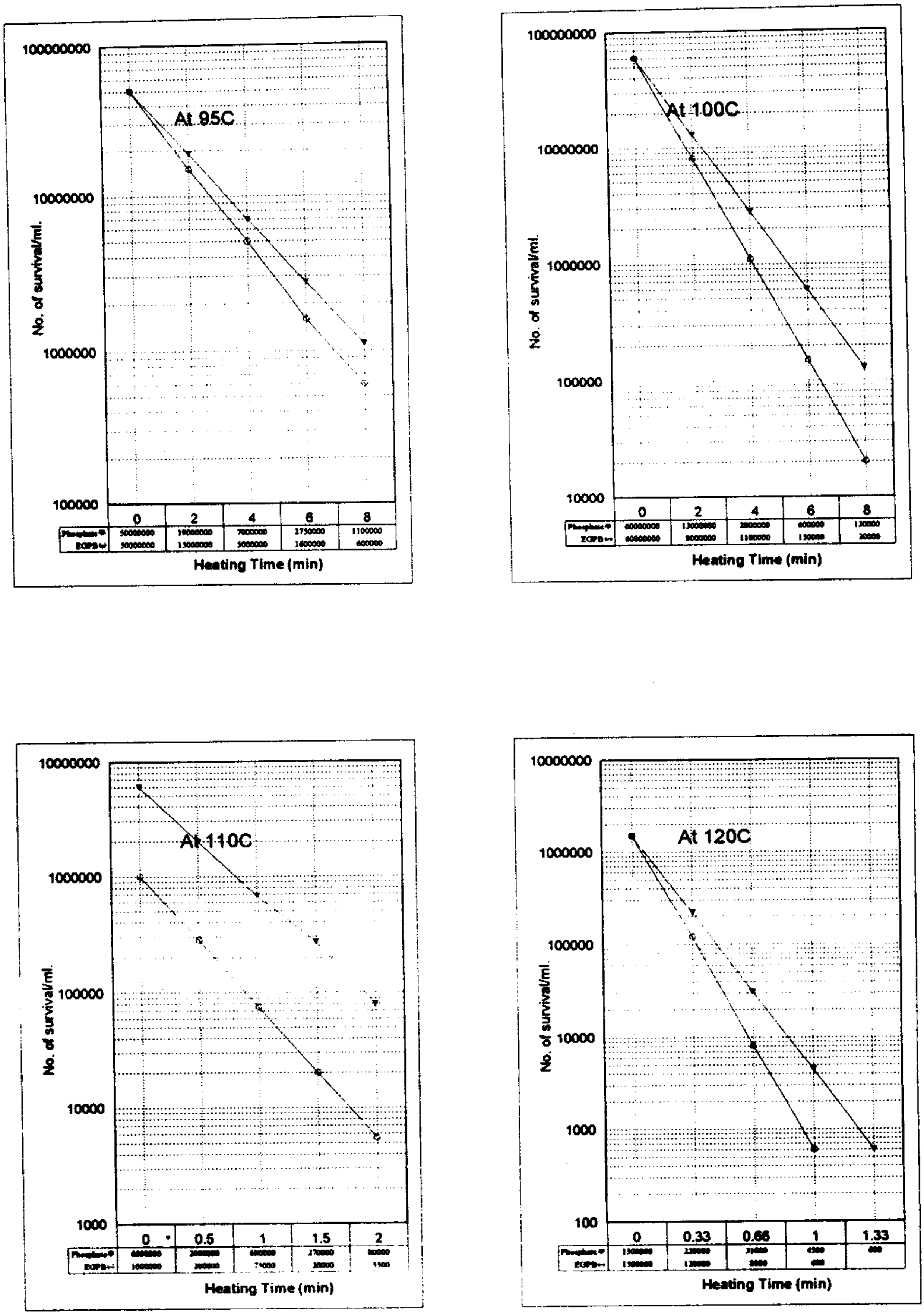

Fig. (4): Survivor curve for spores of *B. cereus* at different heating temperature.

—▲— suspended in phosphate buffer pH = 7.0

—○— suspended in extract of green peas and brine solution (EGPB), pH = 5.5

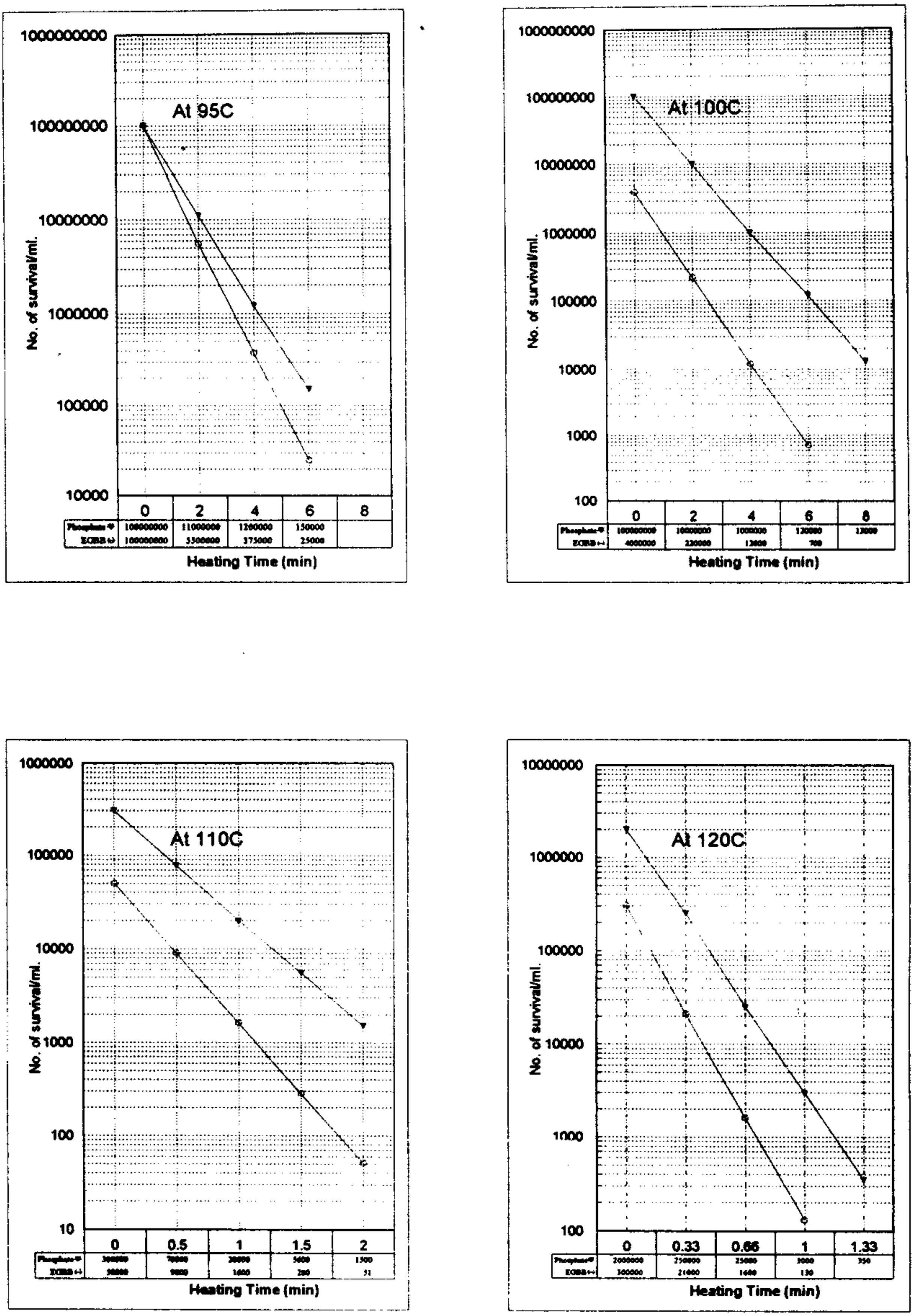

Fig. (5): Survivor curve for spores of *B. licheniformis* at different heating temperature.

—▲— **suspended in phosphate buffer pH = 7.0**

—○— **suspended in extract of green beans and brine solution (EGBB), pH = 5.35** green peas and tomato sauce, respectively. **Condon *et al.*, (1989)** stated that, it was 2.04 min. at $D_{99.1°C}$ and 0.69 min. at $D_{102°C}$ with pH-values 5.57 and 5.5, respectively.

Results in **Table (17)** indicated that, the value of $D_{100°C}$ for spores of *B. coagulans* suspended in phosphate buffer at pH 7.0 was 2.1 min. which was much higher than that reported by **Saleh and El-Sherbeiny, (1994),** who found it to be 1.30 min. for tomato serum at pH 4.4.

With regard to the decimal reduction times for *B. stearothermophilus*, the tabulated data show that, it recorded 4.26 and 2.65 min. in phosphate buffer and extract of green beans and brine solution at 120°C; respectively, as illustrated in **Fig. (3).** The comparison of the obtained "D" values of the three tested organisms, clarify that, the most heat resistant spores are those of *B. stearothermophilus*, which were confirmed by **Gibriel , (1971),** then followed *B. subtilis* , *B. cereus, B. coagulans,* and *B. licheniformis.*

El-Samkary, (1974), stated that, the survivor curves for *B. stearothermophilus* spores were approximate straight lines, which indicates D-values as ($D_{100°C}$ = 262.7, $D_{110°C}$ = 45.72, $D_{120°C}$ = 4.973 min.). **Feeherry *et al.*, (1987),** recorded that, the D-values of *B. stearothermophilus* spores were $D_{121°C}$ = 3.33 min., $D_{123°C}$ = 1.05 min., $D_{142.8°C}$ = 0.62 min. in low-acid canned foods.

Table (17): Decimal reduction time in minutes at different heating temperatures and Z-values (°C) for Bacillus spores isolated from vegetable processing line after exhausting step (spores were suspended in phosphate buffer pH = 7 and extract of vegetables and (brine solution or tomato sauce, pH 4.8 -5.35).

Food Product	Bacterial spores of	Suspensions	$D_{95°C}$	$D_{100°C}$	$D_{110°C}$	$D_{120°C}$	$D_{121.11°C}$**	Z-value°C
			Minutes					
I- Green peas	*B. subtilis*	Phosphate buffer pH = 7.0	4.5	2.8	1.05	0.42	0.39	24.6
in Tomato sauce	*B. subtilis*	Extract of Green peas and tomato sauce pH = 5.6	4.2	2.5	0.95	0.33	0.29	24.2
II- Green okra	*B. coagulans*	Phosphate buffer pH = 7.0	3.2	2.1	0.85	0.35	0.33	25.6
in Brine solution	*B. coagulans*	Extract of Green okra and brine solution pH = 4.8	2.9	1.8	0.75	0.31	0.29	25.8
III- Green beans	*B. stearothermophilus*	Phosphate buffer pH = 7.0	N.D.*	250	34	4.26	3.68	11.72
in Brine solution	*B. stearothermophilus*	Extract of Green beans and brine solution pH = 5.35	N.D.*	230	28	2.65	2.00	10.34
IV- Green peas	*B. cereus*	Phosphate buffer pH = 7.0	4.8	3.0	1.05	0.40	0.37	24.0
in Brine solution	*B. cereus*	Extract of Green peas and brine solution pH = 5.5	4.2	2.5	0.88	0.33	0.29	24.4
V- Green beans	*B. licneniformis*	Phosphate buffer pH = 7.0	3.2	2.0	0.85	0.35	0.32	25.8
in Brine solution	*B. licheniformis*	Extract of Green beans and brine solution pH = 5.35	2.5	1.6	0.66	0.28	0.26	25.8

* N. D. = Not determined.

** Obtained by extrapolation of T.D.T. curve.

The decimal reduction times for spores of *B. licheniformis* suspended in phosphate buffer and extract of green beans and brine solution at 95, 100, 110 and 120°C are tabulated in the same Table. Data also revealed that, the D-values were 0.35 and 0.28 min. in phosphate buffer and extract of green beans and brine solution, respectively at 120°C. **Condon *et al.*, (1989)** found that, D-values for *B. licheniformis* spores were 0.34 - 0.37 min. at $D_{118°C}$.

b)- Measurement of Z-values :

Since the spores of *B. subtilis, B. coagulans, B. stearothermophilus, B. cereus* and *B. licheniformis* are the dominant spore-formers causing spoilage of canned foods, it was decided to determine their relative heat resistance (Z-value).

In each case, decimal reduction times were plotted against temperature on semi-logarithmic paper and the resulting thermal death time (TDT) curves are shown in **Figs. (6, 7, 8, 9 and 10).**

Z-value in the number of temperature degrees required for thermal death time curve to traverse one log cycle (i.e. to reduce the D-value by 90% was computed from the TDT curves. According to **Stumbo, (1973)**.

The tabulated data show that, the Z-values for ***B. subtilis,*** were 24.6 and 24.2°C in phosphate buffer and extract of green peas and tomato sauce, respectively, **(Fig., 6)** where as, the Z-values for *B. coagulans* were 25.6 and 25.8°C in phosphate buffer and extract

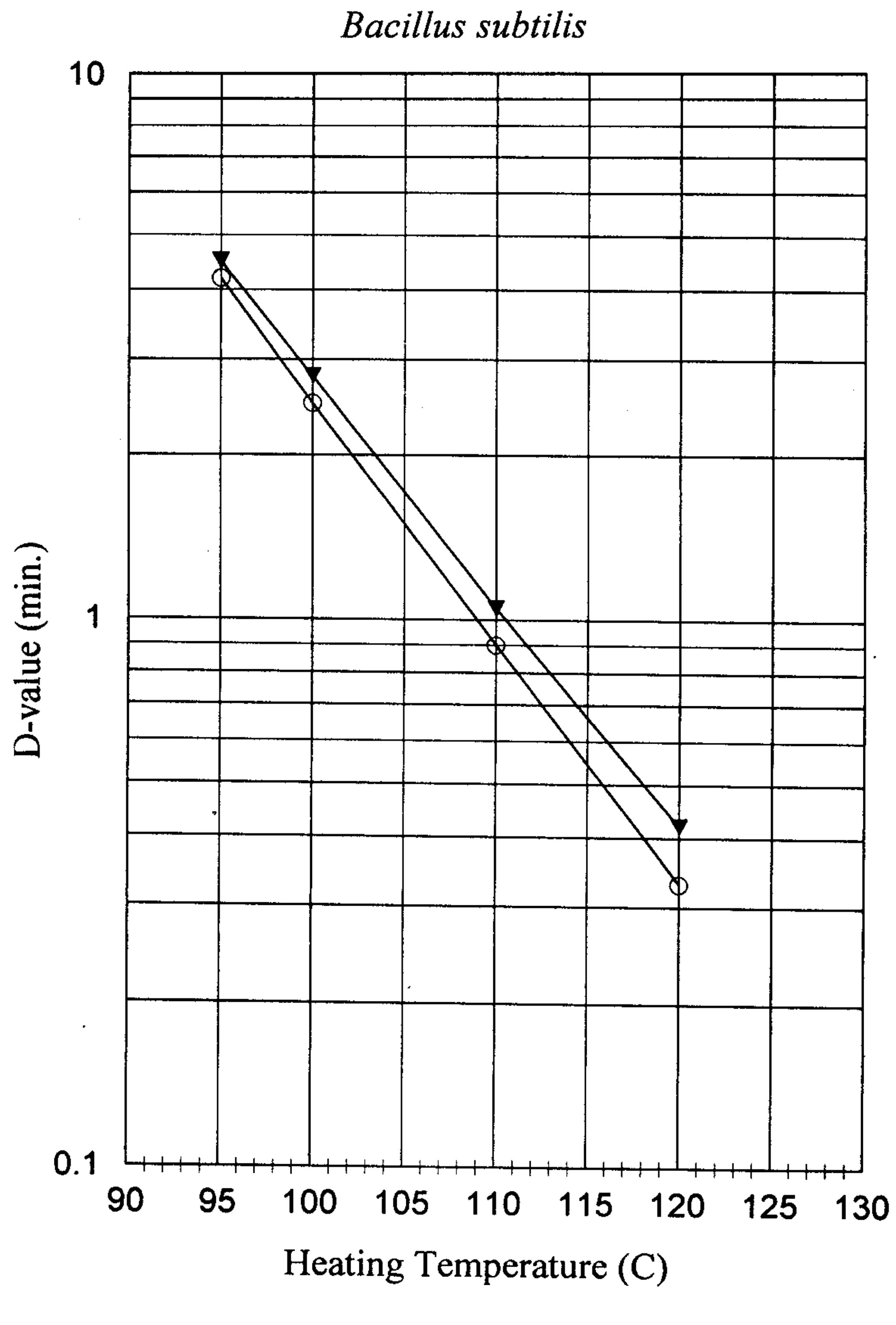

Fig. (6): Thermal destruction curve for spores of ***B. subtilis***.

suspended in phosphate buffer pH = 7.0

suspended in extract of green peas and tomato sauce, pH = 5.6

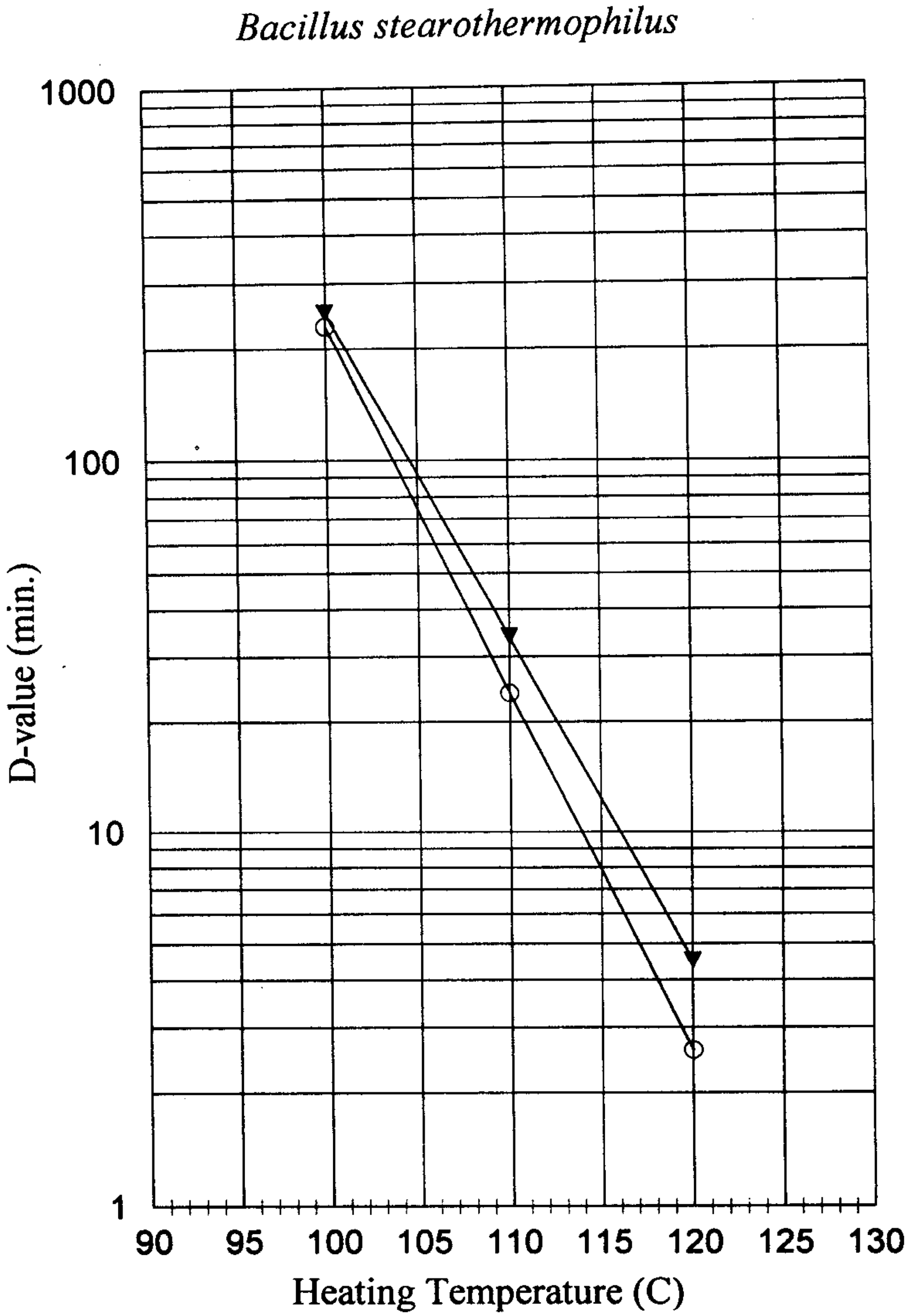

Fig. (8): Thermal destruction curve for spores of *B. stearothermophilus*.

—▲— **suspended in phosphate buffer pH = 7.0**

—○— **suspended in extract of green beans and brine solution, pH = 5.35**

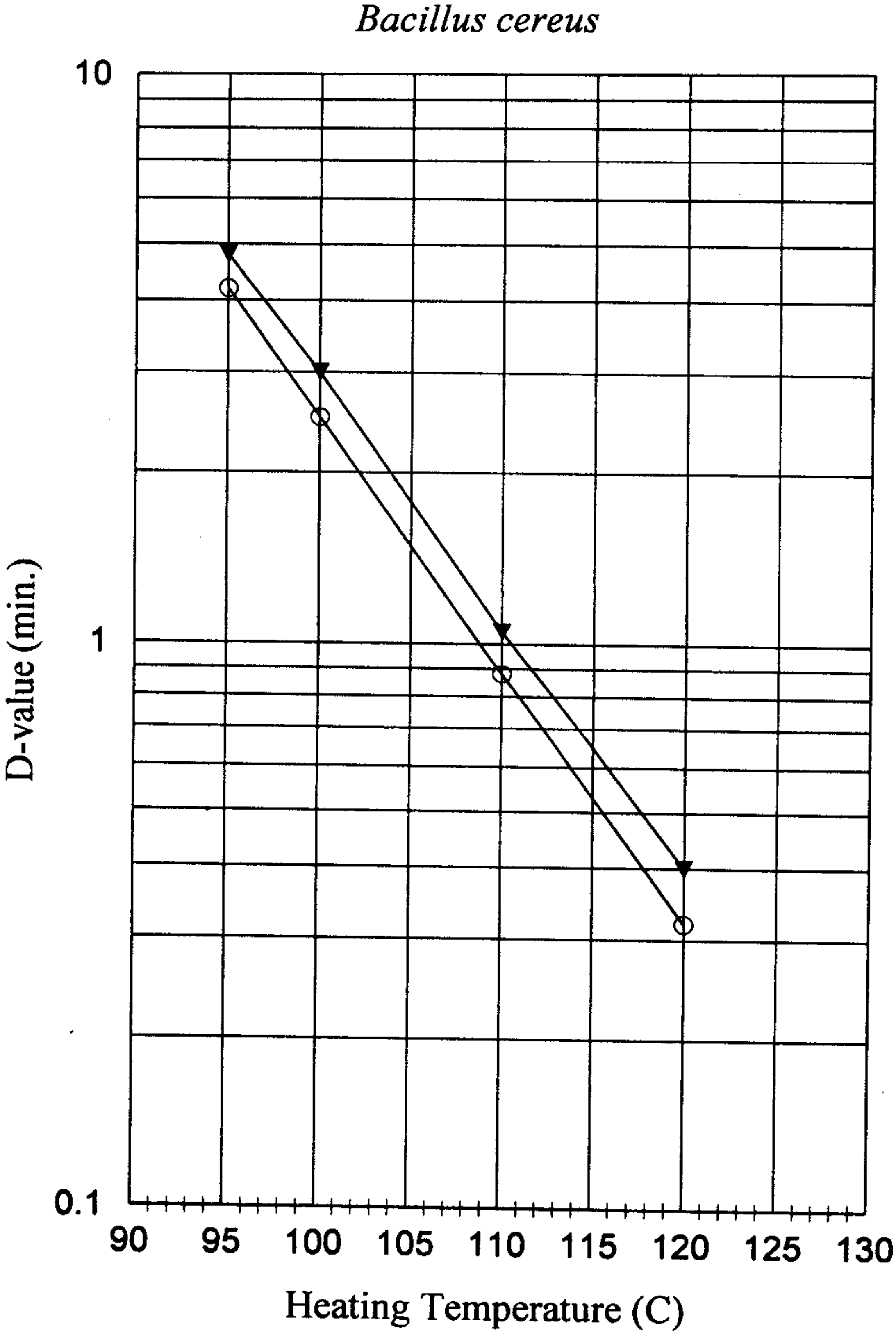

Fig. (9): Thermal destruction curve for spores of ***B. cereus***.

—▲— suspended in phosphate buffer pH = 7.0

—○— suspended in extract of green peas and brine solution, pH = 5.5

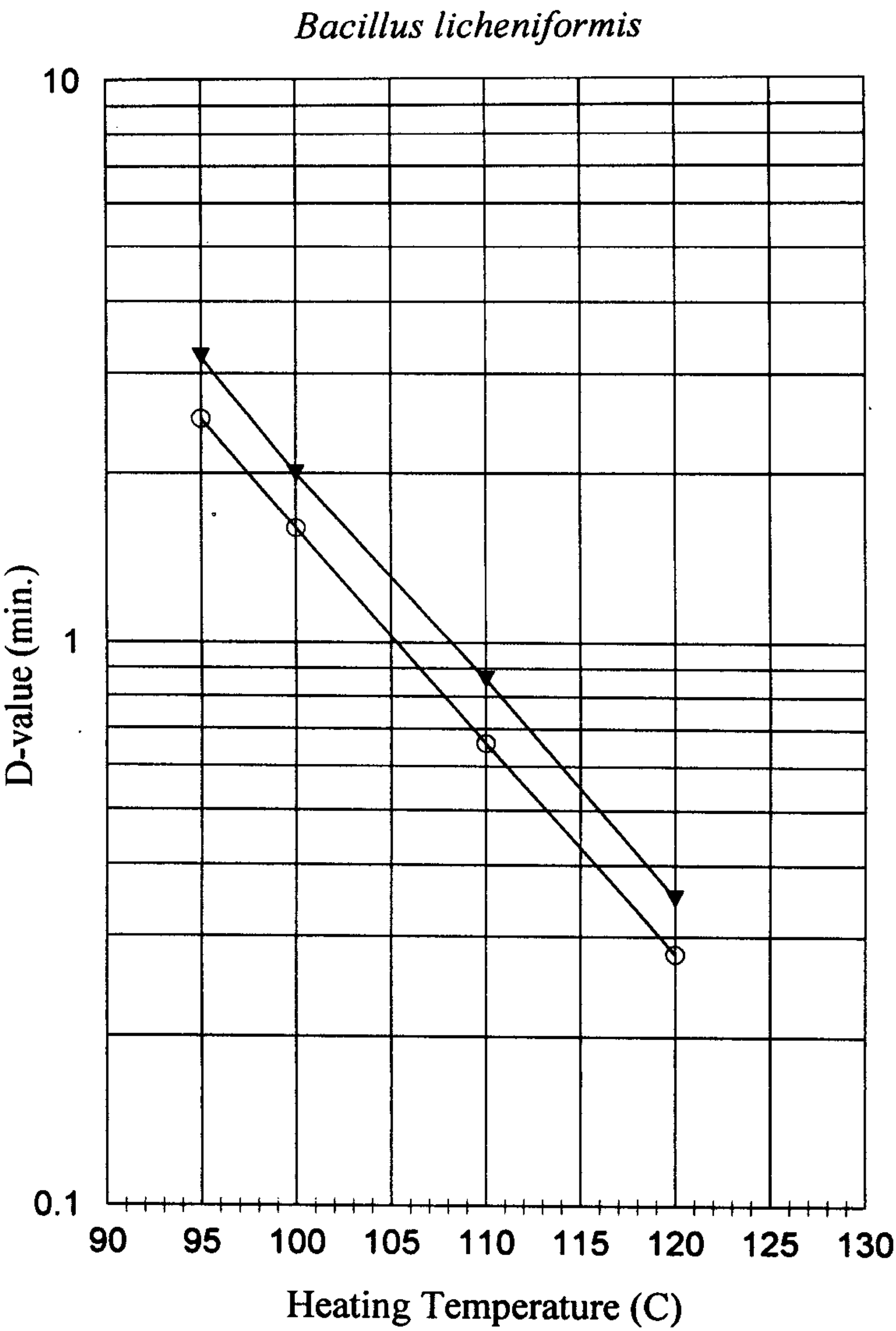

Fig. (10): Thermal destruction curve for spores of ***B. licheniformis***.

suspended in phosphate buffer pH = 7.0

suspended in extract of green beans and brine solution, pH = 5.35

of green okra and brine solution **(Fig., 7).** With regard to Z-values for *B. stearothermophilus*, data recorded indicated that, it were 11.72 and 10.34°C in phosphate buffer and extract of green beans and brine solution, respectively, **(Fig., 8). Gibriel, (1971) and El-Samkary, (1974),** found that, the Z-values of *B. stearothermophilus* suspended in brine solution of canned okra and distilled water was 15°F and 9.6°C, respectively. **Navani *et al.*, (1970) and Scholefield & Abdel-Gadir, (1974),** found that, the Z-values for spores of strains of *B. stearothermophilus* reach 11°C (20°F) approximately. Whereas, the Z-value for *B. cereus,* were 24.0 and 24.4°C in phosphate buffer and extract of green peas and brine solution, respectively **(Fig., 9).** With regard to Z-value for *B. licheniformis* it was 25.8°C in each phosphate buffer and extract of green beans and brine solution. **(Fig., 10).**

2- Evaluation of Thermal Process-Time :

Canned vegetables under investigation can be spoiled by mesophilic and thermophilic heat resistant microorganisms. The deterioration of canned vegetables by thermophilic micro-organisms is a persistent problem.

So, the aim of this part is to optimize the thermal process time of canned vegetables. Heat penetration data were obtained for canned vegetables (green beans - green peas - green okra) (size 360 ml.) which processed at 112.1, 116 and 120.2°C (233.78, 240.8

Table (18): Means of fh-values (min.) of canned green beans, peas and okra in brine solution.

Canned Product	tc *location above the bottom (mm)	Temperature °C			Average	L.S.D. at 0.05
		120.2	116.0	112.1		
Green beans	0.25	5.9	6.3	7.7	6.47	
		5.5	6.2	7.5		
		5.1	6.1	7.9		
		Mean 5.5 a	6.2 b	7.7 c		0.528
Green peas	0.25	3.6	3.85	4.05	3.82	
		3.5	3.95	4.00		
		3.7	3.75	3.95		
		Mean 3.6 a	3.85 a	4.00b		0.173
Green okra	0.33	6.5	4.9	6.2	5.93	
		6.5	5.2	6.0		
		6.5	5.1	6.4		
		Mean 6.5 a	5.1 b	6.2 c		0.290

* tc: The thermocuple location of the slowest heating point.

Table (19): Means of fh-values (min.) of canned green beans, peas and okra in tomato sauce.

Canned Product	tc *location above the bottom (mm)	Temperature °C			Average	L.S.D. at 0.05
		120.2	116.0	112.1		
Green beans	0.50	25.2	27.9	30.3	27.7	
		25.5	28.0	30.0		
		24.9	27.8	29.7		
		Mean 25.2 a	27.9 b	30.0 c		0.502
Green peas	0.50	20.4	22.3	23.5	22.0	
		20.1	22.2	23.7		
		19.8	22.1	23.9		
		Mean 20.1 a	22.2 b	23.7 c		0.431
Green okra	0.50	20.8	23.0	24.0	22.7	
		21.0	23.1	24.0		
		21.2	22.9	24.0		
		Mean 21.0 a	23.1 b	24.0 c		0.257

* tc: The thermocuple location of the slowest heating point.

and 248.36°F). Heat penetration data were plotted as heating curves and cooling curves. Values of mean Fh were obtained and tabulated in **Tables (18)** and **(19)** for canned vegetables in brine solution and tomato sauce, respectively. From the data obtained there are significant differences ($P<0.05$) between retort temperature .which indicated that, increasing retort temperature (Tr) from 112.1°C to 116.0°C to 120.2°C was accompanied by significant decreasing in Fh value from 7.7 to 6.2 to 5.5 min., from 4.0 to 3.85 to 3.6, from 6.2 to 5.1 to 6.5 min. for canned green beans, peas and okra in brine solution, respectively. On the other hand, from 30 to 27.9 to 25.2, from 23.7 to 22.2 to 20.1, from 24.0 to 23.1 to 21.0 min. for canned green beans, peas and okra in tomato sauce, respectively. Heating and cooling curves parameters **(Fig., 11 - 16)** combined with heat resistance parameters of isolated spore-formers were used to evaluate the carried out thermal processing as indicated in **Tables (20), (21),** and **(22)** using the mathematical method **(Stumbo, 1973)**.

It could be seen **Table (20)** that, thermal processing times of 35, 25 and 15 min. holding at 112.1°C to 116.0°C to 120.2°C after come up times 3.5, 4.5 and 5.5 min., respectively, were resulted in F-values of 4.91 - 15.54, 7.02 - 16.03 and 9.23 - 12.58 for green beans in brine solutions, respectively. On the other hand, thermal processing times of 65, 50 and 35 min. holding at 112.1°C to 116.0°C to 120.2°C after come up times 3.2, 3.5 and 4.5 min.,

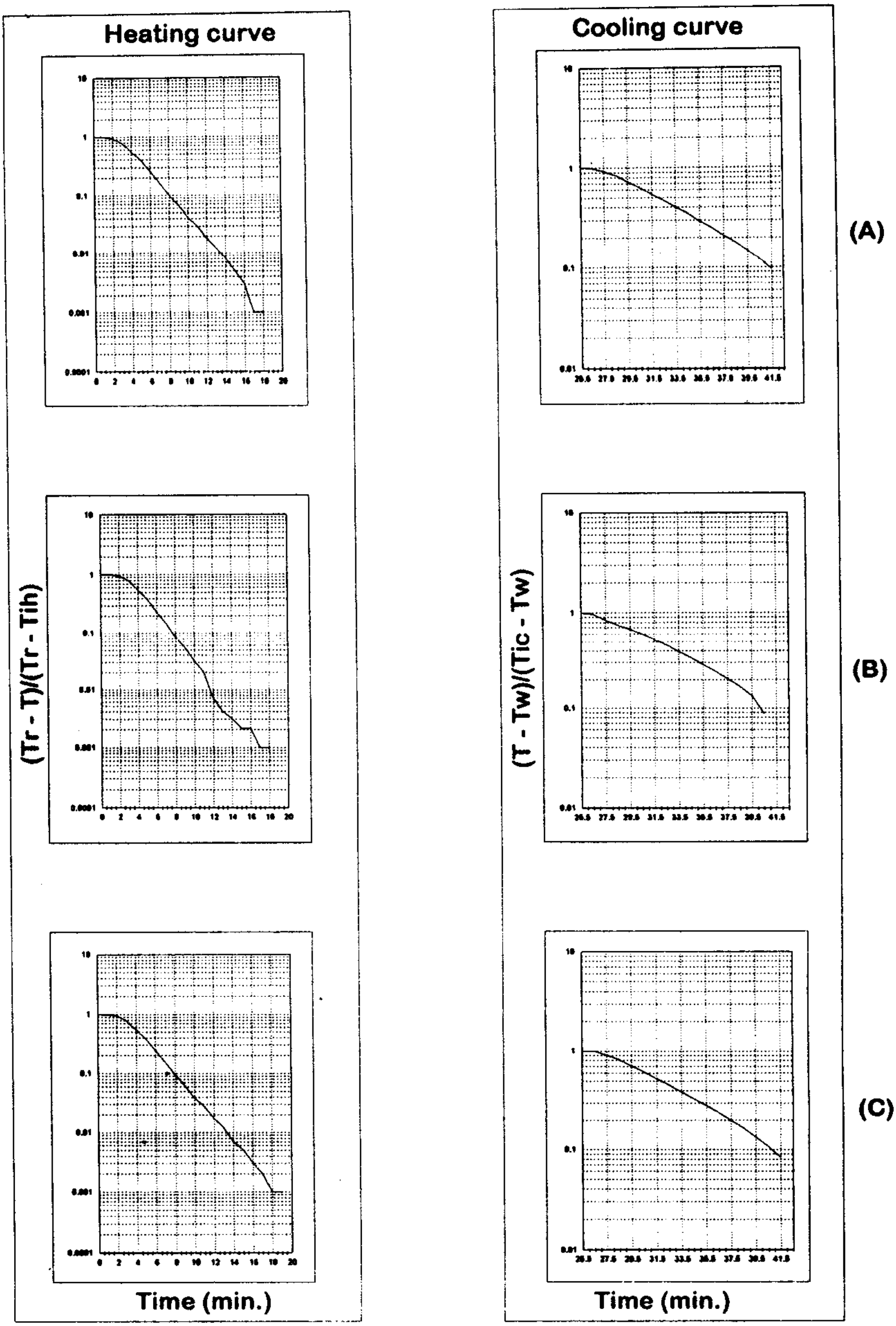

Fig. (11): Heating and cooling curves for green beans in brine solution heated at different temperature and time.

(A):120.2°C/15 min., (B): 116°C/25 min. and (C): 112.1°C/35 min.

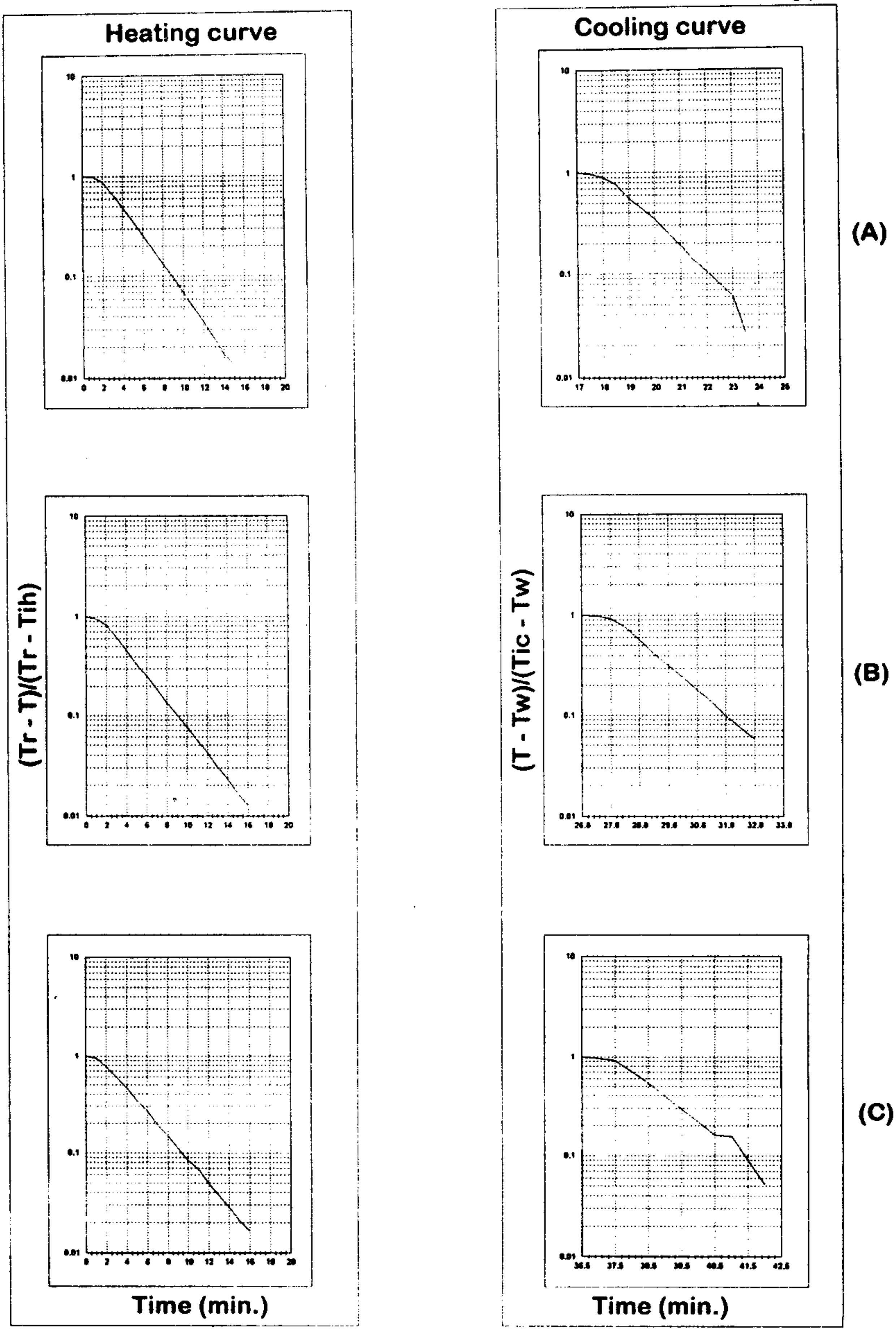

Fig. (12): Heating and cooling curves for green peas in brine solution heated at different temperature and time.

(A):119.9°C/15 min., (B): 116°C/25 min. and (C): 112.1°C/35 min.

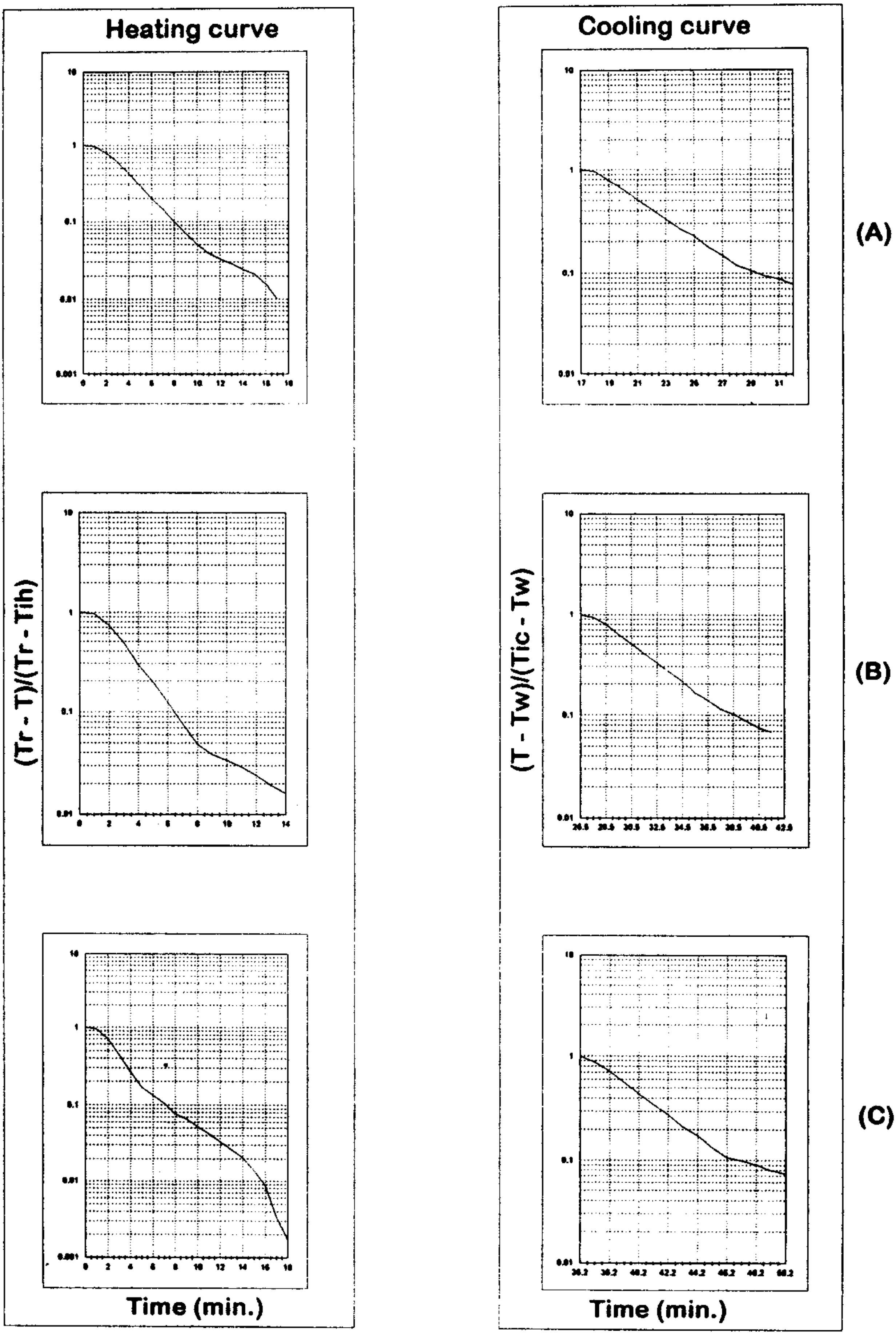

Fig. (13): Heating and cooling curves for green okra in brine solution heated at different temperature and time

(A):120.2°C/15 min., (B): 116°C/25 min. and (C): 112.1°C/35 min.

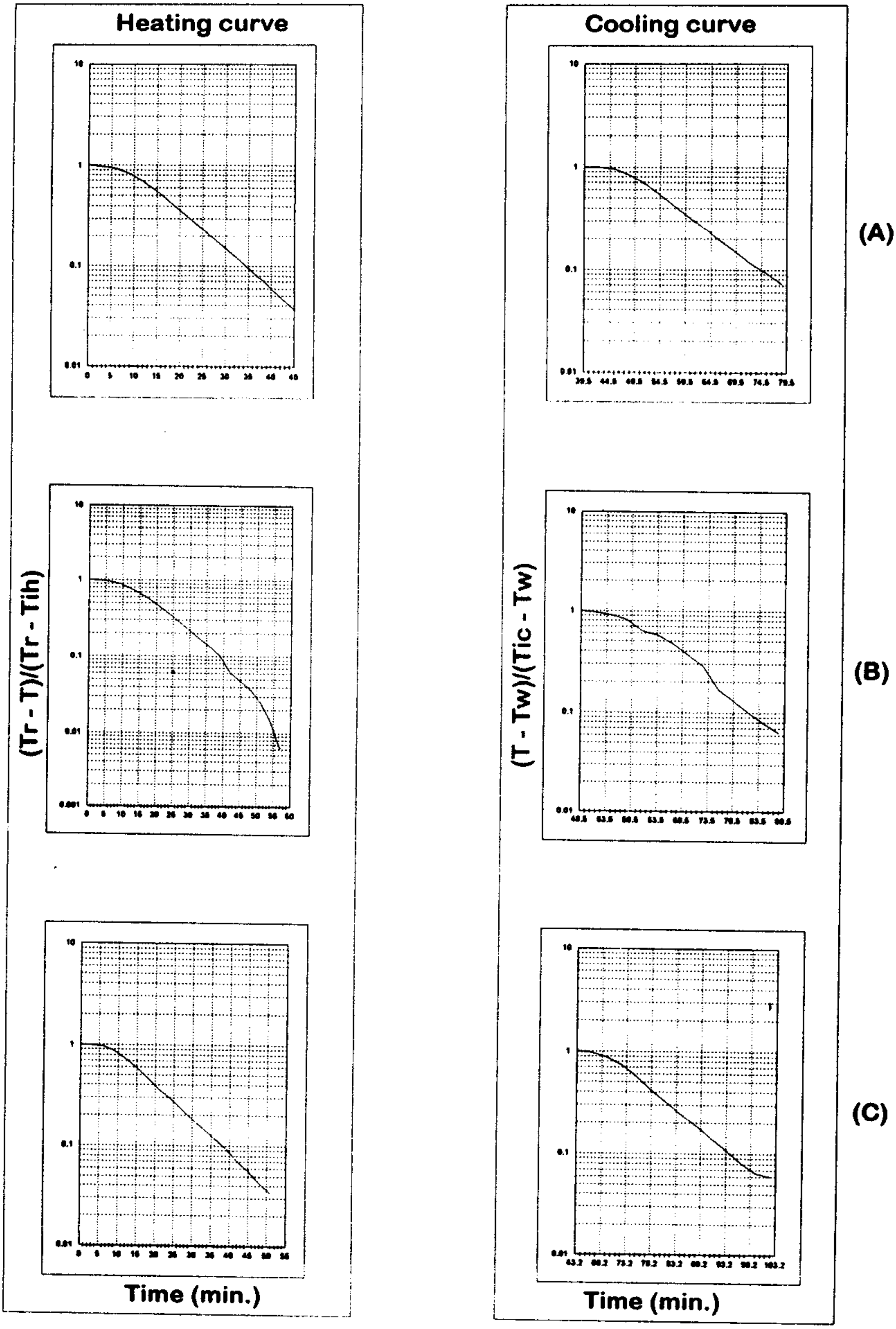

Fig. (14): Heating and cooling curves for green beans in tomato sauce heated at different temperature and time

(A):120.2°C/35 min., (B): 116°C/45 min. and (C): 112.1°C/65 min.

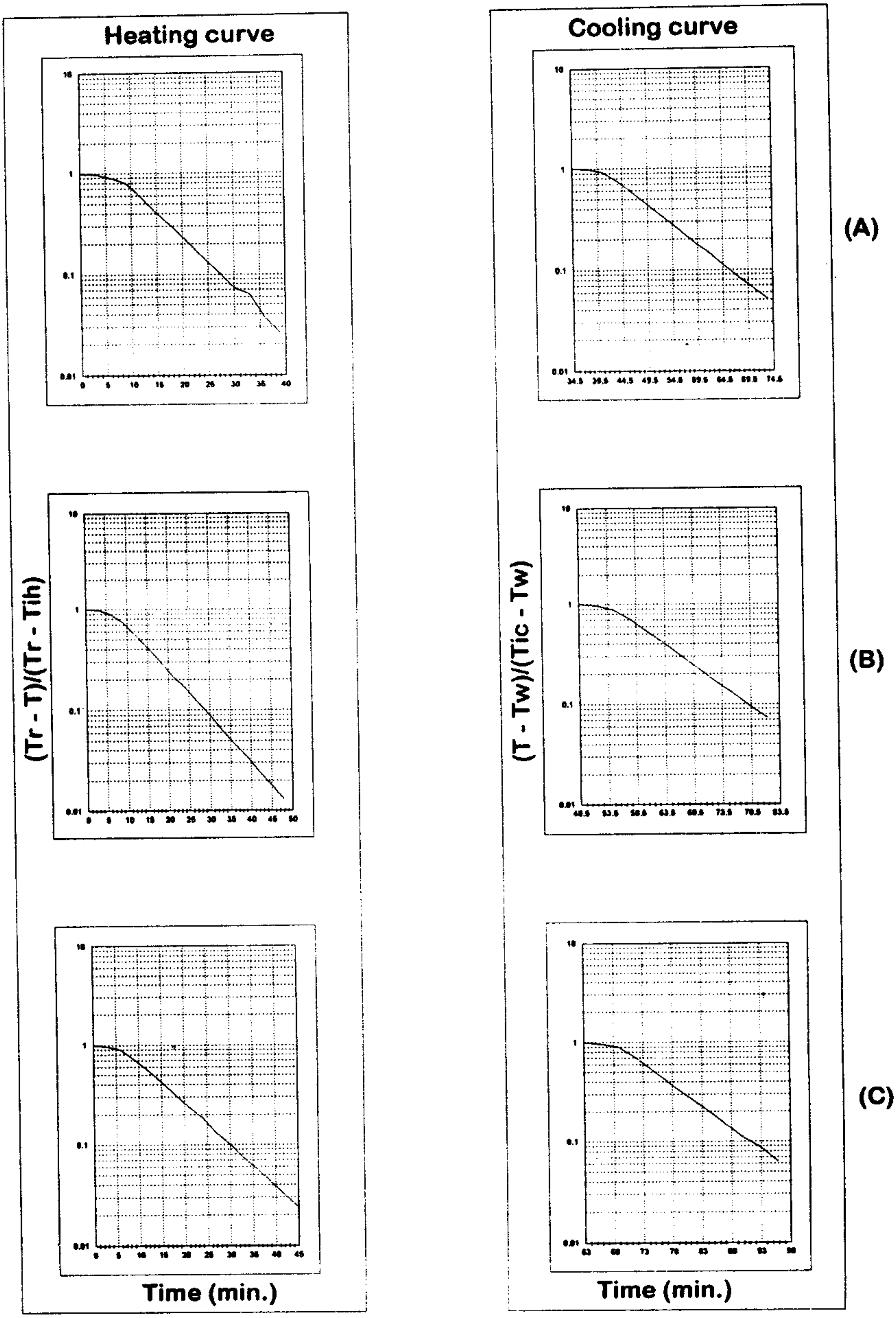

Fig. (15): Heating and cooling curves for green peas in tomato sauce heated at different temperature and time.

(A):119.9°C/30 min., (B): 116°C/45 min. and (C): 112.1°C/60 min.

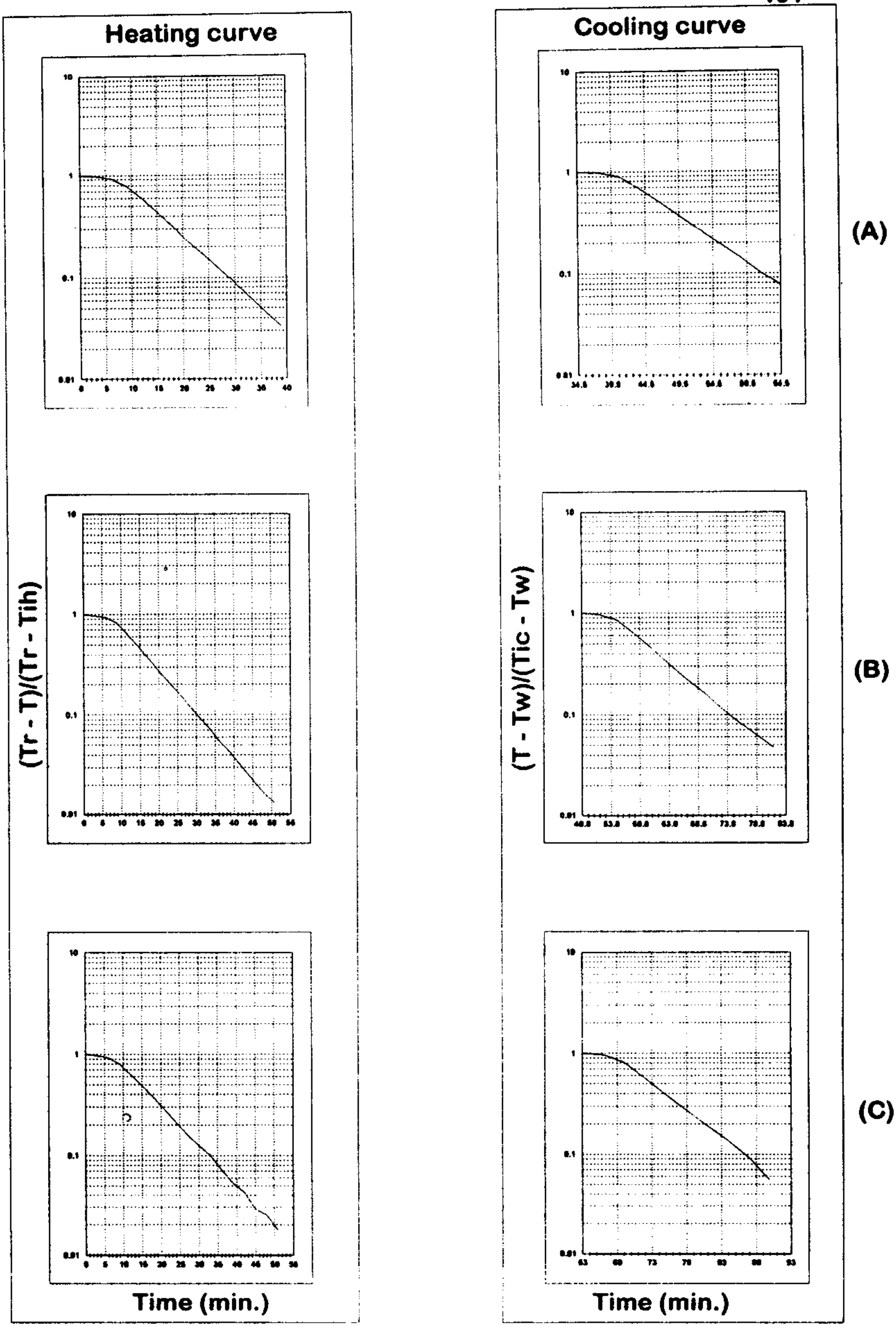

Fig. (16): Heating and cooling curves for green okra in tomato sauce heated at different temperature and time.

(A):120.2°C/30 min., (B): 116°C/45 min. and (C): 112.1°C/60 min.

respectively, were resulted in F-values of 4.08 - 16.02, 4.18 - 14.25 and 5.16 - 12.95 for green beans in tomato sauce, respectively.

Data in **Table (21)** show that, thermal processing times of 35, 25 and 15 min. holding at 112.1°C to 116.0°C to 119.9°C after come up times 1.5, 1.8 and 2.0 min., respectively, were resulted in F-values of 4.60 - 18.16, 6.66 - 12.39 and 9.22 - 13.31 for canned green peas in brine solutions, respectively, while thermal processing times of 60, 45 and 30 min. holding at 112.1°C to 116.0°C to 119.9°C after come up times 3.0, 3.5 and 4.5 min., respectively, were resulted in F-values of 4.35 - 17.60, 6.19 - 16.69 and 4.92 - 11.66 for canned green peas in tomato sauce, respectively.

With respect to data in **Table (22)** thermal process times of 35, 25 and 15 min. holding at 112.1°C to 116.0°C to 120.2°C after come up times 1.3, 1.5 and 2.0 min., respectively, were resulted in F-values of 4.22 - 14.00, 6.77 - 14.96 and 7.94 - 12.38 for canned green okra in brine solutions, respectively, while thermal processing times of 60, 45 and 30 min. holding at 112.1°C to 116.0°C to 120.2°C after come up times 3.00, 3.80 and 4.25 min., respectively, were resulted in F-values of 4.34 - 17.29, 5.78 - 16.33 and 4.83 - 11.14 for canned green okra in tomato sauce, respectively.

Calculation of F were based on previously determined "Z" values of 24.2°, 25.8°, 10.34° and 24.4°C (43.56°, 46.44°, 18.60°

Table (20): Evaluation of the carried out thermal process time as "F" value (based on different Z-values) and determination of optimum thermal process time (based on commercial concept) for canned green beans.

Retort Temp. °C	Thermal processing parameter	Green beans in brine solution				Green beans in tomato sauce			
	Spore former No. *	1	2	3	4	1	2	3	4
112.1	Come up time "I" min.	3.5				3.2			
	Holding up time "P" min.	35				65			
	g °F	1.77×10^{-3}				0.968			
	f_h min.	7.7				30			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	14.67	15.54	4.91	14.78	15.77	15.57	4.08	16.02
	U min.(to cover the commercial concept)	25.17	23.87	79.57	24.99	35.17	23.87	79.57	24.99
	Required optimum time "tB" min.	35.18	33.88	89.33	35.00	66.91	65.61	121.31	66.73
116.0	Come up time "I" min.	4.5				3.5			
	Holding up time "P" min.	25				50			
	g °F	3.5×10^{3}				3.3			
	f_h min.	6.2				27.9			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	15.50	16.03	7.02	15.46	13.11	14.25	4.18	13.26
	U min.(to cover the commercial concept)	17.37	16.85	33.35	17.30	17.37	16.85	33.35	17.30
	Required optimum time "tB" min.	23.98	23.16	38.50	23.61	57.59	57.07	72.70	57.52
120.2	Come up time "I" min.	5.5				4.5			
	Holding up time "P" min.	15				35			
	g °F	6.1×10^{-2}				6.34			
	f_h min.	5.5				25.2			
	Z °F	43.56	46.44	18:60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	12.53	12.38	9.23	12.58	12.03	12.95	5.16	12.15
	U min.(to cover the commercial concept)	11.65	11.59	13.08	11.64	11.65	11.59	13.08	11.64
	Required optimum time "tB" min.	19.90	19.84	20.90	19.89	45.35	45.29	46.78	45.34

F for 12 D concept = 2.52 min. F for commercial concept 10.68 min. for green beans

* *1- B. subtilis* *2- B. coagulans* *3- B. stearothermophilus* *4- B. cereus.*

Table (21): Evaluation of the carried out thermal process time as "F" value (based on different Z-values) and determination of optimum thermal process time (based on commercial concept) for canned green peas.

Retort Temp. °C	Thermal processing parameter	Green peas in brine solution				Green peas in tomato sauce			
	Spore former No. *	1	2	3	4	1	2	3	4
112.1	Come up time "I" min.	1.5				3.0			
	Holding up time "P" min.	35				60			
	g °F	9.7×10^{-8}				0.36			
	f_h min.	4.0				23.7			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	17.22	18.16	4.60	17.33	16.23	17.60	4.35	16.41
	U min.(to cover the commercial concept)	23.81	22.57	75.25	23.63	23.81	22.57	75.25	23.63
	Required optimum time "tB" min.	28.62	27.38	80.06	28.44	45.51	44.27	96.95	45.33
116.0	Come up time "I" min.	1.8				3.5			
	Holding up time "P" min.	25				45			
	g °F	1.6×10^{-5}				1.26			
	f_h min.	3.85				22.2			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	12.32	12.32	6.66	12.39	15.32	16.69	6.19	15.52
	U min.(to cover the commercial concept)	16.42	15.94	31.54	16.36	16.42	15.94	31.54	16.36
	Required optimum time "tB" min.	21.28	20.80	35.35	21.22	43.22	42.74	56.03	43.16
119.9	Come up time "I" min.	2.0				4.5			
	Holding up time "P" min.	15				30			
	g °F	3.87×10^{-3}				4.76			
	f_h min.	3.6				20.1			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	13.07	13.31	9.22	13.09	11.14	11.66	4.92	11.21
	U min.(to cover the commercial concept)	11.02	10.96	12.37	11.01	11.02	10.96	12.37	11.01
	Required optimum time "tB" min.	15.96	15.90	17.31	15.95	28.68	28.62	30.03	28.67

F for 12 D concept = 2.52 min. F for commercial concept 10.10 for green beans

* *1- B. subtilis* *2- B. coagulans* *3- B. stearothermophilus* *4- B. cereus.*

Table (22): Evaluation of the carried out thermal process time as "F" value (based on different Z-values) and determination of optimum thermal process time (based on commercial concept) for canned green okra.

Retort Temp. °C	Thermal processing parameter	Green okra in brine solution				Green okra in tomato sauce			
	Spore former No. *	1	2	3	4	1	2	3	4
112.1	Come up time "I" min.	1.3				3.0			
	Holding up time "P" min.	35				60			
	g °F	2.9×10^{-4}				0.53			
	f_h min.	6.2				24.9			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	13.10	14.00	4.22	13.22	16.28	17.29	4.34	16.42
	U min.(to cover the commercial concept)	25.08	23.78	79.27	24.90	25.08	23.78	79.27	24.90
	Required optimum time "tB" min.	33.46	33.16	87.65	33.28	59.57	58.27	113.76	59.39
116.0	Come up time "I" min.	1.5				3.8			
	Holding up time "P" min.	25				45			
	g °F	1.24×10^{-3}				1.467			
	f_h min.	5.1				23.1			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	14.45	14.96	6.77	14.51	15.44	16.33	5.78	15.60
	U min.(to cover the commercial concept)	17.30	16.79	33.23	17.24	17.30	16.79	33.23	17.24
	Required optimum time "tB" min.	23.76	23.25	38.60	23.70	50.42	49.91	63.66	50.36
120.2	Come up time "I" min.	2.0				4.25			
	Holding up time "P" min.	15				30			
	g °F	0.44				2.54			
	f_h min.	6.5				21.0			
	Z °F	43.56	46.44	18.60	43.92	43.56	46.44	18.60	43.92
	Evaluated "F" min.	11.25	11.52	7.94	12.38	10.93	11.14	4.83	10.95
	U min.(to cover the commercial concept)	11.61	11.54	13.03	11.60	11.61	11.54	13.03	11.60
	Required optimum time "tB" min.	19.63	19.56	20.80	19.62	42.72	42.86	43.97	42.92

F for 12 D concept = 2.52 min. F for commercial concept 10.64 in. for green beans

* *1- B. subtilis* *2- B. coagulans* *3- B. stearothermophilus* *4- B. cereus.*

and 43.92°F) for *B. subtilis, B. coagulans, B. stearothermophilus,* and *B. cereus* , respectively **(Table, 17).**

Calculated F-value to cover 12 D concept is 2.52 min. (based on Dr of *Clostridium botulinum* is 0.21 min., **(Stumbo, 1973)** which is lesser than calculated F-value required to cover the commercial concept (10.68, 10.10 and 10.64 min.) for canned green beans, peas and okra, respectively, either in brine solution or tomato sauce, based on Dr of *B. stearothermophilus* is 2.00, the highest obtained Dr **(Table, 17).**

These values were calculated using the following equation :

$$F = Dr (\log a - \log b)$$

where: value of **a** was calculated as a product of count of spore-former/25 g (24, 12, 25 spores/25g). For green beans, peas and okra, respectively. **Table (14)** multiplied by weight of can (227.5 g for blanched green beans or green peas, 210 g for blanched green okra), value of **b** is 0.001 (0.1% spoilage percent).

Data in **Table (20)** indicated that, holding times of 35, 25 and 15 min. at 112.1°C to 116.0°C to 120.2°C cover the required F based on commercial concept (10.68 min.) except for *B. stearothermophilus* F = 4.91, 7.02 and 9.23, 4.08, 4.18 and 5.16 for canned green beans in brine solution and tomato sauce, respectively.

So, the optimum time "tB" was calculated and tabulated in **Table (20),** it is clear that, "tB" value ranged from 33.88 to 89.33 and from 23.16 to 38.50 and from 19.84 to 20.90 min. for canned green beans in brine solution at 112.1°C to 116.0°C to 120.2°C, respectively, and ranged from 65.16 to 121.31 min. and from 57.07 to 72.70 min. and from 45.29 to 46.78 min. for canned green bean in tomato sauce at the same retort temperature, respectively.

Data in **Table (21)** indicated that, holding times of 35, 25 and 15 min., 60, 45 and 30 min. at 112.1°C to 116.0°C to 119.9°C cover the required F based on commercial concept (10.10 min.) except for B. stearothermophilus F = 4.60, 6.66 and 9.22, 4.35, 6.19 and 4.92 for canned green peas in brine solution and tomato sauce, respectively.

So, the optimum time "tB" was calculated and tabulated in **Table (21).** It is clear that, "tB" value ranged from 27.38 to 80.06 and from 20.80 to 35.35 and from 15.90 to 17.31 min. for canned green peas in brine solution at 112.2°C to 116.0°C to 119.9°C, respectively, and ranged from 44.27 to 96.95 min. and from 42.74 to 56.03 min. and from 28.62 to 30.03 min. for canned green peas in tomato sauce at the same retort temperature, respectively.

Data in **Table (22)** indicated that, holding times of 35, 25 and 15 min., 60, 45 and 30 min. at 112.1°C to 116.0°C to 120.2°C cover the required F based on commercial concept (10.48 min.) except for *B. stearothermophilus* F = 4.22, 6.77 and 7.94, 4.34, 5.78 and 4.83 for canned green okra in brine solution and tomato sauce, respectively.

So, the optimum time "tB" was calculated and tabulated in **Table (22),** it is clear that, "tB" value ranged from 33.16 to 87.65 and from 23.25 to 38.60 and from 19.56 to 20.80 min. for canned green okra in brine solution at 112.1°C to 116.0°C to 120.2°C, respectively, and ranged from 58.27 to 113.76 min. and from 49.91 to 63.66 min. and from 42.86 to 43.97 min. for canned green okra in tomato sauce at the same temperature, respectively. So, it could be recommended the use of retort temperature of 116.0°C (240°F). It resulted in greater retentation for nutrition and sensory quality factors retention than processing at higher or lower temperatures. Also, it covers F for commercial concept for *Bacillus stearothermophilus* and increase the shelf life of canned vegetables storaged in hot weather (40°C) (Tropical climate). The retort temperature 116°C (240°F) could be used for 38.5, 35.35 and 38.60 minutes for canned green beans, peas and okra in brine solution, respectively. On the other hand, the retort temperature 116°C (240°F) could be used for 72.70, 56.03, 63.66 minutes for canned green beans, peas and okra in tomato sauce, respectively.