IV. RESULTS AND DISCUSSION

4.1. Major constituents of edible portion of mango, guava and orange:

Data recorded in Table (1) show the major constituents of edible portion of the obtained fresh mango, guava pulps and orange juice, for the varieties available (Balady) for these fruits that used in the industry, in Egypt, especially in the Kalubia Governorate.

The juices were analyzed for their moisture, protein, ash, fat, crude fiber and carbohydrates. The results for these analyses were 82.43, 0.88, 0.310, 0.230, 0.90 and 15.25% for mango juice; 84.73, 0.96, 0.432, 0.306, 0.680 and 12.89% for guava juice and 86.44, 0.82, 0.302, 0.130, 0.37 and 11.938% for orange juice, respectively. These results are in agreement with those obtained by Pearson (1987) who found that water 83.0%; fiber 1.5% and protein 0.5%. Also Watt and Merrill (1975) and McCance and Widdowson's (1992) found that moisture (81.7-82.4%); protein 0.7% ash (0.223-0.4%), fat (0.2-0.4%) and total carbohydrate (14.1-16.8%) for raw mango juice; respectively. Also the obtained data are inagreement with McCance and Widdowson's (1992) who determined the composition of raw guava for water, protein, fat and total carbohydrate, the values were 84.7, 0.80, 0.50 and 5.0, respectively.

Pearson (1987) determined the chemical composition of orange juice and found that moisture was 88.1% and protein 0.81%. Also, these results are in agreement with those obtained by Huessein *et al.* (1963) and Bareh (1997) who found the total soluble solids of orange juice was within the range from 11.5 to 14.4°Brix. Data are in agreement

Table (1): Major constituents of edible portion of mango, guava and orange (mean±S.E.)

Component		Type of fruit		
		Mango	Guava	Orange
Moisture	%	82.43±0.01	84.73±0.005	86.44±0.014
Protein (6.25)	%	0.88±0.01	0.96±0.002	0.82±0.0014
Ash	%	0.31±0.001	0.432±0.042	0.302±0.0007
Ether extract	%	0.23±0.004	0.306±0.007	0.130±0.003
Crude fiber	%	0.90±0.001	0.680±0.001	0.37±0.003
Carbohydrate*	%	15.25±0.026	12.89±0.051	11.938±0.019

* Carbohydrate were calculated by difference.

with those obtained by Soliman (1969) and Sharoba (1999). They found the moisture content in orange juice was within the range from 86.64 to 87.99%.

4.2. PART 1: Mango nectar:

4.2.1. Effect of canning process on the chemical properties of mango nectar:

Chemical properties of mango nectar are greatly affected by the variety, stage of maturity and growing conditions. It may be worth while to refer to some components that constitute fruit juice (Tressler and Joslyn, 1961). Table (2) shows the chemical properties of mango nectar.

4.2.1.1. Total solids and soluble solids:

The total solids and soluble solids content is an important factors in the production of juices and nectar. It is well established that the higher of the total solids the best in the quality of the juice and the nectar made from this juice.

Total solids were 16.30, 18.70, 18.72, 18.70 and 18.57% for raw, preheated, processed at 91.3°C/35 min, processed at 94.9°C/25 min and processed mango nectar at 99.9°C/15 min, respectively. While soluble solids were 14.50, 16.79, 16.82, 16.73 and 16.80°Brix for those products, respectively.

Table (2): Effect of canning processing on some chemical properties of mango nectar (mean±S.E.)

Properties	Raw mango nectar	Preheated mango nectar	Processed mango nectar at		
			91.3°C/35 min.	94.9°C/25 min.	99.9°C/15 min.
Total solids %	16.30±0.22	18.70±0.22	18.72±0.16	18.70±0.13	18.57±0.15
Soluble solids %	14.50±0.18	16.79±0.16	16.82±0.46	16.73±0.31	16.80±0.03
Acidity (as citric) %	0.39±0.02	0.38±0.01	0.38±0.005	0.40±0.02	0.40±0.02
pH value	3.50±0.01	3.53±0.01	3.63±0.02	3.62±0.01	3.65±0.02
Ascorbic acid (mg/100 g)	3.41±0.21	1.24±0.02	1.09±0.04	1.08±0.07	1.06±0.06
Total sugars %	12.16±0.12	12.71±0.15	12.53±0.13	12.54±0.24	12.66±0.16
Non reducing sugars %	11.03±0.06	11.43±0.08	10.86±0.17	10.91±0.06	11.04±0.10
Reducing sugars %	1.13±0.09	1.28±0.08	1.67±0.13	1.63±0.03	1.62±0.08
Total carotene (mg/L)	0.396±0.012	0.374±0.011	0.311±0.017	0.336±0.01	0.348±0.012

Data calculated on fresh weight.

4.2.1.2. Titratable acidity and pH value:

Titratable acidity would be of great importance since the ratio of total soluble solids to acidity will affect flavour. Data in Table (2) showed that the titratable acidity (as citric acid) was 0.39% for raw mango nectar. Preheating or any of the thermal processing have no noticeable effect on titratable acidity that it ranged from 0.38 to 0.40%. These results are in agreement with those obtained by El-Sayed (1966) and Brekke *et al.* (1975). They reported that the total acidity ranged from 0.21% to 0.51% (as citric acid) for mango. On the other hand, the pH values were 3.50 and 3.53 for raw and preheated mango nectar, respectively. While pH values of processed mango nectar at 91.3°C/35 min; 94.9°C/25 min. and 99.9°C/15 min. were 3.63; 3.62 and 3.65, respectively.

Brekke *et al.* (1975) recorded pH values of mango ranged from 3.85 to 4.5.

4.2.1.3. Ascorbic acid (Vit. C):

Ascorbic acid retention is considered a good indication for high quality product due to its reducing effect which reflects some technical properties; such as colour retention. In addition, it has a high nutritive value being one of the important vitamins.

Levels of vitamin C were 3.41 and 1.24 mg/100 g for raw and preheated mango nectar, respectively. While processed mango nectar at 91.3°C/35 min., 94.9°C/25 min and 99.9°C/15 min. contained 1.09, 1.08 and 1.06 mg Vit. C/100 g nectar, respectively. The data indicated the loss in vitamin C due to the effect of thermal processing of the mango nectar. El-Sayed, (1966) reported that vitamin C values was

50.42 and 29.45 mg Vit. C/100 g (on dry basis) for whole fruit and after processing (canned), respectively. Also, Brekke *et al.* (1975) reported that mangoes contained of ascorbic acid ranged from 9 to 40 mg/100 g.

4.2.1.4. Total sugars and reducing sugars:

Total sugars in mango nectar are prime importance since their effect on flavour which is considered the most important quality attribute. Data in Table (2) showed that the reducing sugars tended to increase after carrying out the thermal process while total sugars content was stable; this increase is due to the effect of both acidity of nectar and heat treatment during the manufacture of canned mango nectar (El-Sayed, 1966). As shown in Table (2) total sugars; reducing sugars and the non reducing sugars were 12.16; 1.13 and 11.03% for raw mango nectar respectively. Preheated mango nectar contained 12.71, 1.28 and 11.43%, respectively. After thermal processing of nectar these sugars were 12.53, 1.67 and 10.86% at 91.3°C/35 min.; 12.54, 1.63 and 10.91% at 94.9°C/25 min. and 12.66, 1.62 and 11.04% at 99.9°C/15 min., respectively. The obtained data were in agreement with those observed by El-Sayed (1966) who calculate the reducing sugar, non-reducing sugar and total sugars were 20.98%; 50.42 and 71.40% (on dry weight basis) of mango juice after canning, respectively. Chan and Kwok (1975) reported 12.15% total sugars in Hayden mango puree. Sucrose content of mango puree was 9.00% and the total reducing sugar was 3.15%. Also Pearson (1987) and McCance and Widdowson's (1992) found that the total sugars were 15.3 and 13.8% in ripe raw mango, respectively.

4.2.1.5. Carotenoid content:

The carotenoid content were 0.396 and 0.374 mg/L for raw and preheated mango nectar. After processing at 91.3°C/35 min.; 94.9°C/25 min. and 99.9°C/15 min. carotenoid contents were 0.311, 0.336 and 0.348 mg/L, respectively. These results were in agreement with those obtained by El-Sayed (1966). He found that the carotene content in mango juice after canning was 3.68 mg/100 g.

Brekke *et al.* (1975) reported 1.4 to 5.0 mg/100 g of total carotenoid content of mango cultivars in Hawii during 6 crop years. Also, Hulme (1971) reported 12.5 mg carotenoids per 100 g mango pulp. The results of (McCance and Widdowson's, 1992) ranged from 300 to 3000 µg carotene per 100 g for raw mangoes.

4.2.2. Effect of canning process on enzyme activity of mango nectar:

4.2.2.1. Pectinmethylesterase activity:

Pectinmethylesterase enzyme is the main factor which greatly influence the quality; stability and processability because it is the highest enzyme stability in the nectar. As shown in Table (3) the enzyme activity of (PME) in raw mango nectar was 82.7 PME unit $X10^6$/g. Siddalingu *et al.* (1985) reported that the PE activity (PE unit = $1X10^4$ per cm^3) ranged from 1.16 to 5.83 for raw mango pulp which could be expressed as 29 to 145 for mango nectar containing 25% mango pulp and PE unit = $1X10^6/cm^3$. Preheating process decreased the activity of this enzyme to 40 PME unit $X10^6$/g. On the other hand, thermal processing at 91.3°C/35 min., 94.9°C/25 min and 99.9°C/15 min. reduced the activity to 6.3, 6.6 and 10 PME unit $X10^6$, respectively.

Table (3): Effect of canning processing steps on enzyme activity of mango nectar (on fresh weight).

Treatment of nectar	Pectinmethylesterase PME unit $x10^6$	Peroxidase (O.D./min) $x10^3$	Polyphenoloxidase (O.D./min) $x10^3$
Raw mango nectar	87.20	15.30	2.60
After preheating	40.0	2.9	0.20
After thermal processing at: 91.3°C/35 min.	6.30	0.0	0.0
94.9°C/25 min.	6.60	0.0	0.0
99.9°C/15 min.	10.00	0.0	0.0

4.2.2.2. Peroxidase and polyphenoloxidase activity:

Peroxidase and polyphenoloxidase enzymes are important enzymes due to their effect on colour and of flavour the juices. As shown in Table (3) the activities of peroxidase and polyphenolxidase in raw mango nectar were 15.3 and 2.6 O.D./min. $X10^3$, respectively. Preheating process led to decrease their activities to 2.9 and 0.2 O.D./min. $X10^3$; respectively.

Thermal processing at 91.3°C/35 min, 94.5°C/25 min and 99.9°C/15 min resulted in no activity for either peroxidase or polyphenoloxidase.

4.2.3. Evaluation of thermal process for mango nectar:

In high acid foods having pH $\leq$ 4, the spoilage is generally caused by non-sporulating bacteria like lactobacilli and leuconostoc, yeasts and moulds. Among the moulds, *Byssochlamys fulva* is more important. Heat resistance of lactobacilli, yeasts and moulds has been found to be lower than that of the heat resistant enzyme systems such as peroxidase, pectinesterase (PE) and polyphenoloxidase present in fruits. These enzyme cause undesirable changes unless inactivated (Dastur *et al.*, 1968). Thermal process schedule evolved on the basis of the enzyme inactivation rendered the canned product microbiologically safe (Nath and Ranganna; 1983). So, it was decided to evaluate the optimum thermal processing of mango nectar on the base of heat resistance parameters of pectinmethylesterase which is the highest resistance enzyme. Heat penetration data were obtained for canned mango nectar (size 360) Ø 65x110 min. which was processed at 91.3°C/35 min.; 94.9°C/25 min. and 99.9°C/15 min. Heat

penetration data were plotted as heating and cooling curves (Fig. 1). The values of f_h values were obtained and tabulated in Table (4).

Data indicated that increasing retort temperature from 91.3°C to 94.9°C and 99.9°C was accompanied by noticeable decreasing in f_h value from 28.11 to 25.47 and 21.75 for heating phase and f_c from 36.46 to 33.31 and 28.0 min. for cooling phase for canned mango nectar, respectively.

Heating and cooling curves parameters (Fig. 1) were used to evaluate the carried out thermal processing as indicated in Table (4). It could be seen that thermal processing times of 35, 25 and 15 min. holding at 91.3°C; 94.9°C and 99.9 °C after come up times 12; 6 and 14 min. resulted in F-value of 2.024; 2.89 and 2.775 min., respectively, for mango nectar.

Calculation of "F" values were based on reviewed "Z" and D values of enzyme pectinesterase (PE) using the $D_{100}^{11.9} = 0.33$ min. according to Siddalingu *et al.* (1985) applying the equations discribed by (Stumbo, 1973).

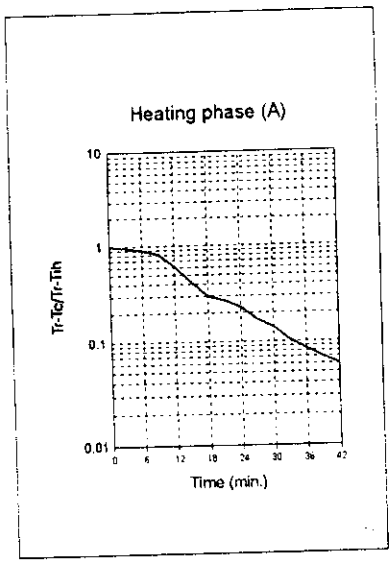
The enzyme retentions as percent were calculated using the following equation:

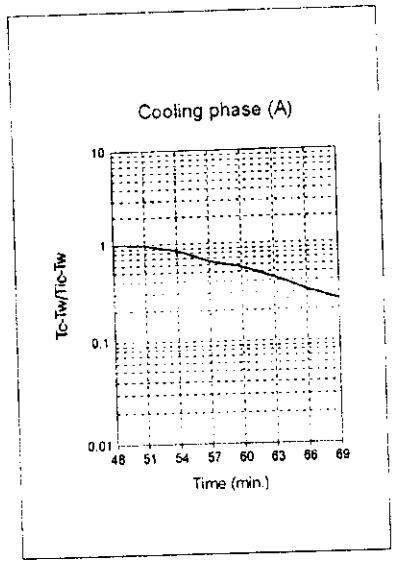
$$F = D_r (\log a - \log b)$$

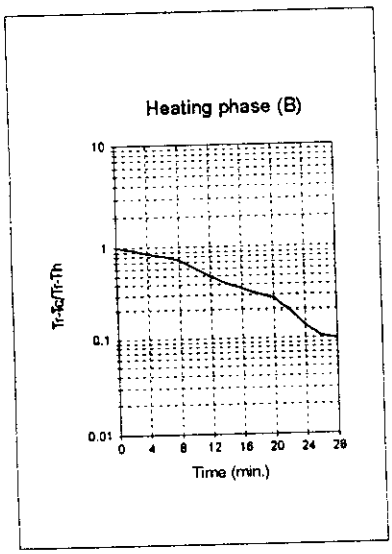
where: a: 100% of enzyme activity.

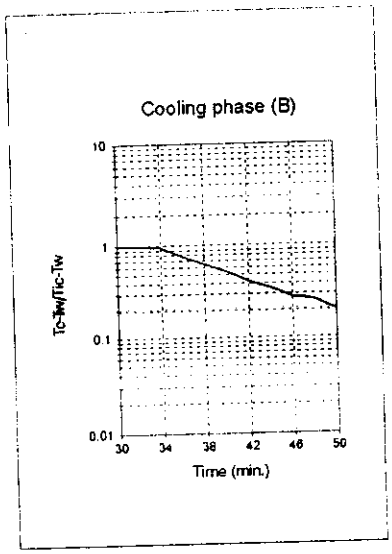
b: Is the value of the percent enzyme activity retained at the end of process.

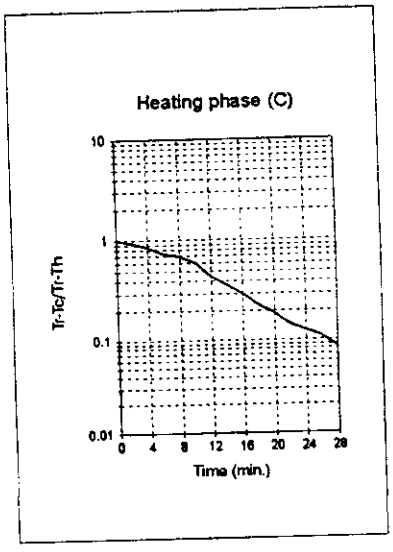
As shown in Table (4) the enzyme retentions percent was 7.36×10^{-5}; 1.73×10^{-7} and 3.89×10^{-7} for the process at 91.3°C/35 min., 94.9°C/25 min. and 99.9°C/15 min., respectively.











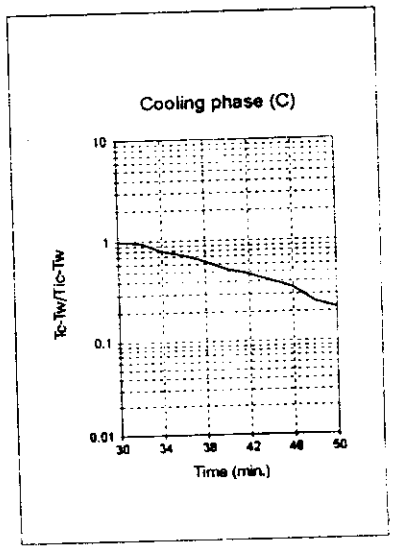


Fig. (1): Heating penetration curves for canned mango nectar (Ø65x110 mm) thermally treated at 91.3°C (A), 94.9°C (B) and 99.9°C (C).

Table (4): Evaluation of the carried out thermal process as % enzyme retention for mango nectar in cans (Ø 65 x 110 mm).

Thermal processing parameters	Canned mango nectar		
	A	B	C
Retort temperature (°C)	91.3	94.9	99.9
Come up time (min.)	12.0	6.0	14.0
Holding time (min.)	35.0	25.0	15.0
Initial temperature (°C)	42.2	67.6	51.1
f_h (min.)	28.11	25.47	21.75
f_c (min.)	36.46	33.31	28.0
J_h	0.98	1.07	0.92
J_c	1.08	1.01	1.13
Z value reference* (°C)	11.9	11.9	11.9
Reference temperature*(°C)	100	100	100
D value of (P.M.E.)* (min.)	0.33	0.33	0.33
F value for process (min.)	2.024	2.890	2.775
Decimal reduction of enzyme equivalent to F value used for process calculation (F/D)	6.130	8.760	8.409
% of enzyme retention	7.36×10^{-5}	1.73×10^{-7}	3.89×10^{-7}

* Siddalingu *et al.* (1985).

The decimal reduction of enzyme equivalent to "F" value used for process calculation (F/D) were 6.12; 8.76 and 8.409 for the three process, respectively. To illustrate the effect of initial temperature of mango nectar on the verified F value, the obtained heat penetration data were converted to obtain new data at new initial temperature using equation of (Schultz and Olson, 1940). The new calculations are presented in Table (5).

Comparing data of Tables (4 and 5) indicated that increasing the initial temperature is accompanied by increasing the verified F values. For example the process B has initial temperatures 42.2 and 67.7°C which was accompanied by F values 1.737 and 2.89, respectively (Tables 4 and 5).

To determine the optimum holding time to the converted heat penetration data of thermal process, calculations were carried out on the base of $5.45X10^{-4}$ pectinmethyesterase (PE) enzyme activity retention (F = 1.737 min.) as shown in Table (6). It could be noticed that the optimum holding time were 32.74, 25 and 12.75 min. for 91.3; 94.9 and 99.9°C at come up times 12; 6 and 14 min. and constant initial temperature of 42.2°C, respectively.

To evaluate the optimum process time at different retort temperatures (90 and 100) and different initial temperatures (50, 60 and 70°C), equation of (Schultz and Olson, 1940) was applied on the obtained heat penetration data for these retort and initial temperatures. New data were plotted (not shown), new parameters were obtained and new calculations was carried out. Table (7) represents the obtained optimum holding times.

Table (5): Evaluation of the carried out thermal process time as % enzyme activity retention for mango nectar in cans (Ø 65 x 110 mm) at constant initial temperature 42.2°C.

Thermal processing parameters	Canned mango nectar		
	A	B	C
Retort temperature (°C)	91.3	94.9	99.9
Come up time (min.)	12.0	6.0	14.0
Holding time (min.)	35.0	25.0	15.0
Initial temperature (°C)	42.2	42.2	42.2
f_h (min.)	28.11	24.69	20.62
f_c (min.)	36.46	33.31	28.0
J_h	0.98	0.92	0.88
J_c	1.08	1.01	1.13
Z value reference* (°C)	11.9	11.9	11.9
Reference temperature*(°C)	100	100	100
D value of (P.M.E.)* (min.)	0.33	0.33	0.33
F value for process (min.)	2.024	1.737	2.620
Decimal reduction of enzyme equivalent to F value used for process calculation (F/D)	6.13	5.26	7.94
% of enzyme retention	7.36×10^{-3}	5.45×10^{-4}	1.15×10^{-6}

* Siddalingu *et al.* (1985).

Table (6): Evaluation of the optimum thermal process time when enzyme retention = 5.45×10^{-4}% and constant initial temperature 42.2°C for mango nectar.

Thermal processing parameters	Canned mango nectar		
	A	B	C
Retort temperature (°C)	91.3	94.9	99.9
Come up time (min.)	12.0	6.0	14.0
Initial temperature (°C)	42.2	42.2	42.2
f_h (min.)	28.11	24.69	20.62
f_c (min.)	36.46	33.31	28.0
J_h	0.98	0.92	0.88
J_c	1.08	1.01	1.13
Z value reference* (°C)	11.9	11.9	11.9
Reference temperature*(°C)	100	100	100
D value of (P.M.E.)* (min.)	0.33	0.33	0.33
% of enzyme retention	5.45×10^{-4}	5.45×10^{-4}	5.45×10^{-4}
Required F value (min.)	1.737	1.737	1.737
Optimum holding time (min.)	32.74	25.0	12.75

* Siddalingu *et al.* (1985).

Table (7): Optimum thermal process time (min.) on the base of F = 1.73 min. and b = 5.45×10^{-4}% for canned mango nectar (Ø 65 x 110 mm) at different initial and retort temperatures.

Retort temperature (°C)	Initial temperatures (°C)		
	50	60	70
90	37.86	26.70	22.70
100	17.36	16.03	13.57

4.2.4. Sensory evaluation for canned mango nectar:

Sensory evaluation is generally the final guide of the quality from the consumers point of view. Thus, it is beneficial to make a comparsion between the three thermal processes which were applied. The texture, colour, taste, odour and overall acceptability were evaluated. From the data recorded in Table (8) it is clear that no significant differences for processed mango nectar at 91.3°C/35 min; 94.9°C/25 min and 99.9°C/15 min. in texture, colour and overall acceptability. On other hand the scores showed significant difference in taste and odour of the same processed mango nectar. The highest score in taste and odour were 21.8 and 22.1, respectively, for processed mango nectar at 99.9°C/15 min.,.

Generally the highest score in overall acceptability was 86.6+0.23 of mango nectar processed at 99.9°C/15 min. and the lowest score was 84.5±0.22 in mango nectar processed at 94.9°C/25 min.

Table (8): Sensory evaluation of mango nectar (mean of 10 panelists ± S.E.)

Processed mango nectar	Sensory attributes (scores)				
	Texture (25)	Colour (25)	Taste (25)	Odour (25)	Overall acceptability (100)
91.3°C/35 min	21.1±0.36 [a]	21.7±0.37 [a]	20.5±0.32 [a]	21.5±0.38	84.8±0.23 [a]
94.9°C/25 min.	21.6±0.40 [a]	21.5±0.40 [a]	20.9±0.35 [a]	20.5±0.40	84.5±0.22 [a]
99.9°C/15 min.	20.9±0.29 [a]	21.8±0.27 [a]	21.8±0.34	22.1±0.17	86.6±0.23 [a]
L.S.D. at ≥ 0.05	N.S.	N.S.	0.532	0.515	N.S.

a: there is no significant difference between any two means have the same letter within any attribute.

Table (9): Effect of canning processing on some chemical properties of guava nectar (mean±S.E.)

Properties	Raw guava nectar	Preheated guava nectar	Processed guava nectar at		
			90.4°C/35 min.	95.1°C/25 min.	99.8°C/15 min.
Total solids %	15.97±0.12	17.28±0.12	17.45±0.14	17.57±0.07	17.47±0.11
Soluble solids %	14.82±0.09	15.52±0.21	15.63±0.07	15.62±0.14	15.63±0.17
Acidity (as citric) %	0.196±0.001	0.192±0.006	0.200±0.002	0.203±0.002	0.202±0.002
pH value	3.38±0.01	3.39±0.01	3.34±0.01	3.35±0.01	3.35±0.01
Ascorbic acid (mg/100 g)	26.50±0.45	22.83±0.27	20.00±0.16	21.30±0.29	22.78±0.17
Total sugar %	12.37±0.11	13.42±0.10	13.66±0.16	13.47±0.21	13.25±0.19
Non reducing sugar %	10.57±0.40	11.42±0.10	10.72±0.06	10.54±0.06	10.43±0.11
Reducing sugar %	1.80±0.04	2.00±0.05	2.94±0.05	2.93±0.17	2.82±0.10
Total carotene (mg/L)	0.174±0.004	0.091±0.003	0.055±0.006	0.057±0.005	0.061±0.003

Data calculated on fresh weight.

4.3.1.2. Titratable acidity and pH value:

The acidity of guava nectar is the factor plays an important part in the flavour acceptance of the nectar and manufactured products. The acidity values obtained from the tested guava nectar were 0.196 and 0.192% (as citric acid anhydrous) for raw guava nectar and after preheated, respectively. After processed at 90.4°C/35 min., 95.1°C/25 min. and 99.8°C/15 min. The acidity was 0.200, 0.203 and 0.202%, respectively. These results were in agreement with the data obtained by Yeh (1970) who obtained the acidity 0.17-0.29% as citric acid of guava nectar content 15-25% guava juice.

On the other hand the pH values was 3.38 and 3.39 of raw (prepared) guava nectar and after preheating respectively. After processing at 90.4°C/35 min; 95.1°C/25 min and 99.8°C/15 min were 3.34; 3.35 and 3.35 pH values respectively. these results agreement with Luh (1971) who discussed that the pH values in majority of the common guava in Hawaii fill into the sour or sub-acid category with pH values ranging from 3.0-3.5.

4.3.1.3. Ascorbic acid (Vit. C):

From the data presented in Table (9) it could be noticed that the ascorbic acid in prepared guava nectar was 26.5 mg Vit. C /100 g and the loss of ascorbic acid during preheating was 22.83 mg Vit. C/100 g. But after processing the guava nectar at 90.4°C/35 min., 95.1°C/25 min. and 99.8°C/15 min. were 20.00, 21.30 and 22.78 mg Vit. C/100 g.

From these results it could be stated that the preheating had high effect on the ascorbic acid content (Vit. C); while pasteurization had

no marked effect on it. This may be attributed to the fact that the preheating was done in an open vessel exposed to the air which caused the oxidation of ascorbic acid. In addition, it may be also due to the complete inhibition of ascorbic acid oxidase by the thermal process (El-Sayed, 1966).

Rahman *et al.* (1964) found that the ascorbic acid content was 300 mg/100 ml., while Boyle *et al.* (1957) found that the Vit. C ranged from 143.8 to 492 mg/100 g.

4.3.1.4. Total sugars and reducing sugars:

Total sugars in guava nectar are of prime importance since it affect flavour which is considered the most important quality attribute. As shown in Table (9) the total sugars in raw (prepared) guava nectar and after preheating were 12.37 and 13.42% and non reducing sugars were 10.57 and 11.42%, respectively, but the reducing sugars were 1.80 and 2.00% respectively.

After processing guava nectar at 90.4°C/35 min., 95.1°C/25 min and 99.8°C/15 min. The total sugar were 13.66, 13.47 and 13.25%, non reducing sugars were 10.72; 10.54 and 10.43% and the reducing sugar were 2.94, 2.93 and 2.82%, respectively.

The results showed the reducing sugars tended to increase after preheating and the same after processing. While the total sugar content was stable. The rate of inversion was more obvious in canned guava nectar; the increase in reducing sugar is due to the effect of both acidity and heat used for thermal process (El-Sayed, 1966), while Chan and Kwok (1975) analyzed the guava puree. The results were 5.82% total sugars, 3.43% fructose, 2.08% D-glucose and 0.31% sucrose.

4.3.1.5. Carotenoid content:

The carotenoid content in guava nectar were 0.174 and 0.091 mg/L for prepared and after preheating guava nectar, respectively. After processing at 90.4°C/35 min., 95.1°C/25 min. and 99.8°C/15 min. were 0.055; 0.057 and 0.061 mg carotene/L, respectively.

4.3.2. Effect of canning processing steps on enzyme activity of guava nectar:

4.3.2.1. Pectinmethylesterase (PME) activity:

The pectinmethylesterase activity (PME unit $x10^6$/g) were 135.8 and 75.0 for raw and after preheated guava nectar, respectively Table (10). After thermal processing the cans at 90.4°C/35 min. 95.1°C/25 min. and 99.8°C/15 min., the PME unit $x10^6$/g were 26.6, 35.0 and 40.0 for guava nectar respectively The results are in agreement with these obtained by Siddalingu *et al.* (1985) who reported the pectinesterase (PE) activity in guava pulp were ranged from 7.80 to 19.90 (PE unit = $1x10^4$ per cm^3).

4.3.2.2. Peroxidase and polyphenoloxidase activity:

Peroxidase and polyphenoloxidase enzymes are very important that were effective on the colour of juice as showed in Table (10). The activity of peroxidase in raw guava nectar was 22.5 O.D. $x10^3$/min. the activity was decrease after preheating to 0.50 O.D. $x10^3$/min.. On the other hand the activity of polyphenoloxidase were 1.4 and 0.40 O.D. $x10^3$/min. for prepared (raw) and after preheating guava nectar, respectively.

Table (10): Effect of canning processing steps on enzyme activity of guava nectar (on fresh weight).

Treatment of nectar	Pectinmethylesterase PME unit $x10^6$	Peroxidase (O.D./min) $x10^3$	Polyphenoloxidase (O.D./min) $x10^3$
Raw guava nectar	135.8	22.5	1.4
After preheating	75.0	0.5	0.4
After thermal processing at: 90.4°C/35 min.	26.6	0.0	0.0
95.1°C/25 min.	35.0	0.0	0.0
99.8°C/15 min.	40.0	0.0	0.0

Thermal processing at the 90.4°C/35 min., 95.1°C/25 min. and 99.8°C/15 min. was resulted in no activity for either peroxidase or polyphenoloxidase enzyme.

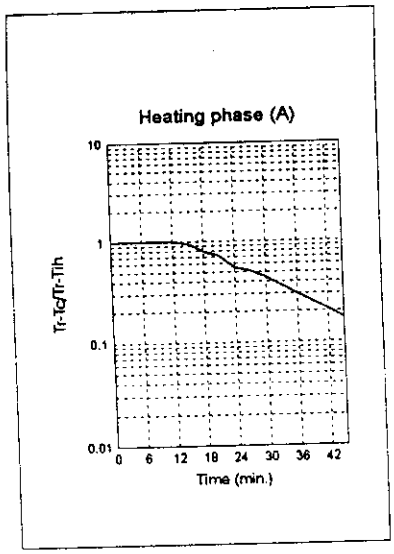
4.3.3. Evalution of thermal process of guava nectar:

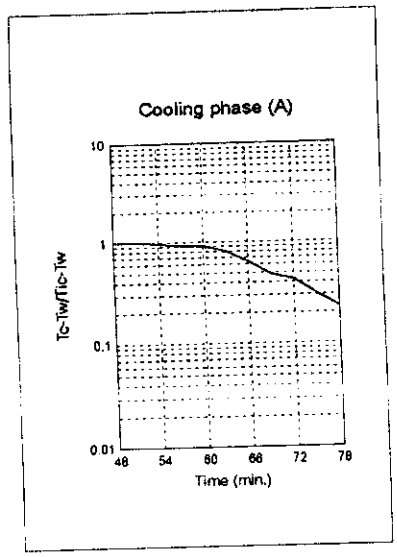
Guava nectar having pH value from 3.30 to 3.50 (acid food) and the heat resistant enzyme such as peroxidase, polyphenoloxidase and pectinmethylesterase were higher than that heat resistance of lactobacilli, yeasts and moulds (Dastur *et al.*, 1968). Thermal process schedule evaluated on the basis of the enzyme inactivation rendered the canned product microbiologically safe (Nath and Ranganna, 1983). So, it was decided to evaluate the optimum thermal process of guava nectar on the base of heat resistance parameter of pectinmethylesterase (PME) which is the highest resistance enzyme.

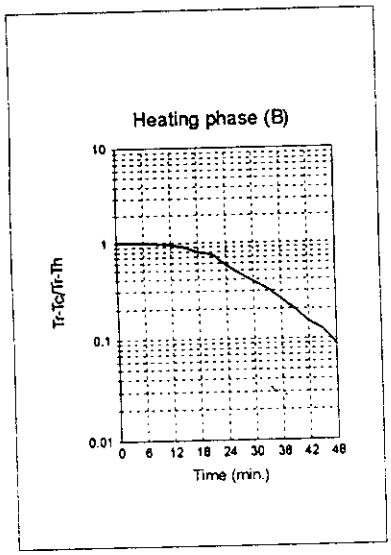
Heat penetration data were obtained for canned guava nectar (Ø 65x110 mm) which was processed at 90.4°C/35 min., 95.1°C/25 min. and 99.8°C/15 min. Heat penetration data were plotted as heating and cooling curves (Fig. 2).

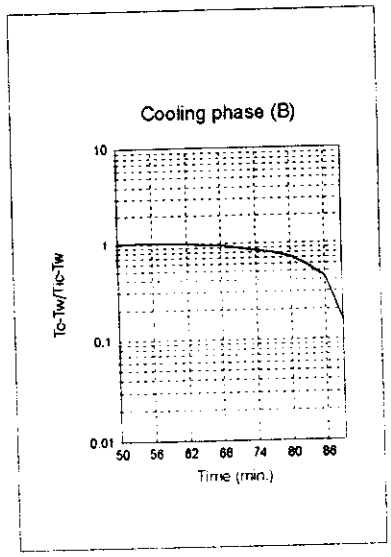
f_h values were obtained and tabulated in Table (11). Data indicated that increasing retort temperature from 90.4°C to 95.1°C to 99.9°C was accompanied by noticeable decreasing in f_h value from 40.4 to 34.32 to 31.6 for heating phase. While f_c increasing from 37.58 to 44.4 to 50.42 for cooling phase for canned guava nectar, respectively.

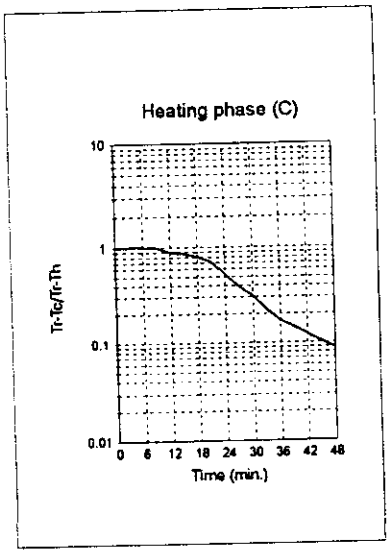
Heating and cooling curves parameters (Fig. 2) were used to evaluate the thermal process. As indicated in table (11) it could be seen that thermal processing times of 35, 25 and 15 min holding at











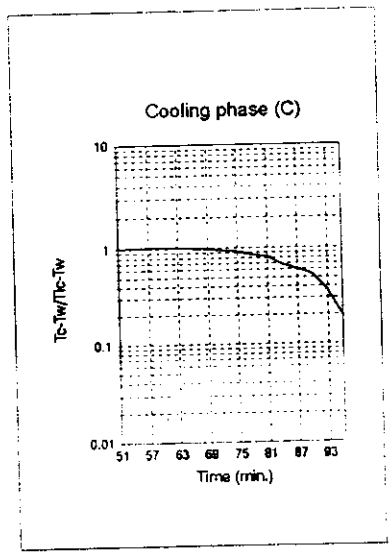


Fig. (2): Heating penetration curves for canned guava nectar (Ø65x110 mm) thermally treated at 90.4°C (A), 95.2°C (B) and 99.8°C (C).

Table (11): Evaluation of the carried out thermal process as % enzyme retention for guava nectar in cans (Ø 65 x 110 mm).

Thermal processing parameters	Canned guava nectar		
	A	B	C
Retort temperature (°C)	90.4	95.1	99.8
Came up time (min.)	12.0	14.0	12.0
Holding time (min.)	35.0	25.0	15.0
Initial temperature (°C)	51.9	45.0	49.5
f_h (min.)	40.4	34.32	31.6
f_c (min.)	37.58	44.4	50.42
J_h	1.59	1.53	1.59
J_c	1.88	1.77	1.80
Z value reference* (°C)	16.2	16.2	16.2
Reference temperature*(°C)	100	100	100
D value of (P.M.E.)* (min.)	0.34	0.34	0.34
F value for process (min.)	2.29	1.855	0.902
Decimal reduction of enzyme equivalent to F value used for process calculation (F/D)	6.756	5.440	2.650
% of enzyme retention	1.76×10^{-4}	3.5×10^{-2}	0.222

* Siddalingu *et al.* (1985).

90.4°C, 95.1°C and 99.8°C after come up times 12, 14, 12 min were resulted in F value of 1.87, 1.11 and 0.383 min., respectively for canned guava nectar.

Calculation of F values were based on reviewed "Z" and "D" values at reference temperature = 100°C of enzyme pectinmethylesterase (PME) using the $D_{100}^{16.2} = 0.34$ min. (Siddalingu *et al.*, 1985) applying the equations described by (Stumbo, 1973). The enzyme retentions percent was calculated using the following equation:

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

where: a: 100% of enzyme activity.

b: Is the value of the percentage enzyme activity retained at the end of process.

As shown in Table (11) the enzyme retentions was $1.76X10^{-5}$, $3.5X10^{-4}$ and 0.222% for the process at 90.4°C/35 min., 95.1°C/25 min. and 99.8°C min., respectively.

The Decimal reductions of enzyme equivalent to F value used for process calculation (F/D) were 6.756, 5.44 and 2.65 for the three process, respectively.

To illustrate the effect of initial temperature of canned guava nectar on the verified F value, the obtained heat penetration data were converting to obtained new data at new initial temperature using equation of (Schultz and Olson, 1940). The new calculation are presented in Table (12).

Comparing data of Tables (11 and 12) indicated that increasing the initial temperature is accompanied by increasing the verified F

Table (12): Evaluation of the carried out thermal process time as % enzyme activity retention for guava nectar in cans (Ø 65 x 110 mm) at constant initial temperature 45.0°C.

Thermal processing parameters	Canned guava nectar		
	A	B	C
Retort temperature (°C)	90.4	95.1	99.8
Come up time (min.)	12.0	14.0	12.0
Holding time (min.)	35.0	25.0	15.0
Initial temperature (°C)	45.0	45.0	45.0
f_h (min.)	40.22	34.32	32.51
f_c (min.)	37.58	44.4	50.42
J_h	1.59	1.53	1.62
J_c	1.68	1.77	1.60
Z value reference* (°C)	16.2	16.2	16.2
Reference temperature*(°C)	100	100	100
D value of (P.M.E)* (min.)	0.34	0.34	0.34
F value for process (min.)	1.621	1.855	0.488
Decimal reduction of enzyme equivalent to F value used for process calculation (F/D)	4.77	5.44	1.436
% of enzyme retention	1.71×10^{-3}	3.5×10^{-4}	3.98

* Siddalingu *et al.* (1985).

value for example process "A" has initial temperature 45°C and 51.9°C which was accompanied by F values 1.621 and 2.29 min., respectively.

To determine the optimum holding time to the a converted heat penetration data of thermal process calculation were carried out on the base of $3.5X10^{-4}$% pectinmethylesterase (PME) enzyme activity retention (F = 1.855 min.) as shown in Table (13). It could be noticed that the optimum holding time were 35.85, 25.0 and 21.28 min for 90.4°C, 95.1°C and 99.8°C at come up times 12, 14 and 12 min. and constant initial temperature of 45°C.

To evaluate the optimum process time at different retort temperature (90 and 100°C) and different initial temperature (50, 60 and 70°C), equations of (Schultz and Olson, 1940) were applied on the obtained heat penetration data for these retort and initial temperature. New data were plotted (not shown) and new parameters were obtained and new calculation were carried out Table (14) represent the obtained optimum holding times.

4.3.4. Sensory evaluation of canned guava nectar:

The sensory properties of canned guava nectar have been evaluated and statistically analyzed for texture, colour, taste, odour and overall acceptability. As shown in Table (15). The data showed that no significant difference between processed guava nectar at 90.4°C/35 min., 95.1°C/25 min and 99.8°C/15 min. in texture, taste and odour. The highest scores for these attributes were 21.3±0.33, 21.1±0.53 and 21.6±0.38 for canned guava nectar processed at 95.1°C/25 min., 90.4°C/35 min. and 99.8°C/15 min., respectively.

Table (13): Evaluation of the optimum thermal process time when enzyme retention = $3.5x10^{-4}$% and constant initial temperature, 45°C, for guava nectar.

Thermal processing parameters	Canned guava nectar		
	A	B	C
Retort temperature (°C)	90.4	95.1	99.8
Come up time (min.)	12.0	14.0	12.0
Initial temperature (°C)	45.0	45.0	45.0
f_h (min.)	40.22	34.32	32.51
f_c (min.)	37.58	44.4	50.42
J_h	1.59	1.53	1.62
J_c	1.68	2.47	1.60
Z value reference* (°C)	16.2	16.2	16.2
Reference temperature*(°C)	100	100	100
D value of (P.M.E.)* (min.)	0.34	0.34	0.34
% of enzyme retention	$3.5x10^{-4}$	$3.5x10^{-4}$	$3.5x10^{-4}$
Required F value (min.)	1.855	1.855	1.855
Optimum holding time (min.)	35.85	25.0	21.28

* Siddalingu *et al.* (1985).

Table (14): Optimum thermal process time (min.) on the base of F = 1.855 min. and b = 3.5×10^{-4}% for canned mango nectar (Ø 65 x 110 mm) at different initial and retort temperatures.

Retort temperature (°C)	**Initial temperatures**		
	50	60	70
90	39.53	34.63	26.99
100	28.32	19.63	15.81

Table (15): Sensory evaluation of guava nectar (mean of 10 panelists ± S.E.)

Processed guava nectar	Sensory attributes (scores)				
	Texture (25)	Colour (25)	Taste (25)	Odour (25)	Overall acceptability (100)
90.4°C/35 min	20.4±0.32 [a]	20.4±0.38 [a]	21.1±0.53 [a]	20.9±0.36 [a]	82.8±0.15 [a,b]
95.1°C/25 min.	21.3±0.33 [a]	20.2±0.39 [a]	19.7±0.20 [a]	20.7±0.35 [a]	81.9±0.30 [b]
99.8°C/15 min.	21.0±0.51 [a]	21.8±0.32	21.0±0.42 [a]	21.6±0.38 [a]	85.4±0.18 [a]
L.S.D. at ≥ 0.05	N.S.	1.14	N.S.	N.S.	2.88

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

While there are significant difference in colour and overall acceptability. The highest scores were 21.8±0.32 and 85.4±0.18 in colour and overall acceptability for canned guava nectar processed at 99.8°C, respectively.

4.4. PART 3: Orange nectar:

4.4.1. Effect of canning process on some chemical properties of orange nectar:

Technological characteristics such as chemical composition, rheological properties and sensory properties play an important role in the processing steps, which are necessary for the production of orange juice concentrate.

Chemical properties of orange juice are greatly affected by the variety; stage of maturity and growing conditions. It may be worth to refer to some components that constitute fruit juice (Tressler and Joslyn, 1961). Table (16) shows the chemical composition of the canned orange nectar.

4.4.1.1. Total solids and soluble solids:

The total solids and soluble solids were 13.85% and 12.83°Brix for raw orange nectar respectively and after preheating at 85°C to fill in the cans were 14.03% and 13.63°Brix, respectively. Thermal processing at 90.2°C/30 min., 95.2°C/20 min. and 100.1°C/15 min. were 14.04 and 13.68; 14.03 and 13.67 and 14.04% and 13.66°Brix for orange nectar, respectively. These results are in agreement with those obtained by Hussein *et al.* (1963) and Bareh (1997) who found the total soluble solids were within the range from 11.5 to 14.4°Brix. Also, the results are in agreement with those obtained by Soliman (1969) who found the moisture content in orange juice was 87.99%. Also, the results are in agreement with those obtained by Pearson (1987), who found the water was 88.1%. While Sharoba (1999) found that the

Table (16): Effect of canning processing on some chemical properties of orange nectar (mean±S.E.)

Properties	Raw orange nectar	Preheated orange nectar	Processed orange nectar at		
			90.2°C/35 min.	95.2°C/20 min.	100.1°C/15 min.
Total solids %	13.85±0.01	14.03±0.01	14.04±0.01	14.03±0.01	14.04±0.01
Soluble solids %	12.83±0.01	13.63±0.01	13.68±0.02	13.67±0.01	13.66±0.01
Acidity (as citric) %	0.306±0.01	0.292±0.01	0.294±0.01	0.294±0.01	0.295±0.01
pH value	3.56±0.01	3.55±0.01	3.57±0.01	3.57±0.01	3.57±0.01
Ascorbic acid (mg/100 g)	13.22±0.07	10.68±0.21	8.14±0.01	8.43±0.12	8.86±0.01
Total sugar %	11.81±0.11	12. 03±0.15	12.16±0.085	12.12±0.08	12.13±0.10
Non reducing sugar %	10.44±0.11	10.40±0.18	9.99±0.09	10.14±0.06	10.30±0.08
Reducing sugar %	1.37±0.11	1.63±0.20	2.17±0.09	1.98±0.03	1.83±0.05
Total carotene (mg/L)	0.35±0.01	0.23±0.01	0.200±0.01	0.210±0.02	0.196±0.01

Data calculated on fresh weight.

total soluble solids in balady orange juice was 13.36°Brix; the moisture was 86.64% and soluble solids was 12°Brix.

4.4.1.2. Titratable acidity and pH value:

The total acidity and pH value would be of great importance since the ratio of total soluble solids to acidity will affect on the flavour. From the data obtained in Table (16) it could be concluded the acidity values (as anhydrous citric acid) were 0.306 and 0.292% for raw orange nectar and preheated one; while the pH value were 3.56 and 3.55 respectively. Thermal processing at 90.2°C/30 min., 95.2°C/20 min. and 100.1°C/15 min. of orange nectar results in 0.294, 0.294 and 0.295% acidity (as citric anhydrous). While the pH values were still at 3.57 pH value for the three treatments of the thermal process. These results agreed with Pearson (1972) and Park *et al.* (1983). They reported that the acidity was 1.43% but Sharoba (1999) reported the total acidity was 1.57% in orange juice 12°Brix. While He reported that the pH value was 3.68 but El-Sayed (1966) and Abraham *et al.* (1974) found that pH value was within the range from 3.45 to 4.5.

4.4.1.3. Ascorbic acid (Vit. C):

Ascorbic acid retention is considered a good indication for a high quality due to its reducing effect which reflects some techenical properties, such as colour retention. In addition, it has a high nutritive value being one of the essential vitamins. Table (16) shows that the level of Vit. C in the raw orange nectar was 13.22 mg/100 g nectar, while after preheating the level of the Vit. C beacame 10.68 mg/100 g.

But the results after processing at 90.2°C/30 min, 95.2°C/20 min and 100.1°C/15 min. showed that Vit. C values were decrease to 8.14, 8.43 and 8.86 mg/100 g, respectively. The obtained data were observed before by Sandhu and Bhatia (1985) when they found that orange juice had 12.2 mg Vit. C/100 g. Also the results are in agreement with these obtained by Sharoba (1999) who found the Vit. C in orange juice 12°Brix was 12.7 mg/100 ml. El-Sayed (1966) calculated the Vit. C in the whole fruit of orange and he found the result was 60.85 mg/100 g (on dry weight basis) but after canning process was 54.79 mg Vit. C/100 g.

4.4.1.4. Total sugars and reducing sugars:

The prime importance in the orange juice that was the total sugars since it affect flavour which is considered the most important quality attribute. The data obtained in Table (16) should that the total sugars and reducing sugars were 11.81 and 1.37% for raw orange nectar and the non reducing sugars was 10.44% but after preheating (filling) were 12.03, 1.63 and 10.40, respectively.

While after canning and processing the nectar at 90.2°C/30 min; 95.2°C/20 min. and 100.1°C/15 min. the obtained data were 12.16, 12.12 and 12.13% for total sugar, 2.17, 1.98 and 1.83% for reducing sugar and 9.99; 10.14 and 10.30 for non reducing sugar, respectively. The data showed that canning process caused an increase in the reducing sugars and in the same time a decrease in the non-reducing sugars while the total sugars content was stable; this effect due to the temperature and the acidity of nectar.

Results are inagreement with those observed by Sawyer (1963), Sandhu and Bhatia (1985), Aly (1991) and Sharoba (1999) they found that the total sugar, reducing sugar and non reducing sugars of orange juice were ranged from 6.02 to 7.73%; 3.12 to 3.49 and 1.77 to 3.88%; respectively. Also, Pearson (1987) found that the total sugar in orange juice was 8.5%.

4.4.1.5. Carotenoid content:

The carotenoid contents was 0.35 and 0.23 mg/L for raw orange nectar and after preheating. After processing at 90.2°C/30; 95.2°C/20 min. and 100.1°C/15 min. were ranged from 0.196 to 0.21 mg/L of nectar. These results were in agreement with those obtained by Quinones (1944); Ustun and Sahin (1993) and Sharoba (1999) they found that the carotenoid content in orange juice ranged from 0.41 to 1.091 mg/L.

4.4.2. Effect of canning processing steps on enzyme activity of orange nectar:

4.4.2.1. Pectinmethylesterase activity:

Pectinmethylesterase enzyme is the highest enzyme stability in the nectar so the main factor affecting the quality; stability and processability of the nectar.

The data obtained in Table (17) showed that the PME activities were 198.0 and 66.7 PME unit $x10^6$/g for the raw and after preheating orange nectar, respectively. Thermal processing at 90.2°C/30 min, 95.2°C/20 min. and 100.1°C/15 min. reduced the activity to 0.30; 4.5 and 16.5 PME unit $x10^6$/g, respectively. The data obtained showed

Table (17): Effect of canning processing steps on enzymes activity of orange nectar (on fresh weight).

Treatment of nectar	Pectinmethylesterase PME unit $x10^6$	Peroxidase (O.D./min) $x10^3$	Polyphenoloxidase (O.D./min) $x10^3$
Raw orange nectar	198.00	19.50	1.80
After preheating	66.70	0.40	0.60
After processing at: 90.2°C/35 min.	0.30	0.0	0.0
95.2°C/20 min.	4.50	0.0	0.0
100.1°C/15 min.	16.5	0.0	0.0

that the process at 90.2°C/30 min. was the highest effect on the PME activity but the lower was at 100.1°C/15 min.

The results are in agreement with those obtained by Sandhu and Bhatia (1985) and Sharoba (1999) who reported that the PME was 1.24 PME unit $x10^3$/g for orange juice 12°Brix.

4.4.2.2. Peroxidase and polyphenoloxidase activity:

Peroxidase and polyphenoloxidase activity in many fruits occurs browning reaction and off flavour of the juices. As shown in Table (17) the peroxidase and polyphenoloxidase activities were 19.5 and 1.8 O.D. $x10^3$/min. for raw (prepared) orange nectar, after preheating process these activities were decreased to 0.4 and 0.60 O.D. $x10^3$/min. for peroxidase and polyphenoloxidase, respectively.

Thermal processing the nectar at 90.2°C/30 min., 95.2°C/20 min. and 100.1°C/15 min. resulted in no activity for either peroxidase or polyphenoloxidase enzyme.

4.4.3. Evaluation of thermal process:

The heat resistant enzyme systems such as peroxidase, polyphenoloxidase and pectinesterase (PE) present in acid fruits has been found to be higher than that the heat resistance of lactobacilli, yeasts, and moulds. Thermal process schedule evolved on the basis of the enzyme inactivation rendered the canned product microbiologically safe (Nath *et al.*, 1983). However pectinesterase (PE) enzyme is the highest stable in the orange nectar. So it was decided to evaluate the thermal process and optimize the optimum thermal processing of canned orange nectar on the base of heat

resistance parameters of pectinesterase which is the highest resistance enzyme.

Heat penetration data were obtained for canned orange nectar (Ø 65 x 110 mm) which was processed at 90.2°C/30 min., 95.2°C/20 min. and 100.1°C/15 min. Heat penetration data were plotted as heating curves and cooling curves (Fig. 3). The values of f_h were obtained and tabulated in Table (18) for canned orange nectar. Data indicated that, increasing retort temperature from 90.2°C to 95.2°C to 100.1°C was accompanied by noticeable difference in f_h value from 14.52 to 18.61 to 14.69 for heating phase and f_c was accompanied by noticeable increasing from 17.70 to 21.89 to 23.24 for cooling phase for canned orange nectar, respectively.

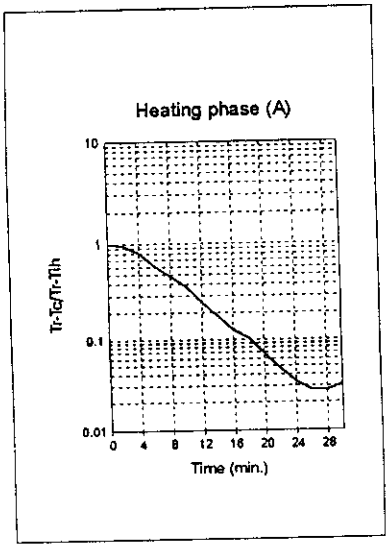
As shown in Fig. (3) heating and cooling curves parameters were used to evaluate the carried out thermal process. As indicate in Table (18) it could be seen that thermal processing times of 30, 20 and 15 min holding at 90.2°C, 95.2°C and 100.1°C, respectively after come up times 8.5, 10.0 and 9.0 min. with initial temperature were 60.9, 46.3 and 45.4°C resulted in F values of 1.07, 1.92 and 6.66 min., respectively for canned orange nectar. Evaluation of the thermal process was based on recommended F value 43 min. (according to Schwimmer, 1981) who determined the F value at 82°C with Z = 14°F = 7.78°C that means F = 0.21 min. at 100°C with the same Z value applying the equation $F_c = F_i \log^{-1} [(t_r - t_x)/Z)$ (Stumbo, 1973).

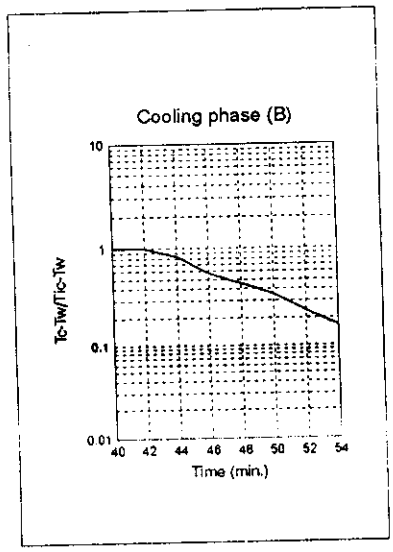
where: T_r = referance temperature.

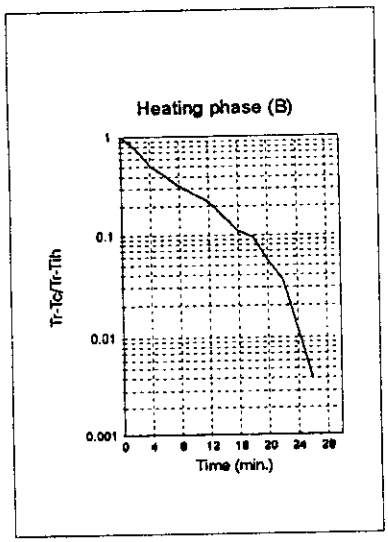
T_x = original temperature (new).

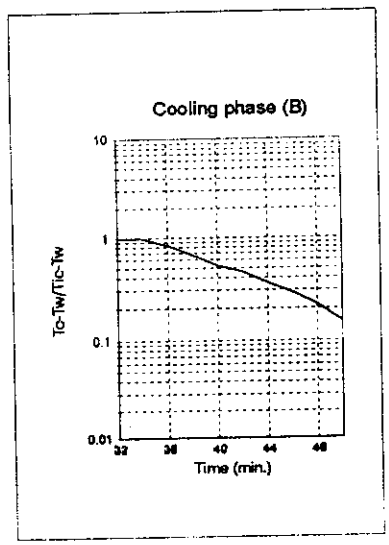
F_i = recommended F at T_r.

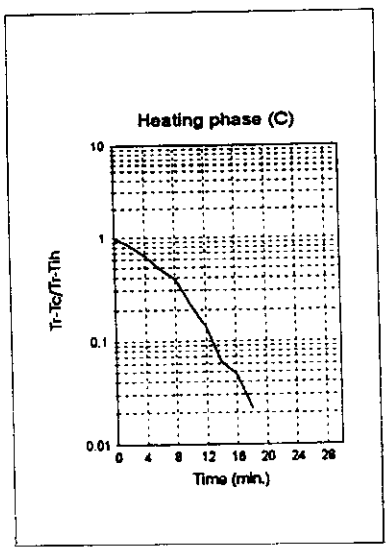
F_c = obtained new F at T_x.











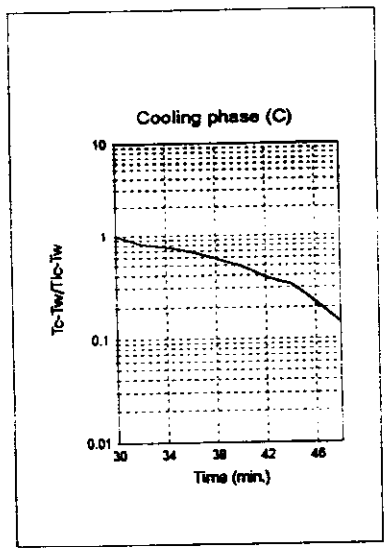


Fig. (3): Heating penetration curves for canned orange nectar (Ø65x110 mm) thermally treated at 90.2°C (A), 95.2°C (B) and 100.1°C (C).

Table (18): Evaluation of the carried out thermal process based on Z = 7.78°C and reference temperature 100°C for orange nectar in cans (Ø 65 x 110 mm).

Thermal processing parameters	Canned orange nectar		
	A	B	C
Retort temperature (°C)	90.2	95.2	100.1
Come up time (min.)	8.5	10.0	9.0
Holding time (min.)	30.0	20.0	15.0
Initial temperature (°C)	60.9	46.3	45.4
f_h (min.)	14.52	18.61	14.69
f_c (min.)	17.70	21.89	23.24
J_h	0.76	0.44	0.355
J_c	1.24	1.20	1.14
Z value reference* (°C)	7.78	7.78	7.78
Reference temperature*(°C)	100	100	100
Recomonded F value* (min.)	0.21	0.21	0.21
F value for process (min.)	1.07	1.92	6.66

* Schwimmer (1981).

To determine the optimum holding time with constant initial temperature the obtained heat penetration data were converting to obtain new data at new initial temperature of thermal process, equation of (Schultz and Olson, 1940) was applied. Calculations were carried out on the base of recommended F value $F_{100}^{7.78} = 0.21$ min. of pectinmethylesterase (PME) enzyme as shown in Table (19). It could be seen that the optimum holding time were 14.86, 6.29 and 1.05 min. at come up times 8.5, 10.0 and 9.0 min and constant initial temperature of 45.4°C for 90.2, 95.2 and 100.1°C retort temperatures, respectively.

To evaluate the optimum process time at different retort temperatures 90, 100) and initial temperature (50, 60 and 70°C) the equations of (Shultz and Olson, 1940) were applied on the obtained heat penetration data for these retort and initial temperatures. New data were plotted not tabulated, new parameters were obtained and new calculations were carried out. Table (20) represent the obtained optimum holding times for canned orange nectar (Ø 65 x 110 mm).

4.4.4. Sensory evaluation for canned orange nectar:

The sensory evaluation of the canned orange nectar processed at 90.2°C/30 min; 95.2°C/20 min. and 100.1°C/15 min. for the texture, colour, taste, odour and overall acceptability were evaluated. The data recorded in Table (21) showed that no significant difference in odour of the treated orange nectar, while there are significant difference in the texture, colour, taste and overall acceptability of orange nectar processed at 90.2°C/30 min, 95.2°C/20 min. and 100.1°C/15 min. The highest score in texture and colour were 20.33±0.47 and 19.7±0.25 for

processed orange nectar at 95.2°C/20 min. and 100.1°C/15 min., respectively. Also the highest scores were 19.9±0.36 and 78.8±0.07 for orange nectar processed at 100.1°C/15 min. in taste and overall acceptability, respectively. The lower score in all attributes was for orange nectar processed at 90.2°C/30 min.

Table (19): Evaluation of the optimal thermal process time based on recommended F value = 0.21 min. with constant initial temperature for orange nectar in cans (Ø 65 x 110 mm).

Thermal processing parameters	Canned orange nectar		
	A	B	C
Retort temperature (°C)	90.2	95.2	100.1
Came up time (min.)	8.5	10.0	9.0
Initial temperature (°C)	45.4	45.4	45.4
f_h (min.)	14.61	18.61	14.69
f_c (min.)	17.7	21.89	23.24
J_h	0.755	0.42	0.355
J_c	1.24	1.20	1.14
Z value reference* (°C)	7.78	7.78	7.78
Reference temperature*(°C)	100	100	100
Required F value* (min.)	0.21	0.21	0.21
Optimum holding time (min.)	14.86	6.29	1.05

* Schwimmer (1981).

Table (20): Optimum thermal process time (min.) on the base of $F_{100}^{7.78} = 0.21$ min.* for canned orange nectar (Ø 65 x 110 mm) at different initial and retort temperature.

Retort temperature (°C)	Initial temperatures		
	50	60	70
90	17.41	16.40	13.31
100	4.63	4.15	2.35

* Schwimmer (1981).

Table (21): Sensory evaluation of orange nectar (mean of 10 panelists ± S.E.)

Processed guava nectar	Sensory attributes (scores)				
	Texture (25)	Colour (25)	Taste (25)	Odour (25)	Overall acceptability (100)
90.2°C/35 min	19.00±0.47 [b]	17.00±0.60 [a]	18.6±0.43	18.6±0.47 [a]	73.20±0.38
95.2°C/25 min.	20.33±0.47 [a]	17.80±0.51 [a]	19.8±0.30 [a]	18.85±0.47 [a]	76.88±0.49 [a]
100.1°C/15 min.	19.50±0.47 [a,b]	19.70±0.25	19.9±0.36 [a]	19.7±0.32 [a]	78.80±0.07 [a]
L.S.D. at ≥ 0.05	1.32	1.47	1.12	N.S.	3.01

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