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Effect of Rotation on the Heat Penetration of Thermally Processed Tuna (*Thunnus albacares*) in Oil in Aluminium Cans

A. Ansar Ali,*, B. Sudhir, and T.K. Srinivasa Gopal*****
Central Institute of Fisheries Technology,
Cochin - 682 029, India

Tuna packed in oil medium was processed in aluminium cans to a Fo value of 10. Heat penetration characteristics were determined by processing to a Fo value of 10 in a rotary retort and comparing the results with the values from a stationary retort. Rotation of the cans has an effect on heat penetration in the thermally processed fish products. For studying the changes in heat penetration during rotation, tuna in oil was packed in aluminium cans (301X203) and subjected to different rotational speeds (2 rpm, 4 rpm, and 6 rpm) during thermal processing to the same Fo value of 10 by rotating the cage of the overpressure autoclave. For the same Fo value of 10 although there was a reduction in process time up to 6 rpm, the reduction in process time beyond 2 rpm was less significant.

Key words: Aluminium cans, heat penetration, Fo value, thermal processing.

Aluminium cans are the indigenously available rigid alternative packaging material for tin cans for the thermal processing of fish products. The dimensions, wall thickness and shape of the cans will affect the heat penetration during thermal processing. For a given container heat penetration will be same if other processing conditions are not altered. The practice of sterilization of foods in hermetically sealed metal containers has been researched extensively since 1920s (Stumbo, 1973; Lopez, 1981; Anon, 1982). The mathematical modeling of thermal processing has also been studied extensively and has been thoroughly reviewed (Hayakawa, 1977a; 1977b; 1978; Holdsworth, 1985.)

One of the methods adopted for reducing the process time is the addition of nisin, but the addition of chemical is not preferred. Hence the only alternative is to agitate the contents by subjecting to rotation of the retort. Reduction in process time will have an advantageous effect on the sensory and nutritional qualities of the thermally processed fish products. Rotation of the cans has an effect on the heat penetration. Heat transfer in liquid, semi viscous or particulate foods can be significantly increased by mechanical agitation during processing. This is the underlying principle of agitating sterilization or retorts. As cage rotates contents are agitated; this eliminates cold spots and reduces processing time as the cans are heated up faster and evenly. Influence of particle shape and particle motion on heat transfer in cans during end over end rotation and the influence of rotational speeds were carried out by Ramaswamy and Sablani (1997a; 1997b). The aim of thermal processing is to produce a product that is safe to consume. The Fo recommended for fish and fish products range from 5-20 (Frott & Lewis, 1994). This is an attempt to study the effect of rotation on the change in heat penetration by subjecting the cage of the retort to different rotational speeds when the tuna in oil was processed to a Fo value of 10.

* Plant Manager, Forstar Insta Foods, New Bombay - 410 208
** Plant Manager, SARA Spices, Kizhakkambalam, Kerala
*** Corresponding author

Materials and Methods

Freshly collected yellow fin tuna (*Thunnus albacares*) was used for the study. After removing the head, gut and fins it was kept in running water to drain the blood. The fish was pre-cooked in steam at 10 lbs steam pressure for one and a half h, cooled and kept at 10°C in the chill room over night. Bones and red meat were removed from the precooked cooled fish and uniform pieces of 1.5 inches length were cut.

Aluminium cans 301X203 (77X56 mm) used for the study were manufactured by M/s Klass Engineering works, Bangalore. 140 g of cooked meat pieces were filled in aluminium cans, 2% salt was sprinkled. Hot double refined groundnut oil (60 ml) was added. The filled cans were then steam exhausted for 10 min and immediately heat-sealed.

Filled aluminium cans were heat processed to a Fo value of 10 in a stationary retort. In the next stage cans were heat processed in a rotary retort by subjecting the cage of the retort to different rotational speeds (2 rpm, 4 rpm and 6 rpm) to study the effect of rotation on heat penetration. Processing were done at 121.1°C in an over pressure autoclave (John Fraser and sons Ltd, Model. No 5682). The thermal data were taken by inserting thermocouple needles into the product. Thermocouple output was measured by using an Ellab CTF 9008 data recorder. The results of heat penetration data of stationary retort were compared with that of rotary retort to find out the effect of rotation on heat penetration.

The recorded data were analyzed using a computer. The heat penetration data were plotted on a semi log paper with temperature deficit (RT-CT) on log scale against time. Lag factor for heating (j_h), slope of the heating curve (fh), time in minutes for sterilization at retort temperature (U), lag factor for cooling (j_c), fh/U, g and the process time were calculated by the method of Stumbo (1973). Actual process time was determined by adding process time (B) and the effective heating period during come up time i.e. 58% of the come up time. Sterility of the product was tested as per IS: 2168 (1971). All the experiments were subjected to statistical analysis and standard deviations were found out.

Results and Discussion

The process time for the tuna in oil processed in aluminium cans in a stationary retort to a Fo value of 10 was 64.43 min. The come up time to attain 121.1°C varied between 3-6 min. Initial temperature of the

Table 1. Heat penetration data for tuna in oil processed in aluminium cans

Sl. No.	Fo and rpm	fh (min)	j_h	j_c	fh/U	g	Total B	process time in minutes	Cook value in minutes
1	Fo 10 with out rotation	38.15±0.86	1.30±0.14	1.17±0.09	3.78±0.15	2.49±0.06	62.09±0.42	64.43±1.20	121.65±5.03
2	Fo 10 and 2 rpm	33.36±1.58	1.37±0.04	1.30 ±0.02	3.4800±0.17	2.30±0.07	54.17±1.45	57.22±2.42	115.35±1.93
3	Fo 10 and 4 rpm	32.37±1.38	1.45±0.14	1.18±0.02	3.35±0.19	2.14±0.12	54.02±1.02	56.16±1.26	114.45±2.74
4	Fo 10 and 6 rpm	32.09±1.47	1.48±0.12	1.22±0.05	3.32±0.15	2.07±0.12	53.75±2.59	55.38±2.60	108.93±2.49

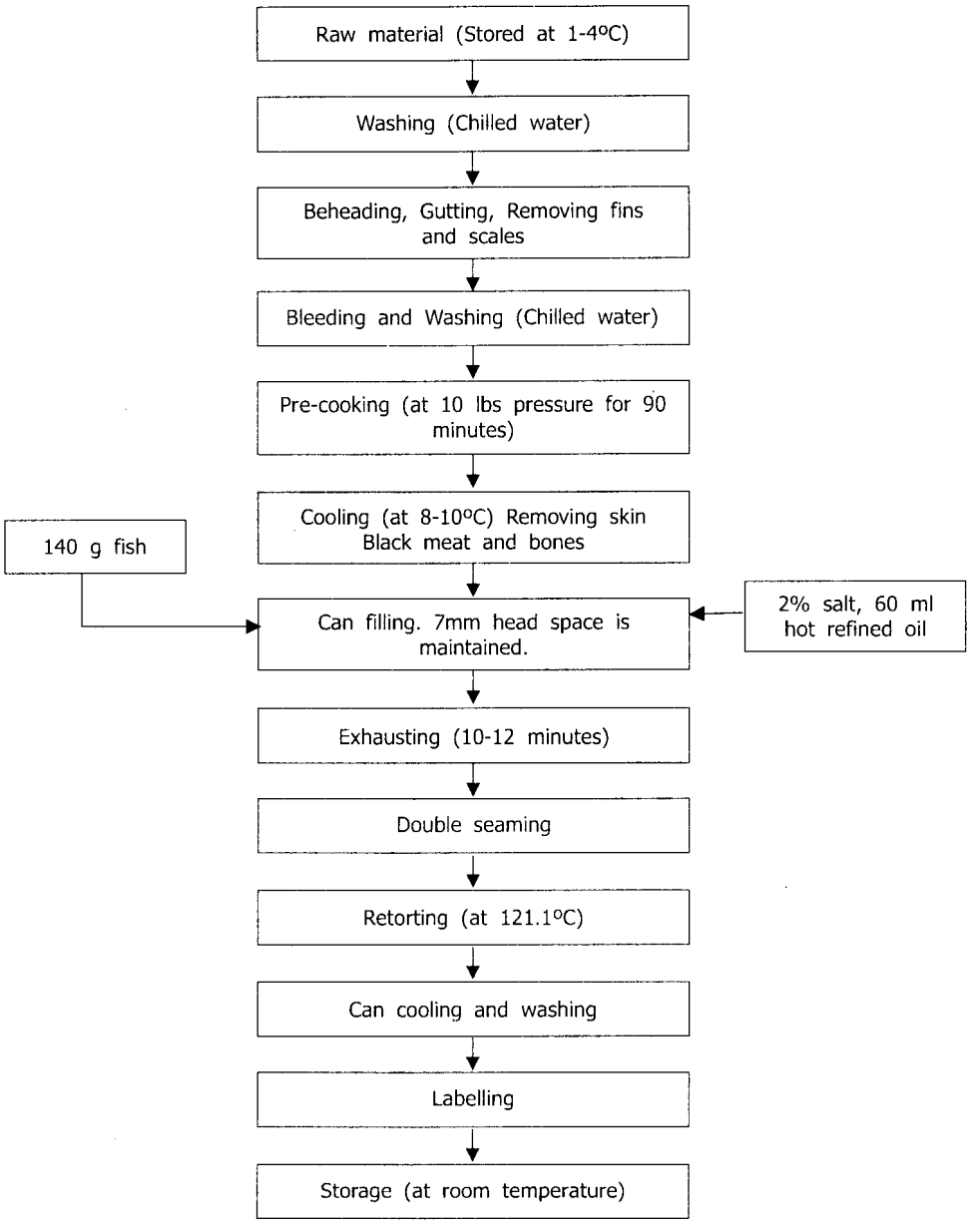

Fig. 1. Canning of Tuna in Oil

products were maintained at 40±3° C. Heat penetration characteristics at the cold spot should be specific, if parameters such as filled weight, head space, type of container, dimension of container, come up time of the retort, heating media and initial temperature (Vanloey, 1994) were uniform for a given product. The come up time should be kept as short as possible (Anon, 1968). For attaining the same Fo value of 10, aluminium cans processed in stationary retort has got a higher processing time compared to aluminium cans processed in rotary retort. The total process time taken to reach a Fo value of 10 with 2 rpm was 57.22 min., with 4 rpm it was 56.16 min and with 6 rpm it was 55.38 min at the same Fo. The heat penetration data is presented in table-1. Cook value, product temperature, Retort temperature, Fo value etc as a function of time was depicted in figures 2-9.

There was reduction in process time up to 6 rpm. But beyond 2 rpm the rate of

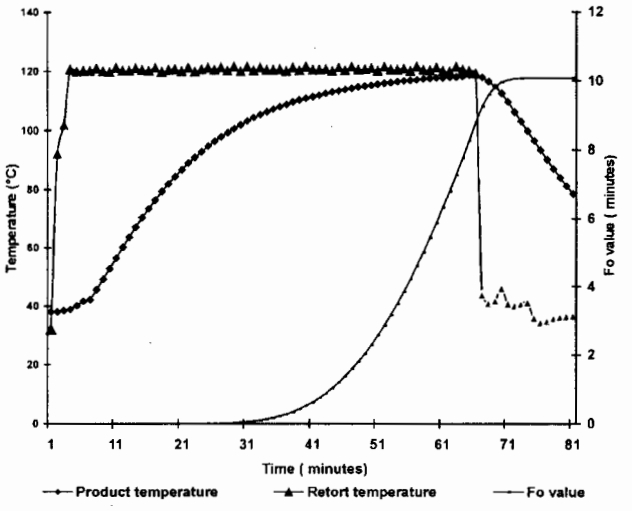

Fig. 2 Heat penetration characteristics and Fo value of thermally processed Tuna in oil to Fo 10 in a Stationary Retort

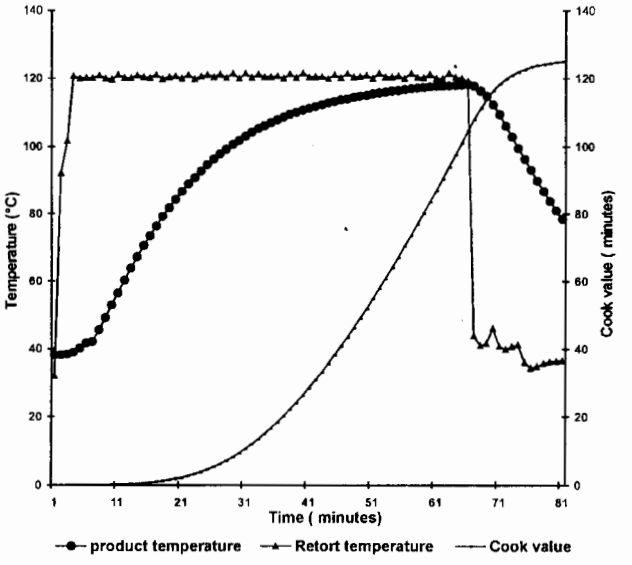

Fig. 3 Heat penetration characteristics and Cook value of thermally processed Tuna in oil to Fo 10 in a Stationary Retort

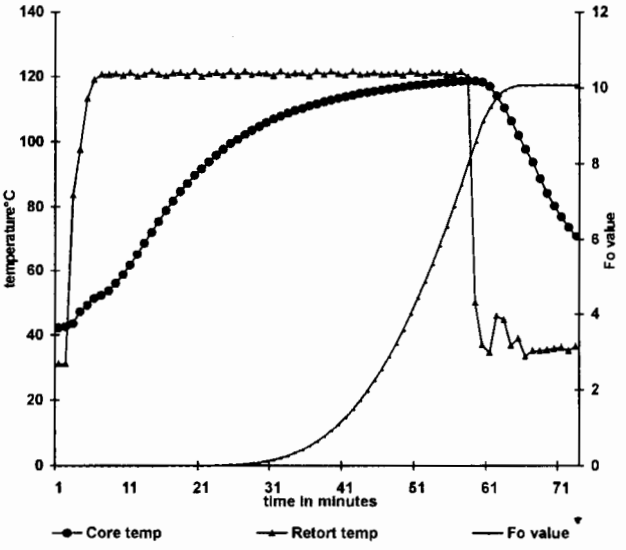

Fig. 4. Heat penetration characteristics of Tuna in oil processed to Fo 10 with 2 rpm

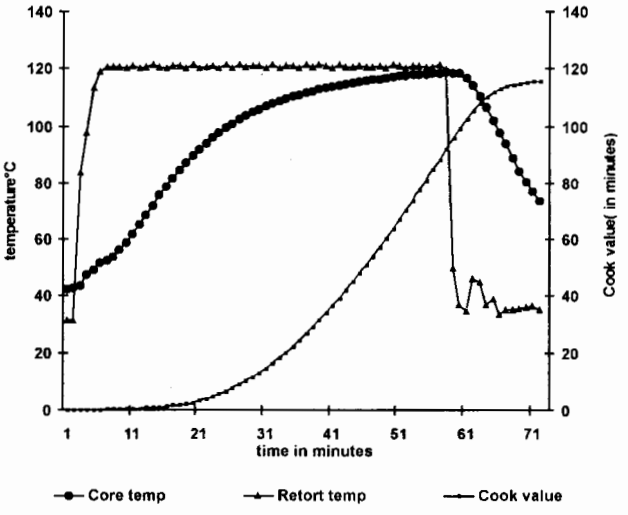

Fig. 5. Heat penetration characteristics and Cook value for Tuna in oil processed to Fo 10 with 2 rpm

reduction in process time was insignificant. At 2 rpm there was a 7.21 min reduction in process time compared to the cans processed in stationary retort processed to the same Fo value of 10. Heat penetration factor fh also decreased with increase in speed of rotation. The fh value for Tuna in oil processed to Fo 10 with 2, 4 and 6 rpm were 33.36 min, 32.37 min and 32.09 min respectively, while that processed in stationary retort has got an fh value of 38.15 min. This decrease in heat penetration factor fh in rotary retort was due to the increase in sterilization value due to faster heat penetration. This is due to the increased ability of the liquid media to move effectively through the agitated cans. Several researchers studying axial or end-over-end rotation came to the conclusion that increasing rotational speed resulted in faster heat penetration, that is lower fh values. (Berry & Bradshaw, 1980; Naveh & Kopelman, 1980; Berry & Dickerson 1981; Berry & Bradshaw 1982; Berry & Kohn horst 1985). However, the influence of rotational speed on heat penetration rate is limited.

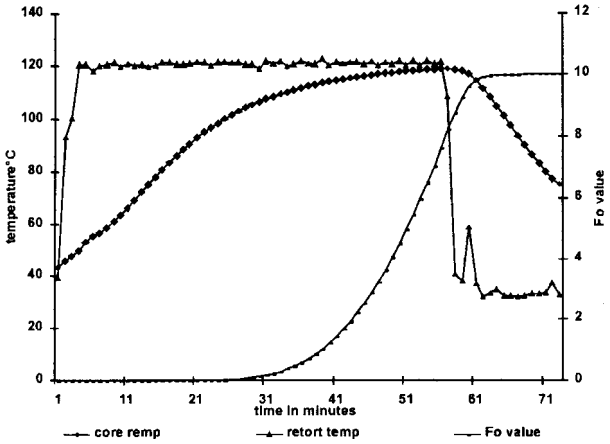

Fig. 6. Heat penetration characteristics of Tuna in oil processed in aluminium cans to Fo 10 and 4 rpm

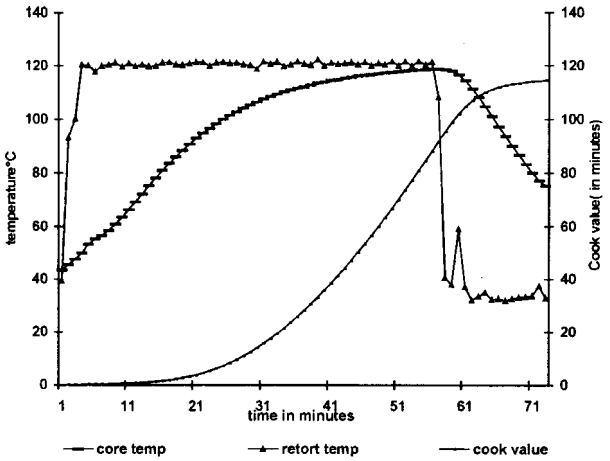

Fig. 7. Heat penetration characteristics and Cook value for Tuna in oil processed to Fo 10 and 4 rpm in aluminium cans

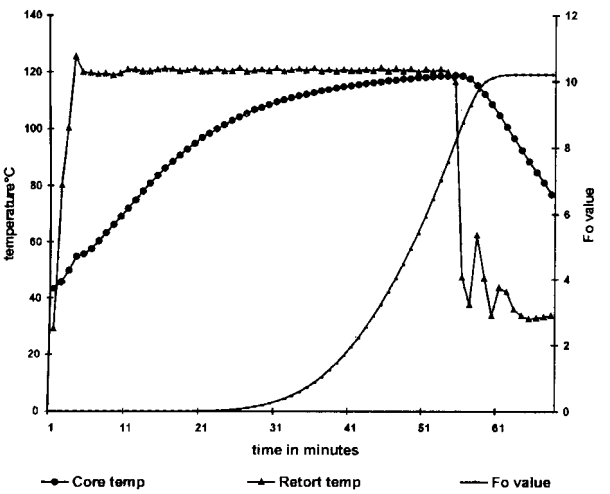

Fig. 8. Heat penetration characteristics of Tuna in oil processed to Fo 10 and 6 rpm in aluminium cans

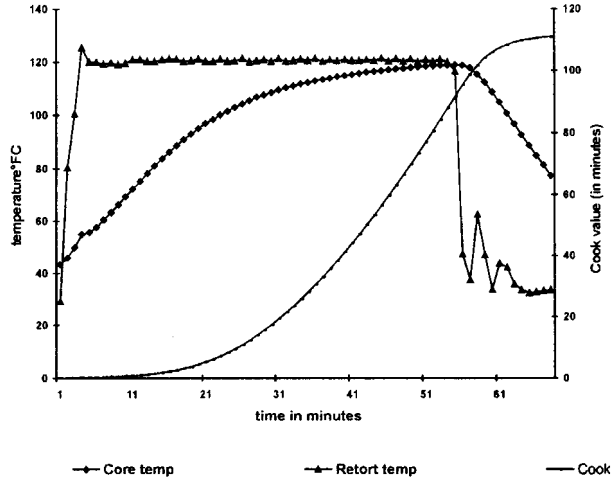

Fig. 9. Heat penetration characteristics and Cook value for Tuna in oil with Fo 10 and 6 rpm processed in aluminium cans

Vanloey (1994) reported that increase in rotational speed above 20 rpm resulted in breakage of the product. The value of fh/U showed a slight decrease due to the decrease in the values of heat penetration factor during rotation. The parameters like fh/U and g is also showing a decreasing trend with the increase in the speed of rotation since these parameters depend upon the heat penetration factor. fh/U is decreasing from 3.78 for the tuna in oil processed to a Fo value of 10 in stationary retort to 3.32 in rotary retort processed to an Fo 10 at 6 rpm. The value of 'g' is also decreasing from 2.49 in stationary retort to 2.07 for the product processed in rotary retort at 6 rpm to the same Fo value.

Total process time was decreasing with increase in the speed of rotation. The process time was reduced by 14 % by rotating to 6 rpm. But beyond 2 rpm the magnitude of reduction in process time was low. That is when tuna in oil packed in aluminium cans was processed to a Fo value of 10 in stationary and rotary retorts, reduction in process time was very less beyond 2 rpm.

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References

Anon (1968) *Laboratory Manual for Food Canners and Processors*, Vol.1, National Canners Association, AVI publishing Co., West Port.

Anon (1982) *Processes for Low Acid Canned Foods in Metal Containers*, Bulletin. 26.L, 12th Edition. National Food Processors Association, Washington, D.C.

Berry, M.R.Jr & Bradshaw, J.G. (1980) Heating characteristics of condensed cream of celery soup in a steriretort; heat penetration and spore count reduction. *Journal of Food Science*, **45**, pp 869-874, 879.

Berry, M.R. Jr. & Bradshaw, J.G. (1982) Heat penetration for slice mushroom in brine processed in still and agitating retorts with comparison to spore count reduction. *Journal of Food Science*, **47**, pp 1698-1704.

Berry, M.R.Jr. & Dickerson, R.W.Jr. (1981) Heating characteristics of whole kernel corn processed in a steriretort. *Journal of Food Science*, **46**, pp 889-895.

Berry, M.R.Jr. & Kohnhorst, A.L. (1985) Heating characteristics of the homogenous milk based formulas in cans processed in an agitating retort. *Journal of Food Science*, **50**, pp 209-214.

Frott, R. & Lewis, A.S. (1994) *Canning of Meat and Fish Products* (Frott, R. & Lewis, A. S., Eds), 202 p, Chapman and Hall, UK.

Hayakawa, K. (1977a) Review on computerized prediction of nutrients in thermally processed canned foods; *Journal of the A.O.A.C*, **60**, pp 1243-1250

Hayakawa, K. (1977b) Mathematical Methods for Estimating Proper Thermal Processes and their Computer Implementation. *Advanced Food research*, **23**, pp 75-79

Hayakawa, K. (1978) A Critical Review of the Mathematical Procedures for Determining Proper Heat Sterilization Processes. *Food Technology*, **32** (3), pp 59-64

Holdsworth, J.D. (1985) Optimization of Thermal Processing-A Review. *Jounal of Food Engineering*, **4**, pp 89-94

IS 2168 (1971) Specification for Pomfret Canned in Oil, Bureau of Indian Standards, New Delhi.

Lopez, A. (1981) *A Complete Course in Canning. Vol I and II* , Canning trade Inc. Cary, NC

Moscarella, F. & Vestito, A. (1994) Heat Treatment in the Peeled Tomatoes Production. *Industrie-Alimentari*; **33** (327) pp 625-630, 10.

Naveh, D. & Kopelman, I.J. (1980) Effects of some processing parameters on the heat transfer coefficient in a rotating autoclave. *Journal of Food Processing and Preservation*, **4**, pp 67-77.

Ramaswamy, H.S. & Sablani, S.S. (1997a) Particle Motion and Heat Transfer in Cans During End-Over End Rotation: Influence of Physical Properties and Rotational Speed. *Journal of Food Processing and Preservation*, **21** (2), pp 105-127

Ramaswamy, H.S. & Sablani, S.S. (1997b) Particle Shape Influence on Heat Transfer in Cans Containing Liquid Particle Mixtures Subjected to End-Over-End Rotation. *Lebensmittel-Wissenschaft-und-Technologi*, **30**(5), pp 525-535.

Sablani, S.S. & Ramaswamy, H.S. (1996) Heat transfer to particles in cans during end-over-end rotation: influence of particle size and volume fraction. *Journal of Food Process Engineering*, **19** (4), pp 403-424, 20.

Stumbo, C.R. (1973) *Thermo bacteriology in Food Processing*, 2nd edition, Academic Press, New York.

Vanloey, A., Francis, A., Hendrickx, M., Maesmans, G., Noronho,J & Tobback. P. (1994) Optimizing Thermal Process for Canned White Beans in water Cascading Retorts, *Journal of Food Science*, **59**(4), pp 828-832