International Specialised Skills Institute

Thermal Processing: International Principles and Practices in Food Preservation

Chris Bourne

George Alexander Foundation International Fellowship

Fellowship funded by The George Alexander Foundation

The George Alexander Foundation

ISS Institute Inc

APRIL 2014

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Published by International Specialised Skills Institute, Melbourne

Extract published on www.issinstitute.org.au

i. Executive Summary

Traditionally thermal processed foods (e.g. canned) have very long shelf lives without the need for refrigeration, but this often comes at the cost of organoleptic and nutritional properties. The long shelf life also easily opens the market to international processors. To remain competitive, the Australian industry needs to continue to develop innovative, high quality products efficiently.

To assist this, the Fellow visited leading equipment manufacturers in the United States of America (USA) and France. Training was received in Canada and the United Kingdom (UK) and a conference was also attended in the UK.

Key opportunities lie in using the latest process design modelling. Finite Difference Modelling provides an opportunity to optimise existing processes for quality and efficiency.

A key factor in optimising quality of thermally processed goods is reducing the amount of over-processing. Statistical approaches can be used to identify critical process and product factors which affect variance in the final product.

Innovative machinery such as aggressive agitation 'Shaka' retorts can lead to dramatically improved product quality while shortening process times.

Other technologies such as High Pressure Processing, Pulsed Electric Field and Microwave can be used in conjunction with lean traditional thermal processes to optimise certain products for quality.

Understanding the opportunities presented by these techniques and technologies and combining this with clever business skills, the Australian food industry can have a brighter future.

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ii. Abbreviations/Acronyms

AgriFoods	Agrifood Skills Australia
FEA	Finite Element Analysis
HACCP	Hazard Analysis Critical Control Points
IFTPS	Institute for Thermal Processing Professionals
IT	Initial Temperature
ISS Institute	International Specialised Skills Institute
RT	Retort Temperature

iii. Definitions

Bacteriology

The study of bacteria. This subdivision of microbiology involves the identification, classification, and characterization of bacterial species.

Ball Method

An approximation of the lethality of a thermal process using initial conditions and characteristic parameters calculated from previously recorded data. The method is less accurate than the General Method but allows for re-calculation if initial parameters or process time change.

Fh

Time in minutes for the straight line portion of the semi-log plot of a heating curve to traverse one log cycle. Used in thermal process modelling to describe the heating rate of a product.

Finite Element Analysis

A computer modelling technique which produces a series of simple calculations to give analysis of complex structures.

j

The lag factor. Used in thermal process modelling to describe the lag before heat reaches the slowest heating point.

General Method

A technique of calculating the lethality of a thermal process using integration of data recorded during the process. It is the most accurate method but least flexible because measured data is needed to perform the calculation.

Headspace

The gap between the product and lid of a container.

Organoleptic

Aspects of food or other substances as experienced by the senses, including taste, sight, smell, and touch, in cases where dryness, moisture, and stale-fresh factors.

Retort

A steam pressure vessel – similar to an autoclave used for heat treatment or sterilisation of canned foods.

Thermobacteriology

Bacteriology concerned with the relationship between bacteria and heat. Thermobacteriology may include the study of the efficacy of heat sterilization techniques.

1. Acknowledgements

Christopher Bourne would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body – International Specialised Skills Institute (ISS Institute)

The International Specialised Skills Institute Inc is an independent, national organisation that for over two decades has worked with Australian governments, industry and education institutions to enable individuals to gain enhanced skills and experience in traditional trades, professions and leading-edge technologies.

At the heart of the ISS Institute are our Fellows. Under the **Overseas Applied Research Fellowship Program** the Fellows travel overseas. Upon their return, they are required to pass on what they have learnt by:

1. Preparing a detailed report for distribution to government departments, industry and educational institutions.
2. Recommending improvements to accredited educational courses.
3. Delivering training activities including workshops, conferences and forums.

Over 200 Australians have received Fellowships, across many industry sectors. In addition, recognised experts from overseas conduct training activities and events. To date, 22 leaders in their field have shared their expertise in Australia.

According to Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010':

> Australia requires a highly skilled population to maintain and improve our economic position in the face of increasing global competition, and to have the skills to adapt to the introduction of new technology and rapid change.
>
> International and Australian research indicates we need a deeper level of skills than currently exists in the Australian labour market to lift productivity. We need a workforce in which more people have skills, but also multiple and higher level skills and qualifications. Deepening skills across all occupations is crucial to achieving long-term productivity growth. It also reflects the recent trend for jobs to become more complex and the consequent increased demand for higher level skills. This trend is projected to continue regardless of whether we experience strong or weak economic growth in the future. Future environmental challenges will also create demand for more sustainability related skills across a range of industries and occupations.

In this context, the ISS Institute works with Fellows, industry and government to identify specific skills in Australia that require enhancing, where accredited courses are not available through Australian higher education institutions or other Registered Training Organisations. The Fellows' overseas experience sees them broadening and deepening their own professional practice, which they then share with their peers, industry and government upon their return. This is the focus of the ISS Institute's work.

For further information on our Fellows and our work see http://www.issinstitute.org.au.

1. Acknowledgements

Fellowship Sponsor: The George Alexander Foundation

The George Alexander Foundation supports activities in the following two areas:

Education

- to help talented young people achieve their full potential in any endeavour
- to support programs designed to improve educational, employment and leadership opportunities for disadvantaged young people

Environment and Conservation

- to develop partnerships with communities, government and the private sector to prevent irreversible damage to the environment and to encourage the maintenance of biodiversity

The Fellow would like to thank the George Alexander Foundation for providing funding support for this Fellowship.

Supporters

Arthur Blewitt	Chief Executive Officer, AgriFood Skills Australia
Ian Britt	Director, Britt & Associates, Canada
Jake Carroll	Information Technology Manager, Queensland Brain Institute
Donna Jack	Commercial Manager, Innoven and Rural Industries, Australia
David Lewis	Managing Director, Foodstream Pty Ltd, Brisbane, Australia
Gordon Young	Managing Director, Foodstream Pty Ltd, Brisbane, Australia

Employer Support

The Fellow acknowledges and appreciates the support of the staff of Foodstream Pty Ltd throughout the Fellowship process.

Organisations Impacted by the Fellowship

- Foodstream Pty Ltd
- Sunrice Australia
- Goulburn Ovens TAFE
- BNY Trading
- CSIRO
- DEEDI

2. About the Fellow

Name Christopher Bourne

Employment

Project Engineer, Foodstream Pty Ltd, Brisbane

Qualifications

Bachelor of Engineering (Mechatronic), University of Queensland, Brisbane, 2007

Approved Retort Supervisor, Innoven TAFE/ Foodstream, 2008

Diploma of Project Management, Brisbane North Institute of TAFE, 2012

Memberships

Institute for Thermal Processing Specialists - joined 2011

Brief Biography

Christopher Bourne is currently employed as a Project Engineer for Foodstream Pty Ltd, a consulting company that provides engineering, food science and training services to the Australian food industry.

Bourne spent his formative years in the Lockyer Valley, Queensland, where he was exposed to agriculture and the machinery associated with food production from an early age. In high school, he focused on maths and science study and went on to complete a Degree in Mechatronic Engineering at the University of Queensland in 2007. Bourne then studied a range of courses throughout the duration of his degree, focusing on Machine Design, Finite Element Analysis (FEA) and Fracture Mechanics, Robotics & Control, Acoustics, Telecoms, and also Digital Systems.

Since graduating from his degree in 2007, the Fellow has worked as a consulting engineer and has been involved in numerous projects covering a broad range of industries and specialty areas – ranging from snow making machines and brick manufacturing equipment, through to excavator attachments. Primarily however, he has focused on special purpose machines for the food industry, including peelers, dryers and cookers. Particular areas of interest for the Fellow are mechanisation, automation, robotics and remote sensing.

In 2008, Bourne attended a Retort Supervisor's course that led to work in thermal processing - carrying out temperature distribution analysis of equipment and thermal penetration studies for food products. Modern techniques of thermal processing have brought together the Fellow's interests in sensors, automation and modelling of industrial processes.

The shift in recent years away from domestic food production and the strong innovation in the food industry overseas, have driven the Fellow's desire to study the world's best practice in thermal processing. Knowledge of machinery and processes used overseas will help the Australian industry to innovate and remain competitive.

3. Aims of the Fellowship Program

The Fellowship provided the opportunity to learn the world's best practice in thermal processing of food, in particular:

- Obtain training in thermal processing from world leaders in the industry. This training would be through the short course 'Thermal Processing: Principles and Practices in Food Preservation' offered by Ian Britt & Associates in Ontario Canada
- Compare older methods (Ball/ Gilespie) of analysing thermal processes with newer Finite Difference modelling
- Analyse the different approaches to predicting quality degradation during thermal processing; in turn evaluating the application of these methods when developing processes for types of new food products
- Research the world's best practice in all aspects of thermal processing of foods – automation, machinery, packaging, modelling etc.

4. The Australian Context

A Brief Description of the Industry

Australia has a rich history of food production and processing; the geographic isolation and abundance of fertile land in coastal areas leading to a largely self-sufficient food industry.

Throughout the 20th Century, many cannery businesses formed throughout Australia. Often owned by grower's co-operatives, these canneries were developed as a way to utilise excess product.

Towards the end of the 20th Century, many of these preservation companies merged and ultimately become part of large multinational corporations. With the pressure to deliver product at lower costs and the flexibility in storage and shipping, there has been a trend towards imported canned commodity food products as opposed to utilising Australian produced goods.

Traditionally, preservation processes of food are designed to satisfy food safety with little consideration for quality. In recent years, developments in polymer materials and advanced machinery have led to new packaging methods of thermally processed foods. Pouches and trays (as compared to cans) allow for better thermal transfer and therefore more efficient cooking processes. Developments in automation have allowed better control over processes as well.

Sustainability is a key factor moving forward in the food industry. Water and energy footprints for production, processing and transport are vital areas to optimise. Finding clever ways to produce high quality, long shelf life foods allows for a reduction in waste by preventing spoilage over time and utilising raw materials which would otherwise be discarded.

Today, food production is Australia's largest manufacturing industry valued at around $100 billion per year. This industry feeds 60 million people worldwide and food security is a key issue the world will face with the demand for food and fibre products predicted to double over the next 40 years.

The AgriFoods Environmental Scan 2009 emphasised that the multinational food manufacturers, food service companies and supermarket chains that dominate global food markets can source their requirements from anywhere in the world.

In the climate of multinational food manufacturers, food service companies and supermarket chains, global competition for food production is stronger than ever and Australia's high labour costs are a significant barrier in commodity markets. To remain competitive in to the future, the Australian industry needs to become more innovative, sustainable and efficient.

SWOT Analysis

The SWOT analysis below explores the thermal processing industry in Australia. By exploring strengths, weaknesses, opportunities and threats, the current situation within this industry can be mapped and opportunities for future development more easily identified.

Strengths

- Increase of food security within Australia.
- Ability to develop new high quality, high margin products.
- Existing network of primary producers, processors and transporters.

4. The Australian Context

Weaknesses

- High labour costs in Australia threaten manufacturing.
- High labour cost in primary production.
- Relatively small domestic market and physical isolation for exports.
- High Australian dollar makes exporting more difficult.

Opportunities

- Reduction of waste through reduction of spoilage.
- The ability to produce higher quality, higher value products rather than commodity items.
- 'Make good' products which would otherwise go to waste.
- Optimisation of processes for energy efficiency.
- Optimisation of processes for productivity efficiency.
- Understanding of requirements in other markets to help build export opportunities.

Threats

- Cheaper operating costs in other countries e.g. New Zealand, South-East Asia, Africa and Eastern Europe.
- Technology developed locally may be adopted by other markets limiting local advantage.
- Product quality of preserved foods often inferior to fresh alternatives.
- Perception associating canned products with poor quality.
- Product appearance/ appeal.

5. Identifying the Skills and Knowledge Enhancements Required

There are examples of areas in Australian industries where there are weaknesses in innovation, skills, knowledge, experience, policies and/ or formal organisational structures to support the ongoing successful development and recognition of individuals and the particular sector.

The focus of all ISS Institute Fellowships is on applied research and investigation overseas by Australians. The main objective is to enable enhancement and improvement in skills and practice not currently available or implemented in Australia and the subsequent dissemination and sharing of those skills and recommendations throughout the relevant Australian industry, education, government bodies and the community.

The areas of applied research for this Fellowship are therefore defined as follows:

1. Up to date training in the latest international advances in thermal processing from world leaders is not readily available in Australia. The Fellow was able to:
   - » Attend the course 'Thermal Processing: Principles and Practices in Food Preservation' by Britt & Associates, in Canada (as recommended by the Institute for Thermal Processing Specialists)
   - » Attend the 7th International Thermal Processing Conference, at Chipping Campden, in the UK
   - » Attend the Thermal Processing – Quality Optimisation course, at Chipping Campden, in the UK.

Receive training in world's best practice in thermal process design and modelling.

2. Differentiate between methods of validating thermal processes as used internationally by:
   - » Visiting industry leaders in Finite Difference Modelling Software in the USA
   - » Obtaining skills and knowledge of the international requirements for thermally processed foods.

Observe and understand the current software models being used in the USA and UK, together with the current international requirements and evaluate their applicability for use in the Australian industry.

3. Differentiate methods of modelling food quality deterioration in thermally processed foods used internationally by:
   - » Visiting world leaders in the USA and UK in thermal processing and modelling.

Observe the latest trends in the industry and relate these to Australian applications.

4. Differentiate between the methods of modelling quality and safety of thermal processes by:
   - » Conducting an analysis of, and record information sourced – including visits, observations and interviews - and combine this knowledge to create better models not currently used in Australia.

Combine the findings of visits and interviews in the USA, Canada and Europe to create a summary of world's best practice and emerging trends in the industry.

6. The International Experience

Overview

The Fellowship applied research tour took place in May and June 2012 and spanned the USA, Canada, UK and France.

Two leading commercial equipment manufacturers, JBT Foodtech (Madera, California, USA) and Steriflow/ Barriquand (Roanne, France), were visited to study the latest available software, systems and machinery for the thermal processing industry.

A five-day training course was undertaken in Guelph, Ontario, Canada. This course is taught by the Executive Director of the Institute for Thermal Processing Specialists (IFTPS).

The International Thermal Processing Conference was attended at Chipping, Camden, in the UK.

A short course – 'Thermal processing – quality optimisation' was taken, also at Chipping Campden in the UK.

This range of experience gave a well-rounded view of the current state and future trends of the industry internationally.

Location: JBT Foodtech, Madera, California, USA

Contact: Terry Heyliger, Thermal Processing Manager

JBT FoodTech (previously FMC) has a rich history in the thermal processing industry dating back to the 1880s. JBT remain a leading manufacturer of batch and continuous retorts worldwide. JBT built retorts are used worldwide and offer a range of styles including continuous rotary, hydrostatic and agitating over-pressure retorts.

Software offerings are a strength for JBT Foodtech. They produce a range of finite difference modelling (FDM) based products such as NumeriCAL and TunaCAL for process optimisation. These packages can potentially improve quality and efficiency greatly and aren't widely used in Australia.

Figure 1: Pilot FMC rotary retort

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NumeriCAL and comparison with other techniques

General method

The general method is the 'gold standard' for process lethality calculation. It uses data collected from the actual process and calculates the lethality using an integration method.

Pros:

- Simple to calculate regardless of the heat pattern complexity
- Gives the most accurate result but requires reliable logged data.

Cons:

- Cannot be extrapolated to re-calculate lethality if parameters change such as initial temperature, process time, process temperature etc
- Calibration is critical since absolute temperature is used in the calculation.

Ball Method

The Ball Method is a mathematical approximation of lethality calculated from the vessel temperature and heating characteristics of the container and product. It generally gives conservative results but offers flexibility for re-calculating results with different parameters.

Pros:

- Easy to re-calculate lethality if parameters change
- Temperature difference is used – absolute calibration of probes is less critical so long as calibration against the reference probe is accurate
- Can be used to calculate processes with broken heating curves.

Cons:

- Less accurate if there is a high initial temperature and low retort temperature
- Uses a simplified, but conservative calculation for the come-up time
- Assumes the core doesn't heat any further once cooling starts which may under estimate lethality for food cooling
- Relies on single 'plateau' process temperature curve
- Not as accurate as the General Method – leads to conservative (over-cooked, but safe) processes.

Finite difference method

A model based on the finite difference method uses a mathematical model to predict temperature throughout the product based on temperature at the previous time step, behaviour of sections surrounding it, its previous temperature, its heating characteristics and process temperature. Once properly configured, it gives accuracy close to the general method, but with the flexibility of ball method. Figure 2, below shows the simulated and measured temperature profiles. Even with this relatively complex stepped heating profile, the simulation closely follows the real data in both heating and cooling.

6. The International Experience

Pros:

- Once properly configured, it can deliver results very close to the general method in both heating and cooling phases
- Flexibility similar to the ball method – i.e. re-calculation in the case of process deviation
- Continues to calculate accurately regardless of heat applied even if it is an abnormal pattern
- The model can be used for different heating modes and different container shapes. Can also be extended to other processes – e.g. chunks through in-line pasteurisation or blanching processes
- Uses similar input parameters to the Ball Method (Fh, J)
- Can be applied by a control system in real-time to calculate lethality on-the-fly and adjust to suit initial conditions and deviations automatically
- Temperature measurement calibration not critical in absolute terms
- Can be configured to target a quality parameter such as nutrient destruction rather than safety
- Can reduce cook time by 15 to 20 per cent.

Cons:

- Costs associated with licensing systems and software
- Model is only as good as the configuration – a poorly set-up model could result in unsafe food. The same is true for other methods, but the risk is higher when using slim error margins
- Regulatory acceptance can be a barrier while the accuracy of the model is being proven.

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Course: Thermal Processing: Principles and Practices in Food Preservation,

Guelph, Ontario, Canada

Contact/Course Leader: Ian Britt, Executive Director, Institute of Thermal Processing Specialists (IFTPS)

This four and a half day course covered a range of topics: Microbiology and Thermobacteriology, Developing Processes, Processing Principles and tutorial sessions.

A copy of the course program is available in Appendix 1. Relevant topics are discussed below.

Process evaluation – American perspective

Traditional thermal process design technology was developed in the early 20th Century, mostly by American Can Company leaders such as Ball, or Myer. Standard factors used to model the death of microorganisms was found experimentally and is largely unchallenged today. Concepts such as HACCP came about during the space race when the challenge of feeding astronauts was important. Embracing digital technology with paperless loggers, real time data collection, real time modelling and advanced control systems is the area changing most currently. The technology as a whole is very mature and safe, but there is room for improvement in quality.

Bentonite is a commonly used food simulator in the USA/ Canada. Depending on the mixture, it can simulate conduction, convection or broken heating patterns in foods. This can give more accurate temperature distribution studies than using water ballast, as is the common practice in Australia.

Factors were given to improve accuracy of measured data through corrections for probes being not quite on the mid-plane and the heat transfer through the probe itself. Logging frequency should be carefully chosen to be out of sync with agitation to give a true average reading.

The Arrhenius function gives options to calculate degradation from energy transfer rather than experimental observations. The results tend to be very similar though.

Heating profiles more complex than the traditional 'plateau' can be used to shorten cycle time, reduce variation and improve quality. The Ball method no longer applies though, so unless a finite difference model is used, any variations will likely result in a rejected batch.

IFTPS priorities moving in to the future

A section of the course covered the IFTPS priorities moving in to the future and where they see the organisation heading.

There has been a shift, particularly in commodity product to production in developing markets. In 2012, IFTPS ran its first outreach seminar in Thailand to ensure good practice and maintain safety in the industry.

The average age of IFTPS members is rising, so legacy plans to educate young members was flagged as an important consideration.

Consistency between regulatory bodies and unification to make sure standards are common worldwide, was seen as an important step to work towards.

Australia has a formal qualification requirement to be able to certify processes – the Approved Persons Course. This qualification is mandatory to be able to submit new thermal process schedules for

6. The International Experience

approval by the Department of Agriculture, Fisheries and Forestry (DAFF). This system is unique to Australia; generally people performing this work identify themselves as Process Authorities. IFTPS has worked to define this as below.

An individual, or group, expert in the development, implementation and evaluation of thermal and/ or aseptic processes. The areas of competency listed below provide a functional description of areas of practice, but are by no means inclusive or exclusive:

- Knowledge of microbial risks, product and packaging characteristics, critical factors, commercial equipment and manufacturing procedures and their effects on the delivery of a thermal process and maintenance of product sterility
- Knowledge of applicable regulations
- Knowledge of the underlying principles, process calculations, analysis tools and evaluation techniques related to thermal processing
- Knowledge and understanding of the appropriate design and methods of conducting studies relating to thermal processing of food, such as heat penetration, temperature and heat transfer distribution studies, thermal-death-time experiments, process validation and verification studies, and applying other scientific methods related to aseptic and/ or thermal processing
- Ability to analyse data generated by scientific studies and evaluate the effectiveness of a thermal processing and packaging system to ensure safe and commercially sterile products
- Experience and ability to identify and evaluate process deviations and spoilage incidents
- Ability to document process establishment methods and results and communicate thermal process requirements and recommendations.

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Conference: 7th International Thermal Processing Conference, Chipping Campden, UK

Contact: Daphne Davies

This two day conference featured presentations covering topical issues in the safety and quality of thermally processed foods, with technical sessions organised around the following themes:

- International food safety and quality issues
- New and improved methods for thermal process modelling and validation
- New and emerging food thermal processing equipment
- The future environmental and sustainability demands on thermally processed foods.

A full copy of the programme outline is available in Appendix 2. Key topics are outlined below.

Sustainability through engineering in practice

Paul Hardman, Senior Engineered Systems Specialist, Spirax Sarco Ltd, UK.

Spirax Sarco are a British-based manufacturer of boiler and pipeline control valves for steam heating. This presentation covered a case study of a major European canning plant where an energy audit was carried out to find waste through poor design and worn or outdated parts.

The core thermal energy balance revealed a 25 per cent loss in flue gases, 25 per cent loss between boiler stack and production, 25 per cent in effluent and only 25 per cent in the product.

After implementing the recommendations there was a six per cent drop in steam use on the first day. This equated to a 1.2MW average heat recovery with 2MW peak saving and a payback period of eight months.

This showed that in typical older factories, there can be 'low hanging fruit' – efficiency gains can come through auditing and replacing equipment which is ageing or no longer adequate.

Advances in Pulsed Electric Field Processing

Christopher Holland, Managing Director, Holmach Ltd

Holmach are a UK based company which specialise in leading edge thermal processing technology. Current systems they are distributing are outlined below:

Pure Pulse

Holmach offer a product which is an application of Pulsed Electric Field processing. The product is pumped through a 2.5-5mm diameter tube in laminar flow. Pulses in the kilovolt range for one to 30 microseconds are applied. This kills bacteria by splitting them.

Some advantages of this process are a low impact on quality and low energy compared with thermal processes. It is only suitable for pumpable products, viscosity and size of particles are restrictions.

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Capital cost is generally higher than traditional thermal processing equipment but is generally cheaper than High Pressure Processing.

Typical products that could benefit from Pulsed Electric Field processing are chilled juices and dairy products which could maintain freshness but lengthen shelf life.

Revtech

RevTech is an innovative machine that applies a thermal treatment while product is conveyed along a rotary spiral. The treatment can be applied dry or with a steam purge. This is ideal for low moisture products such as herbs, spices, nuts and seeds.

Figure 3: Revtech machine, UK

Process efficiency and energy optimisation in a vegetable cannery

Susan Featherstone, Manager Food & Beverage Technology, Nampak R&D, South Africa

This speaker presented a case study of energy efficiency optimisation in a South African cannery. Carbon footprint reduction and energy saving is an issue all businesses are facing.

In terms of cost, energy is a relatively small portion of the cost of canning. Figure 4 shows the results of their study in fruit canning, similar results were found in vegetables and meats.

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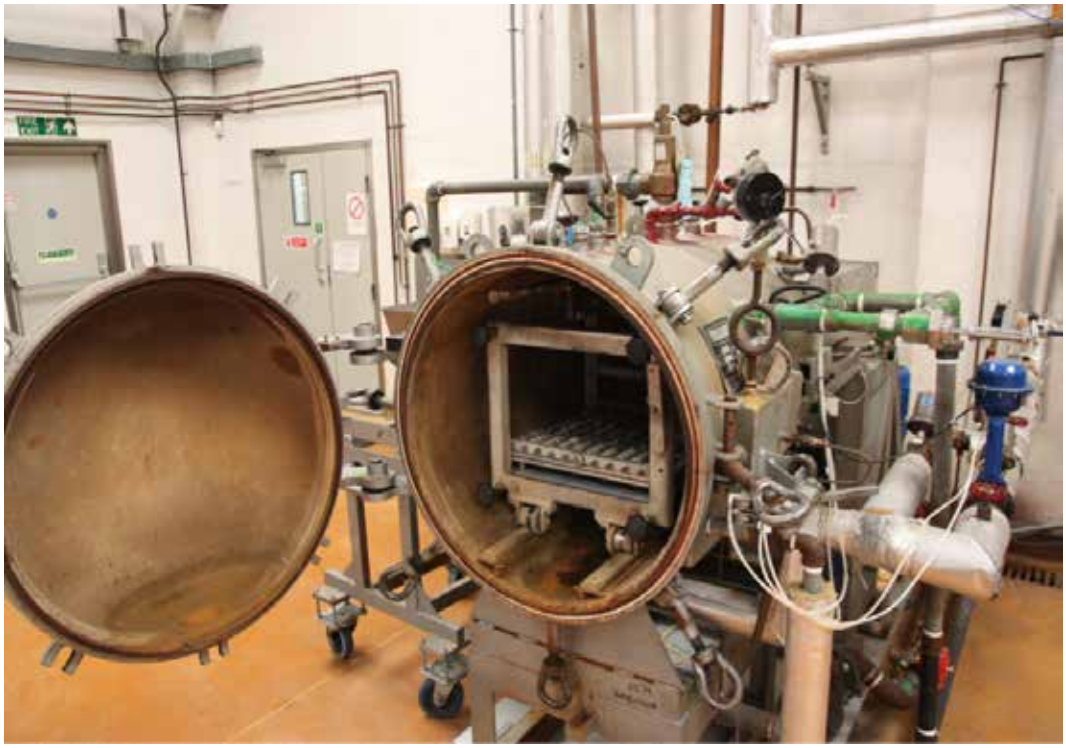

Figure 9: Shaka Prototype machine – Campden BRI, UK

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Figure 5 shows a breakdown of typical energy consumption at different process temperatures. The most significant reductions can generally be found by improving the supporting systems, for example:

- Boiler system
  - » Boiler efficiency
  - » Boiler cladding
  - » Recover heat from blow down
- Refrigeration efficiency
- Install product detecting sensors on conveyers
- Insulate hot and cold machinery
- Use recovered heat
- Heating Ventilation Air Conditioning (HVAC) systems.

There are some minor gains in the retort system such as in Streamline Ingredient preparation and processing (initial temperature and venting). Processing Temperature Figure 6 below shows the relatively insignificant change in steam usage at different processing temperatures.

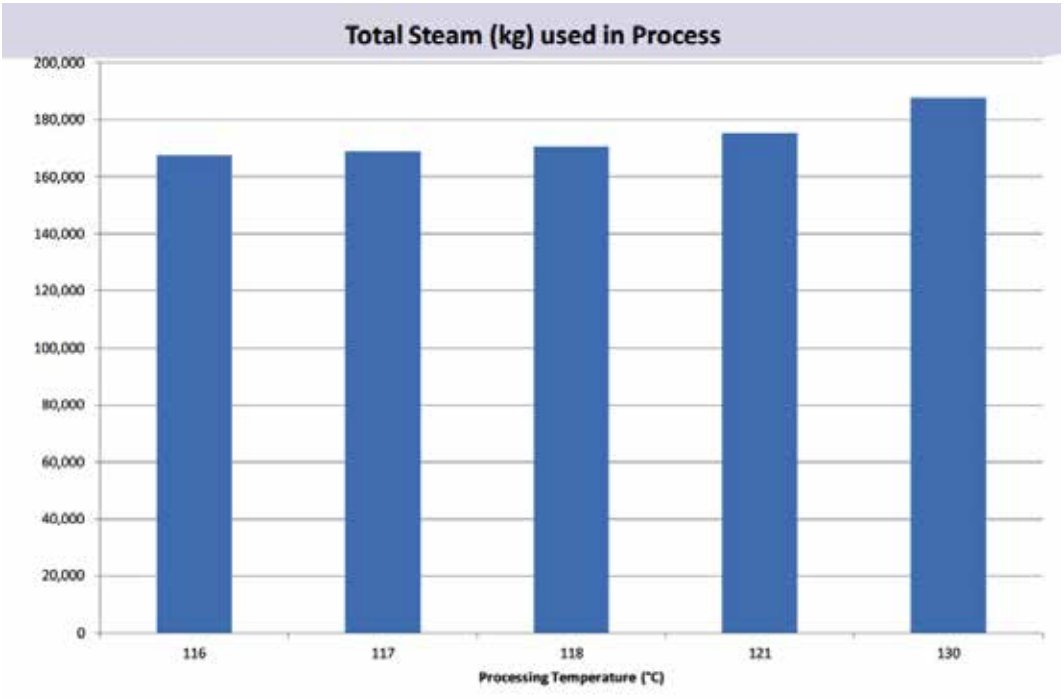

Figure 6 – Processing Temperature

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Novel and non-thermal technologies for food preservation

Nicolas Meneses, Bühler AG

Although beyond the scope of this study, this presentation gave some insight in to combination thermal and other novel techniques which will likely develop in coming years. Some examples of these are:

- High Pressure Processing
- Shockwaves
- Ultrasound
- Pulsed electric field
- Pulsed light
- Cool atmospheric plasma.

There are opportunities to use these technologies to inactivate spoilage organisms. When used in combination with a minimal thermal process, high quality products can be developed.

Figure 7: HPP pilot vessel – Campden BRI, UK

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Course: **Thermal processing – quality optimisation, Chipping Campden, UK**

Contact: **Nick May, Principal Research Officer**

This course is a one-day addition offered to participants of thermal processing courses. It covers practical applications to improve products as well as a range of concepts which may come to fruition in the future.

Statistical approaches to optimisation and sources for variation

A key factor in optimising quality of thermally processed goods is reducing the amount of over-processing. Statistical approaches can be used to identify critical process and product factors which affect variance in the final product. To create a clear picture of variation between and within batches, the Taguchi Method may be used to identify critical factors in heating. Monte Carlo Modelling can also be a powerful tool to model variation using known parameters. With these two combined, variance can be reduced and a less conservative process can be applied.

Opportunities with new technology

Cheaper and more powerful automation can make old concepts more viable and new processing technologies open doors for products which previously couldn't be made.

Cost reduction in technologies such as x-ray allow for real-time headspace checks, which can significantly reduce variation and allow for slimmer safety margins.

Smart phones and tablets bring high power computing to a very low price point. Quality optimisation systems using smartphones etc. will continue to develop in coming years.

Modelling

Campden BRI have a finite difference modelling package which bears many similarities to NumeriCAL (discussed earlier). CTemp can be used to model nutrient degradation as different thermal processes are applied to a product. Figure 8 below shows CTemp plotting the temperature profile from a known product and the theoretical profile with complex steps applied. Temperature difference between the inside and outside of the product is represented graphically to assist with understanding uniformity.

Computational Fluid Dynamics models have been applied to agitated products to simulate bubble movement and optimise agitation speed, fill levels, package selection etc.

Traditional modelling techniques such as the Ball Method have assumptions which can under-estimate lethality. If these limitations are understood, processes can be designed more accurately.

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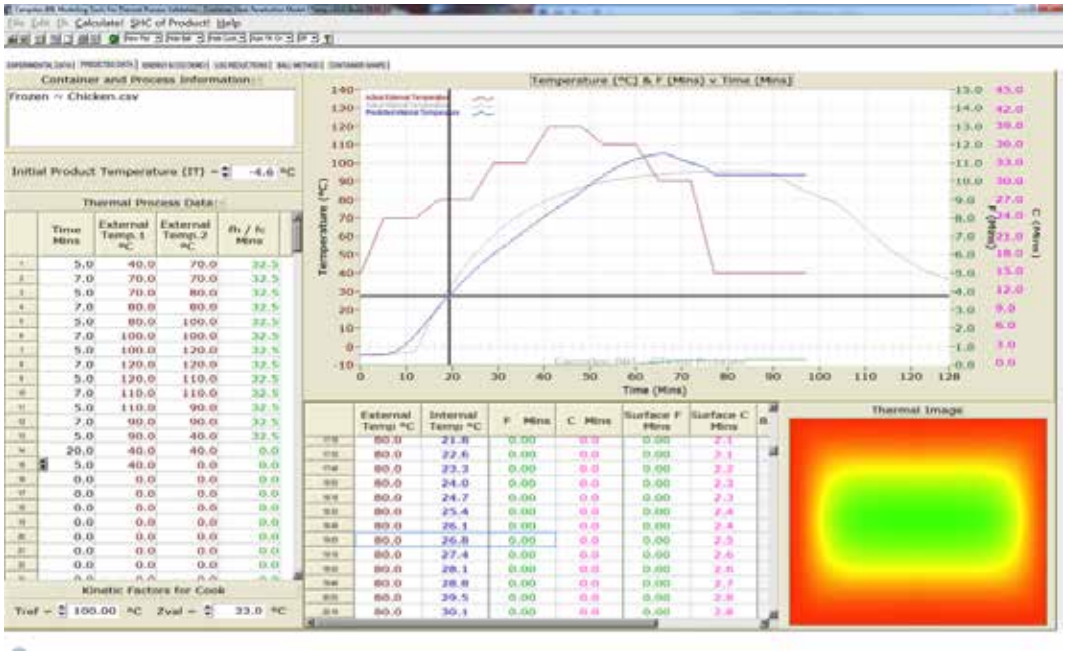

Figure 8 - Campden BRI CTemp finite difference model

Optimisation through Agitation

Agitation is a process whereby the product is moved during the cook to assist stirring and promote even cooking. Products with intermediate viscosity generally benefit most from agitation – low viscosity products self-mix through convection currents and high viscosity products tend not to mix even when agitation is applied. Start/ stop agitation generally gives better mixing results rather than continuous rotary, where the centre of the product can remain relatively stationary.

Preparation parameters can be significant in agitated products. Large particles in the product can assist mixing for example. Air bubbles also force the product to move around them, so low or inconsistent headspace can significantly impact performance. Rheology variation with process temperature can be a significant issue, particularly if the product is too thick or thin at temperature to benefit from the agitation. Product appearance can be an issue with agitation, such as chunks being broken during the process.

Novel concepts for unique products

A number of novel concepts were discussed in the course. Many of these have not been applied commercially, but with improved technology some could become viable.

- Chemical reactions with packaging generally result in poor quality e.g. Pineapple in a can without a lacquer lining. It could be embraced if there was an improvement to colour, taste or texture.
- Dehydro canning; where product is filled with little or no liquid can lead to unique products – for example 'no drain' tuna.
- Flash 18, a depressurised room with a higher water boiling point, so cans can be seamed in the open.
- VO Process – steam directly cooks the product and the package is sealed inside the retort.

Location: Steriflow, Roanne, France

Contact: Claire Brilhac

Steriflow are one of the world's leading manufacturers of Retorts. The facility in Roanne, France manufactures and develops pressure vessels, heat exchangers and supporting control systems in-house. Their most common units are over-pressure static retorts which use a 'water shower' to achieve adequate temperature distribution. These systems are widely used in Australia but an emerging technology 'Shaka' has opportunities in to the future.

Shaka

Agitation of cans while in retorts is commonly used to encourage even heating within the package – otherwise the product on the outside will be overcooked before the inner product has the required heat exposure. Shaka (see Figure 10) involves far more aggressive agitation than traditional methods which results in very even cooking and short processes. Typical stroke is 150mm at 120 to 180 shakes per minute.

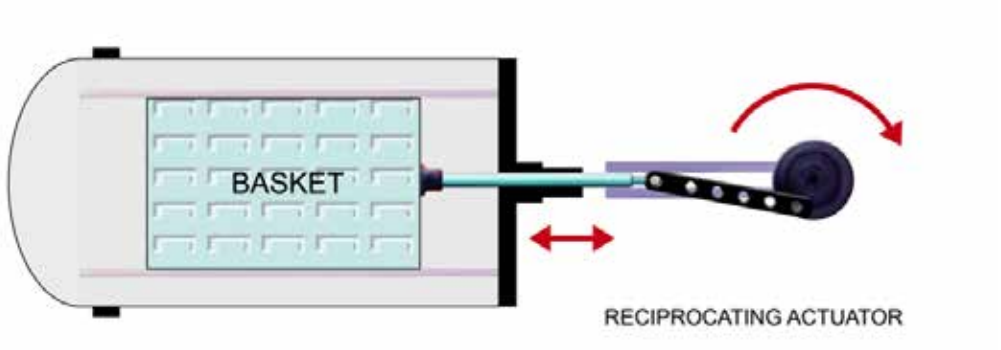

Figure 10 – Schematic view of the Shaka process

In static cooking, processes with relatively low temperature and long cook time are used to prevent over-cooking (and loss of quality) on the outside of the package. Shaka produced product heats evenly throughout the package, so short cycles at high temperatures are possible. Figure 11 below

6. The International Experience

shows a typical leek and potato soup product with process time of 140 minutes static, 50 minutes rotary agitated and 7.5 minutes in a Shaka retort.The result is a shelf stable product with quality similar to a chilled product.

Leek & potato soup (73mm x 110mm retail cans) - process times in minutes

	Come up	To Fo 6 (▲)	Cool	Total - from steam on until end of cooling to 40° C
Static	5.0	80	55	140
Rotary	7.0	29	14	50
Shaka™	2.0	2.5	3.0	7.5

Figure 11: Comparison of Static, Rotary and Shaka cooks of a Leek and potato soup

The short cooks mean smaller machines can be used while maintaining the same line throughput. Products typically suitable for this technology are soups, pasta, red meat and dairy. A high quality, shelf stable fish soup is being processed in Shaka machines and sold commercially in France. The Béchamel Sauce shown below has significant benefits in appearance and flavour when processed in a Shaka retort rather than the traditional Rotary agitation style.

Figure 12: Béchamel Sauce after Rotary (left) and Shaka (right) process.

As is the case with all agitation systems, not all products will suit this setup – there will be little or no benefit in watery or solid products. Mechanically, highly automated loading systems are very desirable to keep up with the quick cycle times. Maintenance is also critical on the agitation system to avoid downtime.

The Shaka process is technology licensed from Zinetec Ltd. Licensing costs of the technology must also be considered but the potential to develop innovative, very high quality products may outweigh these issues.

6. The International Experience

Figure 13: Pasta product in Shaka mounting tray – Steriflow, France

7. Knowledge Transfer: Applying the Outcomes

The following activities will be investigated to transfer the knowledge gained throughout the Fellowship:

Summary Articles

Three summary articles have been written so far:

- One is available on the Foodstream website as a case study. This was featured in the August 2013 email newsletter
- An article 'Thermal Processing: what's on the horizon' has been published in Food & Drink Business magazine, October 2013 issue
- An article has been written and submitted to Food Australia and will be published in an upcoming issue.

Embedding the Transfer of Knowledge within Existing Courses

The course material for training courses the Fellow is directly involved in will be updated to include the findings of this Fellowship. In particular, the areas of quality optimisation and efficiency. The courses will also give students insight in to requirements used in the USA and Europe.

Industry Seminar

A seminar is being developed and will be held in early 2014 following a Retort Supervisor's course. The seminar will have presentations covering the key findings of this Fellowship tour as well as giving an opportunity to directly further engage with the industry.

Paper for the next AIFST conference

The next AIFST conference will be held in Melbourne in June 2014. The Fellow will submit an abstract to present at the conference.

8. Recommendations

Government

- That national, state and regional government give funding and policy support to the Australian food industry to keep it globally competitive and ensure food safety and security.
- That government departments ensure their facilities are readily accessible to small business so that they can develop products effectively.
- That government provides incentives to encourage new and novel technology in the industry.

Industry Networks and Professional Associations

- Australian and international associations work together to unify standards and ensure the Australian industry remains up-to-date through participation in international societies such as IFTPS.
- Support be given to foster innovation in Australia. This must extend beyond research and include market research, marketing and other sound business principles.

Education and Training

- That Australian based training includes new techniques to ensure the industry takes advantage of new and novel technologies in new product development.
- That machine design appropriate for the food industry is taught to support the Australian machine design industry.

ISS Institute

The Australian food industry accounts for around 20 per cent of manufacturing sales and income. DAFF has identified the industry as being integral to Australia's economic and social prosperity. As such, proposals working towards a modern, progressive and secure industry should continue to be supported by groups such as the ISS Institute, George Alexander Foundation, AgriFood Skills Australia.

9. References

Books

Holdsworth, D & Simpsons, S, Thermal Processing of Packaged Foods, 2nd ed., Springer, New York, USA

Articles/Reports

2009 Environmental Scan of the Agrifood Industries, Agrifood Skils Australia

Conference Material

Britt, I 2012, Thermal Processing: Principles and Practices in Food Preservation, Guelph ON, Canada

Featherstone, S 2012, Investigating options for energy saving in canneries in South Africa, 7th International thermal processing conference, Campden BRI, England

May, N 2012, Thermal processing validation methods -what can be improved?, 7th International thermal processing conference, Campden BRI, England

Articles/Reports

Holdsworth, S.D. 1985, Optimisation of Thermal Processing – A Review, Journal of Food Engineering, England

2009 Environmental Scan of the AgriFood Industries, Agrifood Skills Australia, Canberra

Websites

Shaka Process – higher quality ambient foods, Zinetec, viewed 15 August 2012, < http://shakaprocess.com/>

10. Attachments

Appendix 1:

Thermal Processing: Principles and Practices in Food Preservation

Now in our twenty-sixth year

June 4-8, 2012
Guelph Holiday Inn
Guelph, Ontario

Britt and Associates

Course Topics

Our objective in this course is to emphasize an understanding of the interrelationships that exist amongst the many discrete concepts applied in thermal process development.

Microbiology and Thermobacteriology

- Food spoilage organisms
- Thermal effects on cells and spores
- Kinetics of microbial death in moist heat
- Survival: enumeration and probability

Developing Processes

- Analysis of heating and cooling curves
  - Influence of experimental and processing conditions on f_h and j
  - Documenting the critical factors
  - Worst case vs. statistical approaches
- Process lethality
- General method calculations
- Ball formula method in detail
  - Understanding the U-factor
  - Come-up time credit
  - Complex (broken) heating products
  - Departure from underlying assumptions
- Pasteurization process calculations
- Quality attribute calculations
- Process deviations
- Engineered or designed F_o
- Processing plastics
- Sensitivity analysis
  - How do changes in the process/package/product system affect the process
  - Influence of the z-value and processing temperature on lethality

Processing Principles

- Heat transfer fundamentals
- Still and agitated retort systems
- Temperature measurement principles
- Temperature distribution and stability
- Heat penetration principles
- Heat transfer and lethality distribution

Tutorial Sessions

- Thermobacteriology
- Plotting heating and cooling curves
- General method applications
- Ball's formula method
- Resolution of process deviations

Location and Hotel Accommodation

The course will be held at the Holiday Inn Guelph Hotel & Conference Centre, 601 Scottsdale Drive, Guelph Ontario, N1G 3E7. The hotel has set aside a block of rooms at a reduced rate of $109.99 CDN based on availability. Please make your room reservations directly with the hotel (519 836 7124) and mention that you are attending this course (block code BAA) to ensure the reduced rate. Guelph is approximately 70 km (45 miles) from Toronto's Pearson International Airport, and airport transportation may be arranged through Red Car Service, www.redcarservice.com, or phone 519 824 9344; fare at time of printing was $70 CDN + tax (one way, major credit cards accepted).

For more information, please contact:

Britt and Associates
Ian Britt
102 Harvard Road, Guelph, ON N1G 2Z2
519 836 0999 · ian.britt@brittandassociates.com

10. Attachments

Registration

Course Fee: (includes 13% Harmonized Sales Tax) $2295 CDN

The course fee includes: Course notes and handouts; refreshment breaks and lunches.

Payable by: check, international money order, Visa, MasterCard or American Express (fax 519 824 6642 or mail) to:

Britt and Associates
102 Harvard Rd.
Guelph, ON N1G 2Z2

We will start at 8:30 Monday morning and finish at noon on Friday.

Name _____

Title _____

Firm _____

Address _____

City/State/Zip _____

Phone _____ Fax _____

Email _____

Credit Card _____ Expiry _____

Cardholder _____ Signature _____

Appendix 2:

Full Programme- Thermal Processing: Principles and Practices in Food Preservation

Thermal Processing Conference - 13-14 June 2012

Campden BRI, Chipping Campden, Gloucestershire, UK

Day 1

09:00 Registration

09:15 Welcome and Chairman's introduction

09:30 International standards for thermally processed foods

Ian Britt, Executive Director, Institute of Thermal Processing Specialists (IFTPS), USA.

Session 1: Energy and water - the universal ingredients

10:00 Sustainability through engineering in practice

Paul Hardman, Senior Engineered Systems Specialist, Spirax Sarco Ltd, UK.

10:40 Refreshment break

11:10 Advances in Pulsed Electric Field Processing.

Christopher Holland, Managing Director, Holmach Ltd

11:50 Water treatment technologies for food processing

Claudio Comoglio, Ashland Hercules Water Technologies, UK.

12:30 What's new from the sponsors

13:00 Lunch in the Marquee; opportunity to meet our sponsors and visit exhibits & posters

Session 2: Thermal food processing

14:00 Thermal processing in practice Delegates will be divided into four groups, each visiting the following activities:

1. a food law clinic, brief outline of new and emerging issue, followed by discussion and informal Q&A.

2. a demonstration on the heat treatment of low moisture ingredients (e.g. herbs, spices, nuts and seeds)

3. a discussion group on the Campden BRI Canned Food Specifications, a key tool for defining quality attributes of thermally processed foods

4. deflection measurement systems for semi-rigid retortable packaging

15:20 Refreshment break

15:40 Continuous in-pack food retorting systems

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4. deflection measurement systems for semi-rigid retortable packaging

15:20 Refreshment break

15:40 Continuous in-pack food retorting systems

Thierry Lechner, Technical Director, Steritech SA, France

16:20 Process efficiency and energy optimisation in a vegetable cannery

Susan Featherstone, Manager Food & Beverage Technology, Nampak R&D, South Africa

17:00 Close of day 1

18:45 Coaches leave the market square at Chipping Campden for Warwick

19:30 Conference Dinner: Highwayman's supper at Warwick Castle

Day 2

Session 3: Recent advances in thermal processing - what's new in ...

09:00 Process validation of new thermally processed foods

Patricia Ruiz, Processing Technologies Manager, National Centre of Technology and Food Safety (CNTA), Spain.

09:40 Optimising food process sterilisation schedules for safety

Ivan Leguerinel, Professor, Laboratoire Universitaire de Biodiversite et d'Ecologie Microbienne, University of Brest, France.

10:20 Refreshment break

10:50 Novel and non-thermal technologies for food preservation

Nicolas Meneses, Bühler AG

11:30 Microbial controls in food processing environments

Edyta Margas, Hygiene and Novel Technologies Specialist, Campden BRI, UK.

12:20 Buffet lunch in the Marquee; another opportunity to meet our sponsors and visit exhibits & posters

13:30 Paperless thermal process data acquisition, monitoring and validation

Peter Cusworth/David Jones, Yokogawa, UK.

14:20 Biological assessment of samples

Nigel Chitty, ATI Atlas Ltd

14:50 Thermal process validation methods - what can be improved?

Nick May, Thermal Processing Specialist, Campden BRI, UK.

15:30 Closing remarks from the Chairman