RAINBOW TROUT (*SALMO IRIDEUS*) PRODUCED IN FINLAND

V. Heat penetration in canned trout products during processing

Jorma J. Laine

University of Helsinki, Institute of Meat Technology

Received August 24, 1968

The keeping quality of canned foods is based upon sterilization in retorts at elevated temperatures and pressure. In commercial processing the heat treatment is kept as low as possible to preserve the nutritional value, texture, color, flavor and consistence of the packed foods as stable as possible (Laine 1967). In commercial processing the bacterial endospores are not completely destroyed but are brought to dormancy so that they cannot cause any microbiological deterioration of the product (Stumbo 1965).

The proper sterilization for each product and can size is determined by the heat penetration and the amount and thermal resistance of the spores in the product. When these facts are known, the degree of adequate sterilization can be theoretically calculated (Cheftel and Thomas 1963).

Since the death of bacteria is generally logarithmic in practice, it can be described mathematically in the same manner as a unimolecular or a first-order bimolecular chemical reaction. Thermal destruction curves, often referred to as thermal death time curves, reflect the relative resistance of bacteria to different lethal temperatures. They can be conveniently constructed by plotting the logarithm of D or some multiple of D, which is the decimeration time during which 90 per cent of the original amount of spores are destroyed in the direction of ordinates against exposure temperature in the direction of abscissae (Stumbo 1965).

When this technique is used to estimate the initial number of spores and the number of those surviving the time t, D may be calculated as follows:

$$D = \frac{t}{\log a - \log b}$$

where a = Initial population

b = Final population

D = Time required at any temperature to destroy 90 per cent of the spores or vegetative cells of a given organism. Numerically, equal to the number of minutes required for the survivor curve to traverse one log cycle. Mathematically, equal to the reciprocal of the slope of the survivor curve.

t = The effective time of heating in minutes at the particular temperature (Stumbo 1965).

Heat penetration is dependent upon the product, packaging material, filling and processing temperatures, pressure, can size and filling degree. All these factors have a partial influence on the total or sterilization result (Ball and Olson 1957).

Measurements of the heat penetration should be done in the coldest spot of the can. This varies according to the food material and can size. Solid and semisolid products are heated mainly by conduction and the process is slow. In liquid and semiliquid products convection helps the heat movement and the process is fast (Stumbo 1965). In fishery products two phases occur, namely a liquid brine or sauce and a solid fish phase. In these products conduction and convection can be separated.

The most common method of aiding the heat penetration is to rotate the cans during processing. Gisske (1961) has studied the processing of meat and sausage products under rotation. The optimal rotation speed for these products seemed to be 30—40 RPM, whereas 60 RPM had undesirable effects. Wirth (1967) concluded, that the optimal rotation speed for meat products was 30 RPM. Glees (1963) indicated that rotation was the most important factor in reducing the processing times in big and high cans. In these studies the heat penetration was calculated according to the time required to reach + 117°C. In processing fishery products rotation also plays a role in improving the sterilization effect. Because of the fine structure of fish, rotation cannot be as fast as with the meat products. A rotation of 10 RPM is adequate in many instances in order to make the sterilization more effective.

In the present study heat penetration is calculated for two fishery products prepared from rainbow trout (*Salmo irideus*).

Material and methods

The test material consisted of fresh, gutted and iced rainbow trout. Two different products were made, namely trout in its own juice and smoked trout in vegetable oil. They were packed in cans of ø 73 × 64 mm and ø 73 × 103 mm, respectively.

Trout in its own juice was prepared as follows: The fish were cut into 64 mm long pieces. 240 grams of fish were packed in to each can and 2 per cent of salt and 0.2 per cent of spices were added. Smoked trout in vegetable oil was prepared as follows: The trout were brined for two hours in a 15 per cent salt solution. They were then dried for 10 minutes at + 80°C. After drying they were smoked at + 105°C for 50 minutes. The smoked fish were packed in cans; the proportion of fish and oil was 60:40.

After sealing the cans were processed in a Labor-Rotomat autoclave as follows:

Upper drum	+ 130°C
Lower drum	+ 120°C
Pressure	2 At
Movement	0 and 10 RPM

Heat penetration measurements were done thermoelectrically using Ellab (Elektrolaboratoriet Ellab A/S, Copenhagen) thermocouples, model TCSC 19. The measuring point was in all instances the geometrical center of the can. The results were registered with a compensation multirecorder. The recorder registered the temperatures in four cans, the pressure in the drum, and the rotation at intervals of 6 seconds.

In accordance with GLEES (1963), heat penetration was measured with the aid of heat penetration- or f_h-parameters. Comparisons with nonrotating sterilization were made between the times required until + 117°C was reached.

The cooling curve was constructed in the same manner. Cooling was complete when the center point of the can reached a temperature of + 30°C.

To obtain the heating curve, the difference between retort temperature and food temperature was plotted on the log scale against time on the linear scale. This is conveniently accomplished by rotating the semilog paper through 180° and labeling the top line at one degree below the retort temperature, and then plotting the temperatures directly. To obtain the cooling curve, the difference between food temperatures was plotted on the log scale against time on the linear scale. In this case the semilog paper was left in its normal position, the bottom line was labeled at one degree above the cooling water temperature, and the temperatures were plotted directly (STUMBO 1965).

Results

The heating curves of the two trout products tested are presented in Fig. 1. The results indicate that the heat penetration was more rapid in the smoked trout in vegetable oil (can size ø 73 × 103 mm) and that rotation aided the heat penetration considerably. In his case the f_{h117} was reached in 32 minutes with a rotation of 10 RPM and in 38 minutes without rotation. The trout in its own juice (can size ø 73 × 64 mm) had a much slower heating rate and f_{h117} was reached in 79 minutes with a rotation of 10 RPM and 81.5 minutes without rotation. Due to conduction there was no great difference between the rotating and non-rotating sterilization.

When the cooling curves were plotted on the log scale against time on the linear scale it was found that they formed a straight line in all instances. Cooling was considered complete when the temperature reached + 30°C. With the smoked trout in vegetable oil (can size ø 73 × 103 mm) the cooling times were 15.5 minutes for the rotating and 19 minutes for the non-rotating sterilization, and with the trout in its own juice 18.5 and 26 minutes, respectively.

Discussion

Heat penetration characteristics of two canned trout products were studied in a series of experiments where the processing was performed using both non-rotating and rotating (10 RPM) sterilization techniques. The two trout products tested were trout in its own juice and smoked trout in vegetable oil. The processing temperature (+ 120°C) and the pressure (2 At) were the same in all the experiments.

The trout in its own juice (can size ø 73 × 64 mm) was a solid product where the heat penetration occurred by conduction. This can be clearly seen from Fig. 1 where for the first 10—12 minutes of the operation the heat penetration was not logarithmic. After this the slope of the curves both with the rotating and non-rotating processes was gradual and f_{h117} was reached after 79 and 81.5 minutes respectively. At the end of the processing, the differences in cooling times were greater, 18.5 minutes in the rotating and 26 minutes in the non-rotating sterilization. This seems to be influenceb dy the forced convections of the fish juice in the heated and rotated product. When the rotated and nonrotated products, which were sterilized to an F_o-value of 7.5—8.5, were judged organolepticly, no differences in appearance, structure, odor or flavor were observed.

The smoked trout in vegetable oil (can size ø 73 × 103 mm) was a product with a solid and a liquid phase. For this reason heat penetration occurred both by convection and conduction. This can bee seen (Fig. 1) from the very short heating-up times and the steep heat penetration curves. Rotation aided the heat penetration considerably and f_{h117} was reached in the rotated products in 32 minutes. The corresponding value for the non-rotated products was 38 minutes. The same pattern was observed also in the cooling times, which were 15.5 minutes for the rotated and 19 minutes for the non-rotated products. When the rotated products, which were sterilized to an F_o-value of 7.5—8.5, were judged organolepticly, a marked difference in odor and flavor was observed in favour of the rotated products. The structure was slightly better in the non-rotated products however.

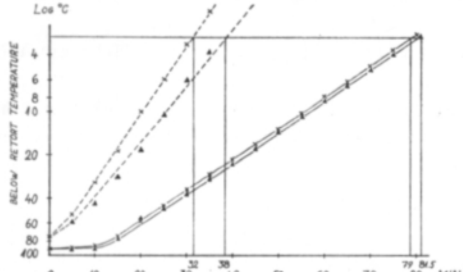

Fig. 1. Heating curves obtained in the sterilization of trout in its own juice (can size 73 × 64 mm) and smoked trout in vegetable oil can size Ø 72 × 103 mm) with a rotation of 0 and 10 RPM.

×———× trout in its own juice, 0 RPM
△———△ trout in its own juice, 10 RPM
×— — —× smoked trout in vegetable oil, 0 RPM
△— — —△ smoked trout in vegetable oil, 10 RPM

On comparing the two trout products with each other, a clear difference in the heat penetration was observed (Fig. 1). In the smoked trout packed in oil, rotation had a favorable effect both on the heat penetration and the quality of the product, whereas in the trout in its own juice, rotation had no practical effect on the heat penetration or the quality of the product. Rotation aided the cooling of both of the trout products and the cooling time from + 117°C to + 30°C was shorter in the rotated trout in its own juice (18.5 minutes) than in the non-rotated smoked trout in vegetable oil (19 minutes).

These experiments indicated that the techniques used in the sterilization of e.g. meat or vegetable products cannot be directly applied to the processing of fish products. Fish has a fine structure, and rotation speeds of 20—40 RPM may cause defects in its appearance. In solid products rotation had no practical effect on the heating time. However, when the fish was packed in oil, rotation aided the heat penetration and improved the quality of the product.

Summary

In the present study the heat penetration of two canned trout products was investigated. Heat penetration was measured and f_{h117} parameter were calculated. In the processing, a comparison with a non-rotating (10 RPM) sterilization was made.

The results indicated that smoked trout in vegetable oil (can size ø 73 × 103 mm) reached f_{h117} in 32 minutes with a rotation of 10 RPM and in 38 minutes without rotation. The corresponding values for trout in its own juice (can size ø 73 × 64 mm) were 79 and

81.5 minutes. At the end of the processing the cooling time from + 117°C to + 30°C was 15.5 minutes for the smoked trout in vegetable oil with a rotation of 10 RPM and 19 minutes in the non-rotating sterilization. The corresponding values for the trout in its own juice were 18.5 and 26 minutes.

REFERENCES

Ball, C. O. and Olson, C. F. W. 1957. Sterilization in food technology. McGraw-Hill Book Co., Inc., 654 p. New York, Toronto, London.

Cheftel, H. and Thomas, G. 1963. Principles and methods of establishing thermal processes for canned foods. Translated from French. Bull. 14, 78 p. Paris.

Gisske, W. 1961. Neue Erkenntnisse über die Methodik des Erhitzens von Fleisch und Fleischwaren. Die Fleischwirtsch. 13: 550.

Glees, A. 1963. Der Einfluss von Überdruck und Wasserumwälzung während der Standsterilisation und der Einfluss der Kopfraumgrösse und des Dosenformates während der Rotationssterilisation auf der Wärmegang von Fleischkonserven. Ibid. 15: 279.

Laine, J. J. 1967. Sterilointimenetelmien vaikutus säilykkeiden laatuun. Lihapäivät 1967. Helsingin Yliopiston Lihateknologian laitos, 47.

Stumbo, C. R. 1965. Thermobacteriology in food processing. Academic Press, 236 p. New York, London.

Wirth, F. 1967. Einflüsse auf die Hitzedurchdringung von Fleisch- und Fleischwaren-konserven bei der Rotationssterilisation. Die Fleischwirtsch. 47: 471.

SELOSTUS

TUTKIMUKSIA SUOMESSA KASVATETUSTA KIRJOLOHESTA (*SALMO IRIDEUS*)

V. Lämmön siirtymisestä tölkitetyissä kirjolohituotteissa sterilointikäsittelyn aikana

Jorma J. Laine

Helsingin Yliopisto, Lihateknologian laitos

Suoritetussa tutkimuksessa seurattiin lämmön siirtymistä kahdessa kirjolohisäilykkeessä sterilointikäsittelyn aikana. Lämmön siirtyminen mitattiin lämmönnousu- eli f_h-parametrien avulla. Lämmönnousu laskettiin prosessin alusta siihen hetkeen, jolloin lämpötila tölkin geometrisessä keskipisteessä saavutti + 117°C. Kokeet suoritettiin käyttäen liikkuvaa (10 kierrosta minuutissa) ja seisovaa sterilointitekniikkaa.

Tulokset osoittivat, että säilykkeissä, joissa savustettu kirjolohi oli pakattu öljyyn (rasiakoko ø 73 × 103 mm) $f_{h\,117\,°C}$ saavutettiin 32 minuutissa liikkuvassa ja 38 minuutissa seisovassa steriloinnissa. Vastaavat arvot säilykkeissä, joissa kirjolohi oli pakattu omaan liemeensä (rasiakoko ø 73 × 64 mm) olivat 79 ja 81.5 minuuttia. Jäähdytysajat + 30°C:een eri tuotteilla olivat seuraavat: savustettu kirjolohi öljyssä 15.5 minuuttia liikkuvassa ja 19 minuuttia seisovassa steriloinnissa, sekä kirjolohi omassa liemessään 18.5 minuuttia liiikkuvassa ja 26 minuuttia seisovassa steriloinnissa.