SUMMARY

Canning and thermal processing are the major section of the food industries in Egypt. This study was carried out for :

I- Studying changes that occur in chemical, microbial and sensory attributes during blanching of green beans, peas and okra.

II- Isolation and identification of aerobes isolates (*Bacillus* spp.) i.e. *B. subtilis, B. coagulans, B. stearothermophilus, B. cereus* and *B. licheniformis* from green beans, peas and okra. Decimal reduction time (D-values) and Z-values for these isolates were determined.

III- Studying heat penetration of canned green beans, peas and okra either in brine solution or in tomato sauce and find out thermal constant parameter (f_h, j_h, j_c).

IV- Studying the optimum thermal process time.

The results can be summarized as follows :

1- Blanching of green beans, peas and okra in boiling water for 1, 3 and 5 minutes decreased the chemical constituents.

2- All major constituents of green beans, peas and okra i.e. protein, ash, fat and fiber were decreased after canning process. However, the higher a decremental reduction was observed when brine solution 1.5% was used compared with canning in tomato sauce.

3- Mineral contents including potassium, iron, phosphorus and calcium were all decreased, whereas, sodium apparently increased due to the addition of brine solution 1.5%.

4- The initial microbial load of green beans, and okra (as a non-protected material) was higher than green peas (as a protected material).

5- Blanching reduced the total plate count of bacteria to over 90 - 96%, according to different blanching times.

6- Canned vegetables showed complete reduction of spore count, however, the total spores counts were lower than 30 spores per 25 g.

7- As for spore-forming bacteria count were recovered in higher quantities for samples thermally treated at 112.1°C (233.78°F) which represented 4, 2 and 5 spores/25 g, 2, 2 and 2 spores/25g for mesophilic and thermophilic spores for samples vegetables canned in brine solution, respectively. While, they were 2, 1 and 2 spores/25g, 2, 1 and 2 spores/25g for mesophilic and thermophilic spores for samples vegetables canned in tomato sauce, respectively.

8- The incidence of such species isolated and identified *Bacillus* from vegetables (green beans, peas and okra) out of 240 colony either from raw or exhausted vegetables packed in brine solution could be arranged in a descending order as 7, 7, 6, 6, 6, 6, 5, 4 and 4 for *B. subtilis, B. licheniformis* , *B.*

brevis, B. stearothermophilus, B. macerans, B. cereus, B. coagulans, B. polymexa and *B. megatherium* , for green beans. While, were 6, 6, 4, 4, 4, 4, 4 and 2 for *B. cereus, B. megatherium, B. subtilis, B. licheniformis* , *B. brevis, B. stearothermophilus,* and *B. macerans, B. coagulans,* for green peas. While, were 9, 9, 8, 8, 6,5, 4 and 3 for *B. subtilis, B. brevis, B. polymexa, B. macerans, B. coagulans, B. cereus, B. stearothermophilus,* and *B. licheniformis* for green okra, respectively. For the vegetables packed in tomato sauce could be arranged in a descending order as 7, 7, 7, 6, 6, 5, 5, 5 and 4 for *B. subtilis, B. licheniformis* , *B. brevis, B. stearothermophilus, B. macerans, B. cereus, B. polymexa, B. coagulans,* and *B. megatherium* , for green beans. While, were 6, 6, 5, 5, 4, 3, 3 and 2 for *B. cereus, B. megatherium, B. licheniformis, B. subtilis, B. macerans, B. brevis, B. stearothermophilus,* and *B. coagulans,* for green peas. While, were 10, 8, 8, 7, 6, 5, 5, and 4 for *B. subtilis, B. brevis, , B. macerans, B. polymexa, B. coagulans, B. cereus, B. stearothermophilus,* and *B. licheniformis* for green okra, respectively.

9- The results indicated that *B. licheniformis* and *B. coagulans* had the least D-value at different heating temperature. While, *B. stearothermophilus* had the highest values at the same heating temperature. While, the values of "D" for *B. cereus,* and *B. subtilis* appeared in between. It can be noticed that

$D_{212°F}$ in minutes for *B. stearothermophilus* , *B. cereus, B. subtilis, B. coagulans,* and *B. licheniformis* suspended in extract of vegetables and (brine-suace) were 230, 2.5, 2.5, 1.8 and 1.6 minutes, respectively. While, the corresponding values were 28, 0.88, 0.95, 0.75, and 0.66 minutes at 230°F, 2.00, 0.29, 0.29, 0.29 and 0.26 minutes at 250°F, respectively. The result indicate that the D-values for the same spores suspended in phosphate buffer pH = 7 were 250, 3, 2.8, 2.1 and 2.00 minutes at 212°F, 34, 1.05, 1.05, 0.85 and 0.85 minutes at 230°F, 3.68, 0.37, 0.39, 0.33 and 0.32 minutes at 250°F, respectively.

10- Z-values for different species of *Bacillus* were computed from the thermal death time curves. The Z-values in°F for spores of *B. coagulans, B. cereus, B. subtilis,* and *B. stearothermophilus* suspended in extract of vegetables with (brine-sauce) were 46.44, 43.92, 43.56 and 18.6°F, respectively.

11- Least significant difference (L.S.D.) was calculated to compare between F_h at different 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 F_h-value from 5.97 to 5.05 to 5.20 which are the average from the three vegetables canned in brine solution while were from 25.9 to 24.4 to 22.1 for canned in tomato

sauces ($P < 0.05$). Heating and cooling curves parameter were combined with heat resistant parameters of isolated spore-former to evaluate the carried out thermal process.

12- Thermal process-time of 35, 25 and 15 min. at 112.1°C, 116.0°C and 120.2°C after come up times of 3.5, 4.5 and 5.5 min., for canned green beans in brine, 1.5, 1.8, 2.0 min. for canned green peas in brine, while were 1.3, 1.5, 2.0 min. for canned green okra in brine, respectively, was resulted in F-values of 4.91 - 15.54, 7.02 - 16.03, and 9.23 - 12.58, 4.6 - 18.16, 6.66 - 12.39, and 9.22 - 13.31, 4.22 - 14.00, 6.77 - 14.96, and 7.94 - 12.38 for canned green beans, peas and okra in brine solution, respectively. These calculation were based on previously determined "Z" values of 24.2, 25.8, 10.34 and 24.4°C for *B. subtilis*, *B. coagulans*, *B. stearothermophilus*, and *B. cereus* respectively. On the other hand, thermal process time of (60 - 65), (45 - 50) and (30 - 35) min. at 112.1°C, 116.0°C and 120.2°C after come up times of 3.2, 3.5 and 4.5, 3.0, 3.5 and 4.5, 3.0, 3.8 and 4.25 min. for canned green beans, peas and okra in tomato sauce, respectively, was resulted in F-values of 4.08 - 16.02, 4.18 - 14.25, and 5.16 - 12.95, 4.35 - 17.60, 6.19 - 16.69, and 4.92 - 11.66, 4.34 - 17.29, 5.78 - 16.33 and 4.83 - 11.14 for canned green beans, peas and okra in tomato sauce, respectively. These F-values calculated at the previously Z-values.

Calculated F-values to cover 12 D concept is 2.52 min. while calculated F-values to cover the commercial concept is 10.68, 10.10 and 10.64 (based on Dr = 2.0 for *B. stearothermophilus*) this indicate that holding time at different retort temperature for all vegetables under investigation is not enough to cover the commercial concept for *B. stearothermophilus* and covered other *Bacillus*. So, the optimum thermal process time to cover the required F-values was evaluated. The evaluated optimum thermal process times were found to be 33.88 - 89.33, 27.38 - 80.06 and 33.16 - 87.65 at 112.1°C, 23.16 - 38.50, 20.80 - 35.35 and 23.25 - 38.60 min. at 116°C, 19.84 - 20.90, 15.90 - 17.13 and 19.56 - 20.80 min. at 120.2°C for canned green beans, peas and okra in brine, respectively. On the other hand, the evaluated optimum thermal process times were found to be 65.61 - 121.31, 44.27 - 96.95 and 58.27 - 113.76 min. at 112.1°C, 57.07 - 70.70, 42.74 - 56.03 and 49.91 - 63.66 min. at 116°C, 45.29 - 46.09, 28.62 - 30.03 and 42.86 - 43.97 at 120.2°C for canned green beans, peas and okra in tomato sauce, respectively.

So, it is recommended to avoid using of retort temperature of 112.1°C (233.78°F) which required long holding time (reach from 89.33min. for canned vegetables in brine solution and 121.31 min. for canned vegetables in

tomato sauce) in turn, may affect on the nutritional, physical properties of the product and degredation of quality and cost energy and labor (soft product) also, to avoid using retort temperature 120.2°C (248.36°F) which required short holding time (reach from 20.9 min.in canned vegetables in brine solution and 46.78 min. for canned vegetables in tomato sauce), in turn, may affect on the quality and physical properties of the product (hard product) it recommended the use of retort temperature 116.0°C (240.80°F), for 38.50, 35.35 and 38.6 min. for canned (green beans, peas and okra) vegetables in brine solution ,72.70, 56.03 and 63.66 min. for canned vegetables (green beans, peas and okra) in tomato sauce to give a good organoleptically.

13. Organoleptic evaluation showed that there were significant difference between different blanching time. Also, between different thermal process (temp. - time) either for canned vegetables in brine solution or tomato sauce for all vegetables under investigation. It is clear that blanching time for 3 min. at 95°C was the best blanching time also, retort temp. 116.0°C was the best temperature to give a good organoleptic quality.