final report

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CSIRO

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High pressure processing workshop for red meat product applications – Red meat under pressure

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FOOD INNOVATION CENTRE
www.csiro.au

High pressure processing workshop for red meat product applications - Red meat under pressure

Anita Sikes and Debra Krause
CSIRO R6644-2-1-7 | MLA A.RMH.0024
16 December 2014

Meat and Livestock Australia (MLA)
Michael Lee

MEAT & LIVESTOCK AUSTRALIA

CSIRO Food and Nutrition Flagship

http://www.csiro.au/Organisation-Structure/Flagships/Food-and-Nutrition.aspx

CSIRO Food Innovation Centre

http://www.csiro.au/Outcomes/Food-and-Agriculture/CSIRO-food-innovation-centre.aspx

Contents

Acknowledgments

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Michael Lee

Emily Thompson

Sam Burke

CSIRO Project Team:

Roman Buckow

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Sieh Ng

Anita Sikes

Lloyd Simons

Rod Smith

Introduction

The "Red meat under pressure" workshop was hosted by CSIRO and MLA on 27th November 2014 at CSIRO's Food Innovation Centre in Werribee, Victoria. The purpose of the workshop was to present commercialisation opportunities in high pressure processing (HPP) technology for red meat applications to Australia's meat processing companies. Invitations (Appendix 1) were sent to 52 selected meat value-adders and brand owners of red meat (Appendix 2). The workshop program (Appendix 3) showcased how HPP could add value and enhance the quality, shelf-life, safety and tenderness of meat products, through recently completed MLA-funded research in HPP, as well as a demonstration of the CSIRO Food Innovation Centre HPP plant and product concept demonstration and tasting. The information presented to workshop participants is given in Appendix 4. CSIRO also assisted with the production of a video, aiming to showcase the outcomes of the HPP work, through enabling video footage of the HPP process in the food processing plant and the preparation of the concept dishes in the kitchen facility.

Workshop participants

The workshop was attended by 17 delegates representing 14 companies in the food manufacturing industry (Appendix 5). Companies included meat companies, HPP processors and packaging companies.

Feedback from workshop participants

Participants were encouraged to complete an 'Expression of interest for further follow up' form and response was received from 15 delegates. Feedback from the workshop was positive with 8 companies expressing interest in finding out more about opportunities for investment in HPP technology in the next 12 months and a further 2 companies in 1-2 years. There were also 8 companies who expressed an interest in finding out more about MLA funding opportunities for future collaborative research. Scanned copies of each feedback form can be found in Appendix 6.

A summary of participant comments is summarised below.

1. Did you find the workshop valuable?

Yes; **15**	No; **0**

What did/didn't you like?

- Learnt some new things, met potential new clients, very good day
- Very informative, interesting concepts, re: tenderisation
- Bringing all participants together is excellent for rapid development of concepts to commercialisation
- Concept of adding value to lesser value meat cuts, shelf-life extension, reduction of food additives, sodium
- Very informative & filled in more gaps of knowledge about HPP process and benefits
- Refresh current knowledge of HPP technology, would like a copy of slide show
- Great to sample product post HPP, really helped to inform opinion
- Enjoyed the meat science trial info and application in industry
- Enjoyed the overview of HPP benefits, i.e. shelf-life extension, meat texture improvement & commercialisation opportunities
- Information on tenderisation of lower grade meats, quick time to prepare compared to normal

methods • Good examples from the chef, all good • The shelf-life cooking, HPP with heat added • Extended shelf-life, micro reduction • First time hearing about HPP

2. Would you come to future workshops in the meat area?

Yes; **15**	No; -**0**

3. Prior to this workshop what was your knowledge of HPP?

None; **2**	some awareness; **7**	previous knowledge; **6**

4. Is your company interested in finding out more about opportunities for investment in HPP technology?

If yes, what is the likely time frame?

Now; **8**	1-2 years; **2**	>2+ years; **4**	n/a; **1**

What are your area(s) of interest?

new concept s for existing products; **9**	markets; **7**	prototype products; **9**
access to HPP technology; **9**	supply chain partnering opportunities; **5**	other (please specify); **0**
• Interested in trialling some more products (Wagstaff) • Slow cooked red meat products for QSR& retail, E-number free red meat smallgoods, shelf-life extension of raw meat using HPP(Beak & Johnston) • Shelf-life extension of raw chilled vacuum packed primal of lamb, beef and pork (Sealed Air)		

5. Is your company interested in finding out more about MLA funding for future collaborative research?

Yes; **9** Longfresh, Preshafood, Top Cut, Wagstaff, Teys, OSI International Foods, Frew Group, BMC, Simpson Farms,	No; **0**	Not stated; **6** Beak & Johnston, Australian Lamb Group x2, Sealed Air, Moira Mac's, I.E.,
• Already working on some funding but additional opportunities always of interest (Teys) • We are always looking at new innovative ideas to adapt to current business and process (Wagstaff)		

6. Are there any other areas of interest your company would like to find out more about?

• Always keen for new areas of technology and development (Wagstaff) • Any further information on MLA activities would be helpful (Preshafood) • Functional foods/ proteins (Longfresh) • MLA Insight workshop (Longfresh)

Next steps

Companies showing interest in exploring opportunities for investing in HPP technology have been identified and prioritised from the feedback obtained, and contact with company representatives will be made by either CSIRO or MLA staff. Access to the workshop information will be made available to all meat industry representatives (including companies who did not attend the workshop) via newsletters, trade journal articles, links to published papers, You Tube videos, etc. CSIRO and MLA project team members will meet in January/February 2015 to discuss potential projects and partner companies.

CSIRO Project Team:

Roman Buckow	Debra Krause
Sieh Ng	Anita Sikes
Lloyd Simons	Rod Smith

18 December 2014

Concept Product Preparation

Video production

Workshop Activities

Concept Products for Demonstration

Lamb Tajine

Goat Curry

Beef Short Rib

Beef Chuck Soft Taco

Concept Products for Tasting

Beef Short Rib

Lamb Tagine

Appendix A HPP workshop invitation

Invitation

www.csiro.au

Red meat under pressure

Commercialisation opportunities in tenderising and extending shelf-life of red meat products

Image source: Meat & Livestock Australia

Tenderising and extending the shelf-life of red meat cuts is possible using innovative high pressure processing (HPP) technology.

Applying pressures of up to 600 MPa, HPP is used routinely in nearly 200 industrial units worldwide mainly for cold pasteurisation of smallgoods, meals, beverages and a variety of produce. HPP can not only tenderise and extend shelf-life, but can also reduce reliance on preservatives and inactivate foodborne pathogens while maintaining colour, flavour and fresh-like characteristics.

This workshop, hosted by CSIRO and MLA, provides the ideal opportunity for Australia's meat processing companies to learn how HPP could add value and enhance the quality, shelf-life, safety and tenderness of red meat products.

You will be able to view and taste tenderised HPP beef, lamb and goat products and see a demonstration of the CSIRO food innovation centre's HPP plant, the only one of its kind in Australia.

At the workshop, CSIRO and MLA will present commercialisation opportunities in HPP technology for red meat applications and showcase recently completed MLA-funded research in HPP. Participating companies will have the opportunity to register their

MEAT & LIVESTOCK AUSTRALIA

Date:

Thursday 27 November 2014

Time:
10:00am - 2:00pm

Location:
CSIRO Food and Nutrition Flagship
671 Sneydes Road
Werribee Vic 3030

RSVP before:
Friday 21 November 2014

RSVP online

RSVP & registration

RSVP enquiries
T: **1300 363 400**
E: enquiries@csiro.au

MLA enquiries
Michael Lee
T: **02 9463 9333**
E: mlee@mla.com.au

interest to invest in further development work such as food safety, shelf-life, scale-up and product development and may qualify for MLA funding for future collaborative research.

Who should attend?

Innovation managers and technology managers in the food production and manufacturing industries.

Cost:

The forum is free of charge. Lunch and refreshments are included.

Event information

CSIRO's food innovation centre

www.mla.com.au

Program outline

- Consumer and market information and insights into positioning potential for HPP of red meat products
- Overview of current product applications (not limited to meat products), commercial applications, business models, current HPP operators in Australia and indicative cost comparison to other processing treatments
- HPP research outcomes for meat quality, shelf-life and safety
- View and taste HPP meat products
- Demonstration of the CSIRO food innovation centre HPP plant
- Facilitated discussion of commercialisation opportunities
    - products and channels
    - local operators, supply chain
    - potential commercial scenarios
    - MLA funding opportunities
- Next steps

Appendix C HPP workshop program

Red meat under pressure workshop

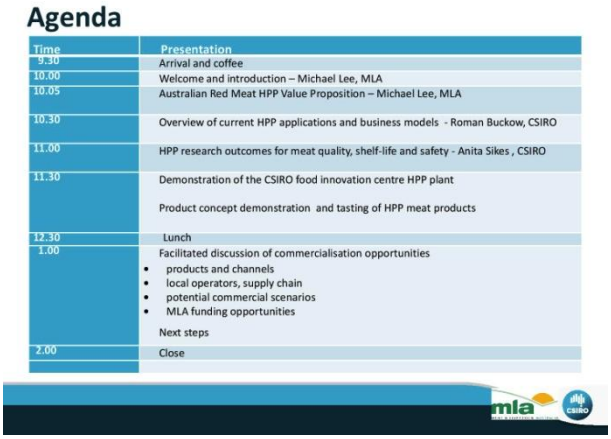
Commercialisation opportunities in tenderising and extending shelf-life of red meat products

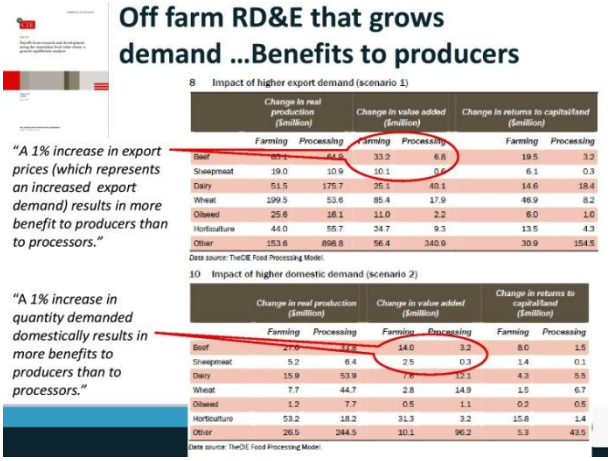
Thursday 27 November 2014

Program

Time	Presentation
9.30	Arrival and coffee
10.00	Welcome and introduction – Michael Lee, MLA
10.05	The Australian red meat HPP value proposition – Michael Lee, MLA
10.30	Overview of current HPP applications and business models - Roman Buckow, CSIRO
11.00	HPP research outcomes for meat quality, shelf-life and safety - Anita Sikes , CSIRO
11.30	Demonstration of the CSIRO food innovation centre HPP plant Product concept demonstration and tasting of HPP meat products
12.30	Lunch
1.00	Facilitated discussion of commercialisation opportunities • products and channels • local operators, supply chain • potential commercial scenarios • MLA funding opportunities Next steps
2.00	Close

Appendix D Presentation delivered to workshop participants





Key Trends in Food, Nutrition & Health 2014

(Julian Mellentin, New Nutrition Business, 2014)

Key Trends in Food, Nutrition & Health 2014

(Julian Mellentin, New Nutrition Business, 2014)

- Australia has one of the highest allergy prevalence rates in the world.
- Surveys indicate that up to 25 percent of the population believe they have some sort of food intolerance

- HPP is a technology platform that inactivates the microbes and therefore does not require any further additives and maintains natural meat flavours

Consumer & Market insights driven RD&E

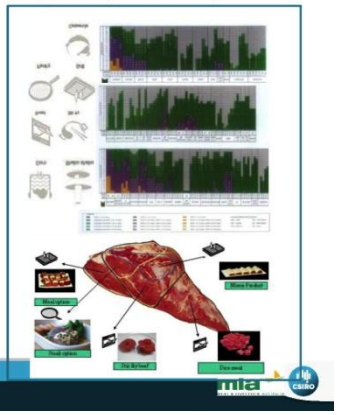
Adding value to secondary cuts (cut/cook)

Beef Chuck- 10hr slow cook

Beef Short ribs- 5hr slow cook

Diced Goat- 3hr stew

Lamb FQ- 3hr stew

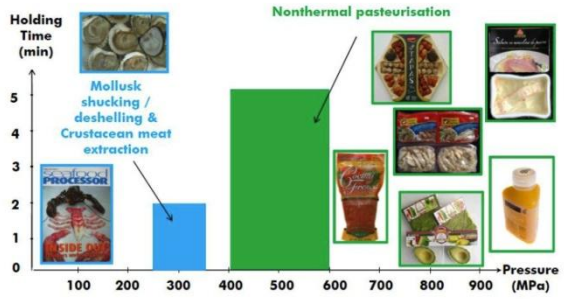


Current cooking platforms

High Pressure Processing - Current Applications, Business Models and Costs

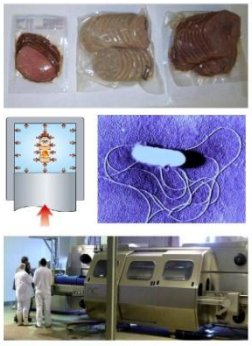
Roman Buckow | Research Group Leader
27 November 2014
www.csiro.au

Commercial application of HPP – pressure range

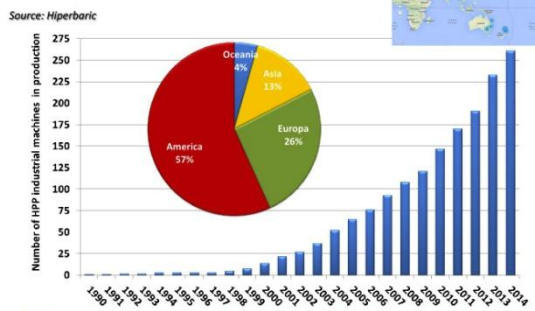


HPP – in more detail

- Technical overview
- Value proposition
- Global uptake & domestic players

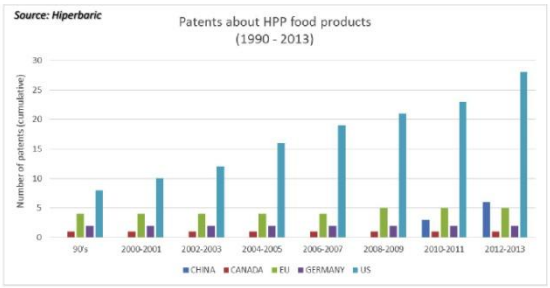


HPP industrial machines



- Total machine number in production (Hiperbaric & competitors): 261

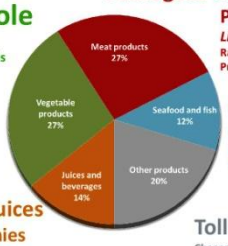
Patents on HPP products & processes



HPP Commercial Products

Pathogens-free sliced cooked meats
Preservative-free deli meats
Listeria-free dry-cured products
Raw beef products
Preservative-free sausages

Guacamole
Wet salads
RTE vegetable meals



Oysters shucking
Lobster meat extraction
Clams & mussels shucking
RTE seafood meals

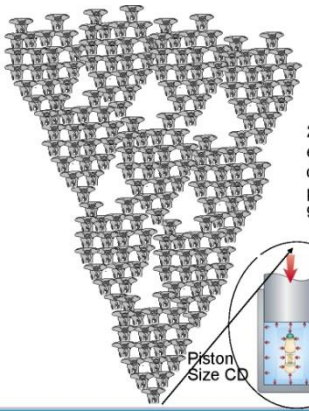
Fruit juices
Smoothies
Vegetable juices

Toll processing
Cheese / Eggs products

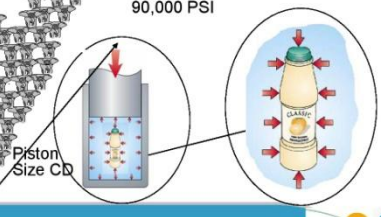
- Global HPP food production estimated in 2014 : + 500 millions Kg

Source: Hiperbaric

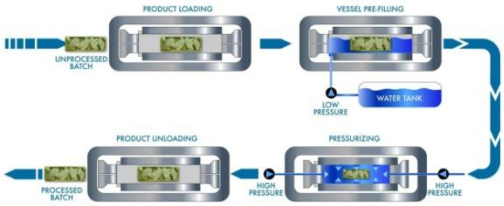
How does it work?



200 elephants weighing 3000 kg each standing on a piston with a diameter of a CD, create a static pressure of 600 MPa, 6000 bar or 90,000 PSI



How does HPP work – process steps



Industrial HPP machines

160 L vessel MULTIVAC

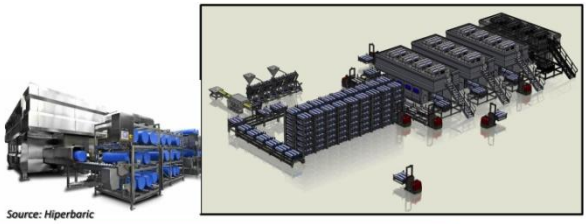
Hiperbaric 420 L vessel

Avure Technologies
350 L vessel

Trends in HPP equipment

Example of automatic processing of big pouches (1):

- Fully automatic line with 3 x 420 L machines
- Automatic transport of carriers with Automatic Guided Vehicles (AGV)
- Maximum production: 97.5 Millions lbs – 45 000 tons/ year



Source: Hiperbaric

Videoclips

HPP systems at CSIRO

- 2 mL kinetic, (700 MPa) and temp
- 300 mL, pressure (800 MPa) and temp
- 2 L, pressure (500 MPa)
- 3L, pressure (800 MPa) and temp
- 35L, pressure (690 MPa) and temp

Current HPP processors in Australia

HPP Meat Value-Adders

New Trends – Wet Salads

http://www.youtube.com/watch?v=BBnNxJ2DV2o

HPP Dairy Products

- Shelf life increase
- Destruction of pathogens
- Retaining bioactivity of functional components

Source: Carole Tonello, Hiperbaric

Wellness Drinks

New Fruit/Veg RTE

Packaging requirements

- Flexible packaging (>15% volume contraction)
- Extra tight seals
- Rounded & reinforced edges
- Minimal head space
- MAP possible
- Tear strength, puncture resistance, surface smoothness generally not affected by HPP
- Often flexible pouches or bottles are inserted in secondary cardboard containers or sleeves after processing

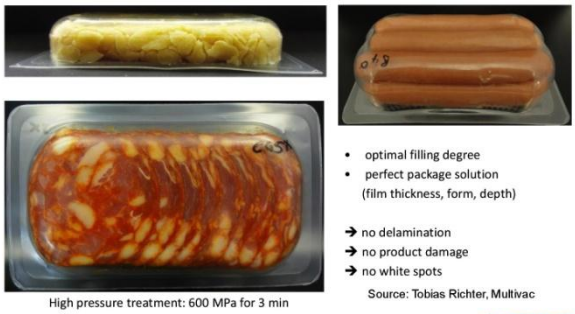
Conventional HPP processing of typical MAP products

Damages could occur when insufficient packaging and processing is used

→ In particular modified atmosphere packs (MAP) have been critical.

Source: Tobias Richter, Multivac

Examples for a suitable HPP packaging concept



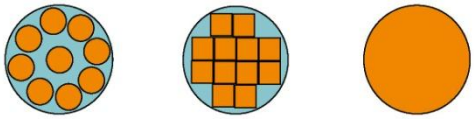
- optimal filling degree
- perfect package solution (film thickness, form, depth)

→ no delamination
→ no product damage
→ no white spots

Source: Tobias Richter, Multivac

High pressure treatment: 600 MPa for 3 min

Optimise packaging



Poor Design Better Design Best Design

HPP packaging and presentation formats

Estimating Costs of HPP

Factors to consider

- Processing conditions (pressure, temperature, time)
- Cycle time
- Capital Costs (size of plant, manufacturer)
- Depreciation period (note: number of cycles is limited)
- Vessel filling efficiency
- Labour costs
- Energy/water costs
- Factory overheads
- Exchange rates

COST FACTORS	VALUE	UNITS
Exchange rates		
EUR:USD	1.331824 [a]	$/€
AUD:USD	1.05045 [a]	$/AUD
JPY:USD	0.011094 [a]	$/¥
General factors		
Electric power	0.11	AUD/kWh
Water	2.74	AUD/m³
Factory overheads	13	%
Depreciation period	10	years
Interest rate per period	10	%/a
Production parameters		
Process pressure	600	MPa
Starting temperature	5	°C
Yearly days of production	216	d/a
Production hours per day	24	h/d
Cycle time	9.0	min
Pressure come up time	3.0	min
Vessel filling estimate	60	%
Product density [b]	1.0	kg/L
Labour		
Engineer(s) per shift	0.1	-
Worker(s) per shift	2	-
Annual costs per Engineer(s)	113000	AUD/a
Annual costs per Worker(s)	90000	AUD/a
Hours per shift	8	h

Costs and Benefits

- **Costs**
- HPP additional processing - $0.20 - $0.50/kg

- **Benefits**
- New product/category opportunity and value add
- Seasonal primal utilisation
- General quality attributes – juiciness and tenderness
- Reduced yield/cook loss
- Extension of product shelf life reducing product returns
- Manufacturing efficiencies due to larger and shorter production runs

Conclusions

Consumers: HPP is a consumer acceptable, environmental friendly, scientifically recognised method to achieve higher quality in certain foods

Processing: Pressure transmission is instantaneous and uniform (not heat transfer controlled, no 'shadow', depth, or uneven distribution effect)- **rapid**, short processing times, assured safety in whole pack, suitable for solids and liquids

Quality: retains flavour and nutrition

Environmentally: safe and no process by-products, no emissions

Packaging:

Package design, geometry and format should be tailored for HPP, Packaging films and laminate structure generally survive HPP well, but MAP and HPP at high temperature can cause delamination and defects

OTR and WVTR can be affected by HPP

Thank you

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www.csiro.au

HPP Research Outcomes – Meat Quality, Shelf-life and Safety

Anita Sikes
27 November 2014

www.csiro.au

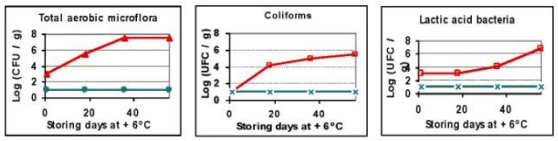
Research Outcomes:

Shelf-life and Safety

Why does the meat industry use HPP ?

Efficiency

- Non- thermal post packaging pasteurization (approved by FSIS in USA)
- Safest alternative for sliced meat products
- Significant shelf life extension
- No size / volume effect : whole, sliced, stripped & diced meat products
- Suitable for vacuum-packed or MAP



HPP treatment of sliced cooked ham at 500 MPa for 8 min at + 8ºC

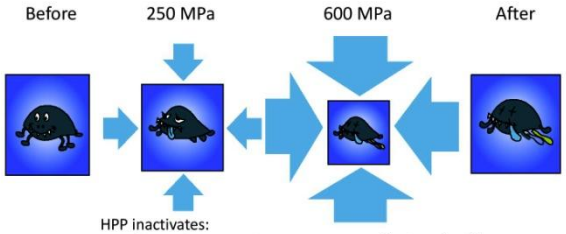
Shelf-life extension

- Cold pasteurisation in the final package
- Increased shelf life
- Destruction of pathogens – Listeria, Salmonella, coliforms
- Stabilisation of preservative-free or low salt content products

Country	Year	Products
Spain	1998	Sliced cooked ham and "tapas"
USA	2001	Sliced cooked products and prosciutto ham
USA	2001	Poultry products
USA	2002	Pre-cooked chicken and beef strips
Spain	2002	Sliced cooked meats products, Serrano cured ham
Italy	2003	Prosciutto ham, salami & pancetta
Germany	2004	Cured and smoked sliced and diced ham
Japan	2004	Nitrites-free bacon, sausages and sliced meat
USA	2005	Ready-to-eat meat based products
Spain	2005	Cured meat products & Serrano ham
Canada	2006	Cured & cooked meat products
USA	2006	Whole roasted chicken
USA	2006	Sliced cooked turkey and chicken
Canada	2006	Ready-to-eat meat meals
USA	2007	Chicken sausages
USA	2008	Cooked pork & beef sliced products
USA	2008	Pet food
Canada	2008	Sausages and bacon
Canada	2009	German style cooked meat products
USA	2009	Sliced RTE meats
Canada	2010	Prosciutto ham and cured meats
Australia	2010	Sliced and diced preservative free poultry products
Switzerland	2011	Cooked pork sliced products and sausages
USA	2011	Prosciutto ham and cured meats
USA	2011	RTE sliced meats
Rumania	2011	RTE pork products
Spain	2011	Serrano ham and cured meats

Source: Carole Tonello, Hiperbaric

Effect of pressure on micro organisms



High pressure can kill microorganisms by interrupting their cellular function without the use of heat that can damage the taste, texture, and nutrition of the food.

HPP inactivates:
- spoilage micro organisms – yeasts, moulds, Lactobacilli
- toxigenic pathogens – S. aureus, Cl. Botulinum
- infectious pathogens – Listeria, Salmonella, E. coli

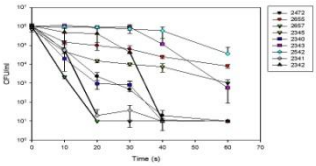
Challenge for HPP:
- inactivation of bacterial spores

In-pack pasteurisation by HPP

Ready-to-eat meats processed at 600MPa for 180s

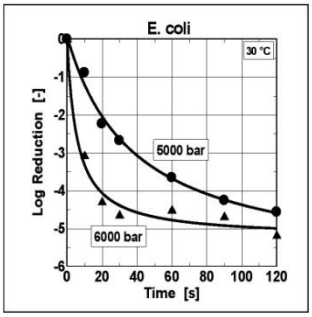
Extension of refrigerated shelf-life from 45-50 days to >98 days

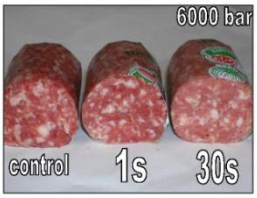
Approx. 4-log reduction of *L. monocytogenes*



Hayman *et al.* 2004

Inactivation of *E.coli* in fresh fermented sausage

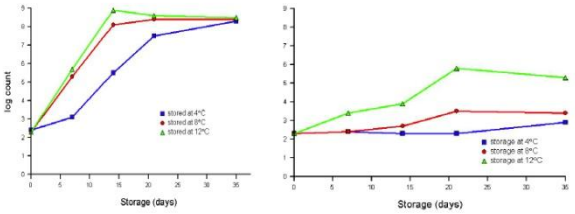




Effect of high pressure & storage temperatures on the microbiological quality of cooked poultry meat

400 MPa/1 min/20°C

600 MPa/10 min/20°C



(Patterson, 2011)

Research Outcomes:

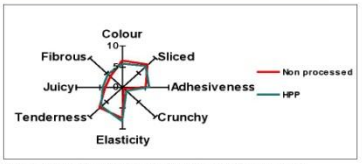
Meat quality

Why does the meat industry use HPP ?

Quality

- No effect on sensorial quality
- Keep fresh taste
- Maintain nutritional value
- Remove chemical preservatives

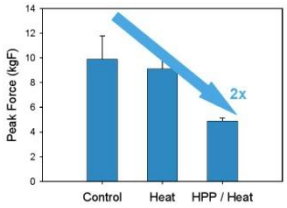
Improved tenderness
Modified functionality



HPP treatment of sliced cooked ham at 500 MPa for 8 min at + 8ºC

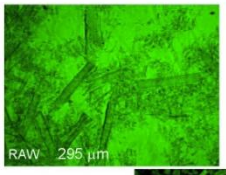
Pressure-heat treatment – neck muscle

- 200 MPa / 60°C / 20 min
- improvement in texture

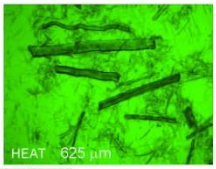


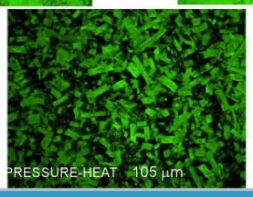
Beef neck muscle (tongue root)
M. Sternomandibularis
High connective tissue content muscle

Pressure and heat effect on muscle fibres



Tough





Tender

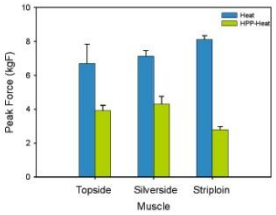
Tenderisation at high temperature – retail muscles

- 200 MPa / 60°C / 20 min
- varying connective tissue content

Raw

Heat treatment
60°C, 20 min

P-H treatment
200 MPa, 60°C, 20 min

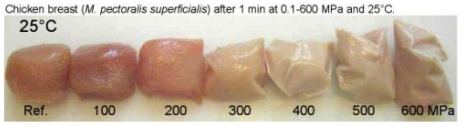


200 MPa / 60°C / 20 min ⟹ 70°C / 30 min ⟹ tender meat

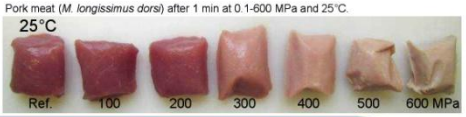
Effect of high pressure on meat colour

Turkey breast (*M. pectoralis superficialis*) after 1 min at 0.1-500 MPa and 25°C.

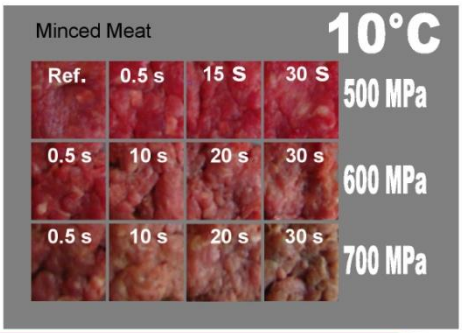
Chicken breast (*M. pectoralis superficialis*) after 1 min at 0.1-600 MPa and 25°C.



Pork meat (*M. longissimus dorsi*) after 1 min at 0.1-600 MPa and 25°C.



Colour change in minced meat

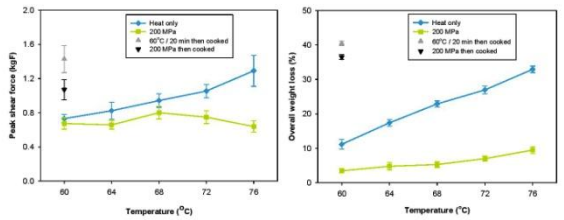


One-step pressure-heat process

- Topside ≈ 150 g, 20 mm thick steak
- One-step P-H process
- 200 MPa for 20 min at 60 – 76°C
- No further cooking
- Measure texture and yield

Texture and yield of P-H treated steaks

One-step process



200 MPa / 76°C / 20 min ⟹ tender meat + increased yield

HPP has potential for assuring quality

hang (AT, TS)	TS
sex (M, F)	M
epbi (est %)	0
hump (cm)	5
cwt	260
uoss	120
MFV? (Y, N)	N
umb	200
days.aged	21
ribfat	8
pHu	5.5
HGP? (Y,N)	N
amc	2
saleyard? (Y,N)	N

cut	muscle	GRL	
spinalis	SPN081	79	5
tenderloin	TDR034	81	5
tenderloin	TDR062	76	4
tenderloin	TDR063	71	4
cube roll	CUB045	72	4
striploin	STA045	67	4
chuck	CHK068	--	
chuck	CHK074	64	4
chuck	CHK078	57	3
chuck	CHK081	--	
chuck	CHK082	--	
thin-flank	TFL051	--	
thin-flank	TFL052	--	

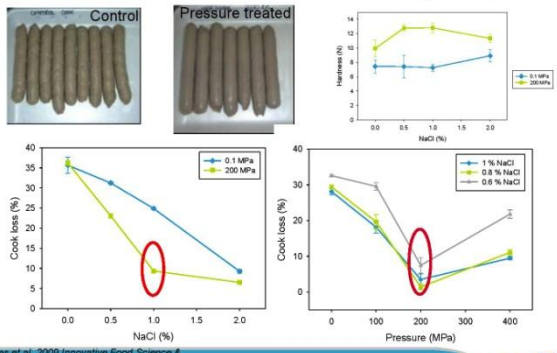
Assured for eating quality by MSA

Not assured by MSA, HPP can move these to 'assured'

Research Outcomes:

Salt reduction in processed meats

Effect of HPP and salt content on quality



Sikes et al. 2009 Innovative Food Science & Emerging Technologies 10:405

Conclusions

- HPP combined with heat can tenderise low-value whole meat cuts
  - one-step process can significantly improve yield
- HPP at low temperature improves the functional properties (binding, texture) of meat batters using reduced salt content
- HPP provides opportunities for the meat industry
  - extension of shelf life
  - ready-to-eat (RTE) meat products : sliced/diced cooked meat products, ready-to-eat meals, marinated meats, dry cured products
  - enhance meat quality of low-value cuts
  - provide healthy, convenient, alternative processed meat products

Thank you

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FOOD INNOVATION CENTRE
www.csiro.au

High pressure processing workshop for red meat product applications - Red meat under pressure

Anita Sikes and Debra Krause
CSIRO R6644-2-1-7 | MLA A.RMH.0024
16 December 2014

Meat and Livestock Australia (MLA)
Michael Lee

MEAT & LIVESTOCK AUSTRALIA

CSIRO Food and Nutrition Flagship

http://www.csiro.au/Organisation-Structure/Flagships/Food-and-Nutrition.aspx

CSIRO Food Innovation Centre

http://www.csiro.au/Outcomes/Food-and-Agriculture/CSIRO-food-innovation-centre.aspx

Contents

Acknowledgments

MLA Project Team:

Michael Lee

Emily Thompson

Sam Burke

CSIRO Project Team:

Roman Buckow

Debra Krause

Sieh Ng

Anita Sikes

Lloyd Simons

Rod Smith

Introduction

The "Red meat under pressure" workshop was hosted by CSIRO and MLA on 27th November 2014 at CSIRO's Food Innovation Centre in Werribee, Victoria. The purpose of the workshop was to present commercialisation opportunities in high pressure processing (HPP) technology for red meat applications to Australia's meat processing companies. Invitations (Appendix 1) were sent to 52 selected meat value-adders and brand owners of red meat (Appendix 2). The workshop program (Appendix 3) showcased how HPP could add value and enhance the quality, shelf-life, safety and tenderness of meat products, through recently completed MLA-funded research in HPP, as well as a demonstration of the CSIRO Food Innovation Centre HPP plant and product concept demonstration and tasting. The information presented to workshop participants is given in Appendix 4. CSIRO also assisted with the production of a video, aiming to showcase the outcomes of the HPP work, through enabling video footage of the HPP process in the food processing plant and the preparation of the concept dishes in the kitchen facility.

Workshop participants

The workshop was attended by 17 delegates representing 14 companies in the food manufacturing industry (Appendix 5). Companies included meat companies, HPP processors and packaging companies.

Feedback from workshop participants

Participants were encouraged to complete an 'Expression of interest for further follow up' form and response was received from 15 delegates. Feedback from the workshop was positive with 8 companies expressing interest in finding out more about opportunities for investment in HPP technology in the next 12 months and a further 2 companies in 1-2 years. There were also 8 companies who expressed an interest in finding out more about MLA funding opportunities for future collaborative research. Scanned copies of each feedback form can be found in Appendix 6.

A summary of participant comments is summarised below.

1. Did you find the workshop valuable?

Yes; **15**	No; **0**

What did/didn't you like?

- Learnt some new things, met potential new clients, very good day
- Very informative, interesting concepts, re: tenderisation
- Bringing all participants together is excellent for rapid development of concepts to commercialisation
- Concept of adding value to lesser value meat cuts, shelf-life extension, reduction of food additives, sodium
- Very informative & filled in more gaps of knowledge about HPP process and benefits
- Refresh current knowledge of HPP technology, would like a copy of slide show
- Great to sample product post HPP, really helped to inform opinion
- Enjoyed the meat science trial info and application in industry
- Enjoyed the overview of HPP benefits, i.e. shelf-life extension, meat texture improvement & commercialisation opportunities
- Information on tenderisation of lower grade meats, quick time to prepare compared to normal

methods • Good examples from the chef, all good • The shelf-life cooking, HPP with heat added • Extended shelf-life, micro reduction • First time hearing about HPP

2. Would you come to future workshops in the meat area?

Yes; **15**	No; -**0**

3. Prior to this workshop what was your knowledge of HPP?

None; **2**	some awareness; **7**	previous knowledge; **6**

4. Is your company interested in finding out more about opportunities for investment in HPP technology?

If yes, what is the likely time frame?

Now; **8**	1-2 years; **2**	>2+ years; **4**	n/a; **1**

What are your area(s) of interest?

new concept s for existing products; **9**	markets; **7**	prototype products; **9**
access to HPP technology; **9**	supply chain partnering opportunities; **5**	other (please specify); **0**
• Interested in trialling some more products (Wagstaff) • Slow cooked red meat products for QSR& retail, E-number free red meat smallgoods, shelf-life extension of raw meat using HPP(Beak & Johnston) • Shelf-life extension of raw chilled vacuum packed primal of lamb, beef and pork (Sealed Air)		

5. Is your company interested in finding out more about MLA funding for future collaborative research?

Yes; **9** Longfresh, Preshafood, Top Cut, Wagstaff, Teys, OSI International Foods, Frew Group, BMC, Simpson Farms,	No; **0**	Not stated; **6** Beak & Johnston, Australian Lamb Group x2, Sealed Air, Moira Mac's, I.E.,
• Already working on some funding but additional opportunities always of interest (Teys) • We are always looking at new innovative ideas to adapt to current business and process (Wagstaff)		

6. Are there any other areas of interest your company would like to find out more about?

• Always keen for new areas of technology and development (Wagstaff) • Any further information on MLA activities would be helpful (Preshafood) • Functional foods/ proteins (Longfresh) • MLA Insight workshop (Longfresh)

Next steps

Companies showing interest in exploring opportunities for investing in HPP technology have been identified and prioritised from the feedback obtained, and contact with company representatives will be made by either CSIRO or MLA staff. Access to the workshop information will be made available to all meat industry representatives (including companies who did not attend the workshop) via newsletters, trade journal articles, links to published papers, You Tube videos, etc. CSIRO and MLA project team members will meet in January/February 2015 to discuss potential projects and partner companies.

CSIRO Project Team:

Roman Buckow	Debra Krause
Sieh Ng	Anita Sikes
Lloyd Simons	Rod Smith

18 December 2014

Concept Product Preparation

Video production

Workshop Activities

Concept Products for Demonstration

Lamb Tajine

Goat Curry

Beef Short Rib

Beef Chuck Soft Taco

Concept Products for Tasting

Beef Short Rib

Lamb Tagine

Appendix A HPP workshop invitation

Invitation

www.csiro.au

Red meat under pressure

Commercialisation opportunities in tenderising and extending shelf-life of red meat products

Image source: Meat & Livestock Australia

Tenderising and extending the shelf-life of red meat cuts is possible using innovative high pressure processing (HPP) technology.

Applying pressures of up to 600 MPa, HPP is used routinely in nearly 200 industrial units worldwide mainly for cold pasteurisation of smallgoods, meals, beverages and a variety of produce. HPP can not only tenderise and extend shelf-life, but can also reduce reliance on preservatives and inactivate foodborne pathogens while maintaining colour, flavour and fresh-like characteristics.

This workshop, hosted by CSIRO and MLA, provides the ideal opportunity for Australia's meat processing companies to learn how HPP could add value and enhance the quality, shelf-life, safety and tenderness of red meat products.

You will be able to view and taste tenderised HPP beef, lamb and goat products and see a demonstration of the CSIRO food innovation centre's HPP plant, the only one of its kind in Australia.

At the workshop, CSIRO and MLA will present commercialisation opportunities in HPP technology for red meat applications and showcase recently completed MLA-funded research in HPP. Participating companies will have the opportunity to register their

MEAT & LIVESTOCK AUSTRALIA

Date:

Thursday 27 November 2014

Time:
10:00am - 2:00pm

Location:
CSIRO Food and Nutrition Flagship
671 Sneydes Road
Werribee Vic 3030

RSVP before:
Friday 21 November 2014

RSVP online

RSVP & registration

RSVP enquiries
T: **1300 363 400**
E: enquiries@csiro.au

MLA enquiries
Michael Lee
T: **02 9463 9333**
E: mlee@mla.com.au

interest to invest in further development work such as food safety, shelf-life, scale-up and product development and may qualify for MLA funding for future collaborative research.

Who should attend?

Innovation managers and technology managers in the food production and manufacturing industries.

Cost:

The forum is free of charge. Lunch and refreshments are included.

Event information

CSIRO's food innovation centre

www.mla.com.au

Program outline

- Consumer and market information and insights into positioning potential for HPP of red meat products
- Overview of current product applications (not limited to meat products), commercial applications, business models, current HPP operators in Australia and indicative cost comparison to other processing treatments
- HPP research outcomes for meat quality, shelf-life and safety
- View and taste HPP meat products
- Demonstration of the CSIRO food innovation centre HPP plant
- Facilitated discussion of commercialisation opportunities
    - products and channels
    - local operators, supply chain
    - potential commercial scenarios
    - MLA funding opportunities
- Next steps

Appendix C HPP workshop program

Red meat under pressure workshop

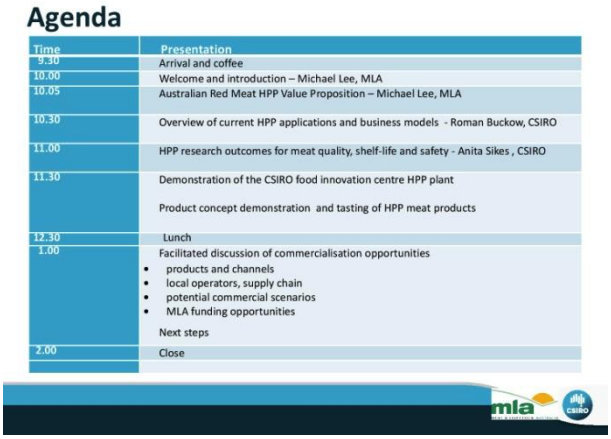
Commercialisation opportunities in tenderising and extending shelf-life of red meat products

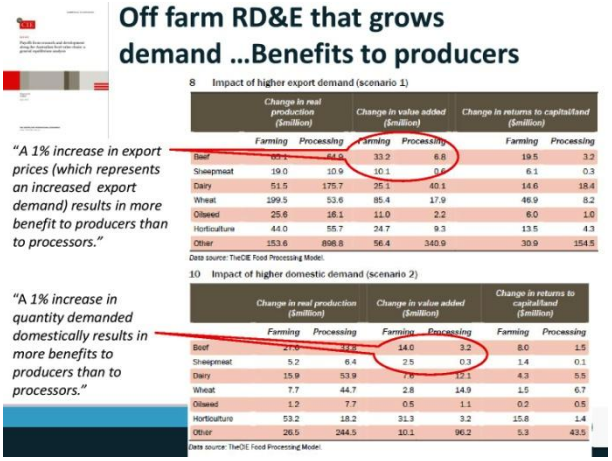
Thursday 27 November 2014

Program

Time	Presentation
9.30	Arrival and coffee
10.00	Welcome and introduction – Michael Lee, MLA
10.05	The Australian red meat HPP value proposition – Michael Lee, MLA
10.30	Overview of current HPP applications and business models - Roman Buckow, CSIRO
11.00	HPP research outcomes for meat quality, shelf-life and safety - Anita Sikes , CSIRO
11.30	Demonstration of the CSIRO food innovation centre HPP plant Product concept demonstration and tasting of HPP meat products
12.30	Lunch
1.00	Facilitated discussion of commercialisation opportunities • products and channels • local operators, supply chain • potential commercial scenarios • MLA funding opportunities Next steps
2.00	Close

Appendix D Presentation delivered to workshop participants





Key Trends in Food, Nutrition & Health 2014

(Julian Mellentin, New Nutrition Business, 2014)

Key Trends in Food, Nutrition & Health 2014

(Julian Mellentin, New Nutrition Business, 2014)

- Australia has one of the highest allergy prevalence rates in the world.
- Surveys indicate that up to 25 percent of the population believe they have some sort of food intolerance

- HPP is a technology platform that inactivates the microbes and therefore does not require any further additives and maintains natural meat flavours

Consumer & Market insights driven RD&E

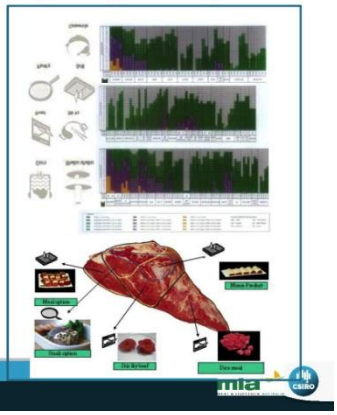
Adding value to secondary cuts (cut/cook)

Beef Chuck- 10hr slow cook

Beef Short ribs- 5hr slow cook

Diced Goat- 3hr stew

Lamb FQ- 3hr stew

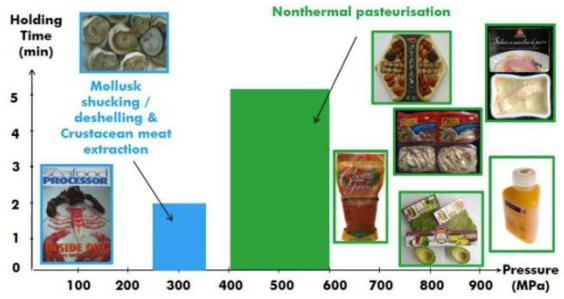


Current cooking platforms

High Pressure Processing - Current Applications, Business Models and Costs

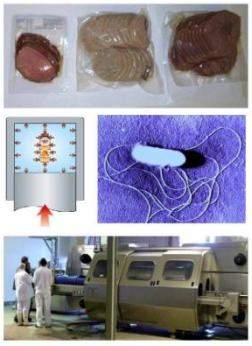
Roman Buckow | Research Group Leader
27 November 2014
www.csiro.au

Commercial application of HPP – pressure range

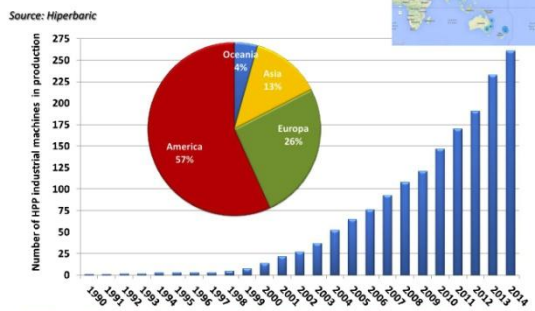


HPP – in more detail

- Technical overview
- Value proposition
- Global uptake & domestic players

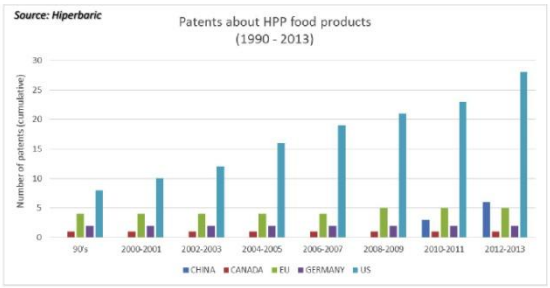


HPP industrial machines



- Total machine number in production (Hiperbaric & competitors): 261

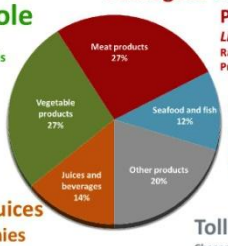
Patents on HPP products & processes



HPP Commercial Products

Pathogens-free sliced cooked meats
Preservative-free deli meats
Listeria-free dry-cured products
Raw beef products
Preservative-free sausages

Guacamole
Wet salads
RTE vegetable meals



Oysters shucking
Lobster meat extraction
Clams & mussels shucking
RTE seafood meals

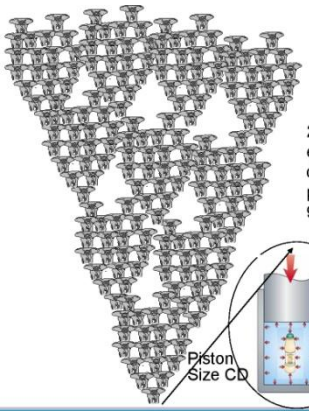
Fruit juices
Smoothies
Vegetable juices

Toll processing
Cheese / Eggs products

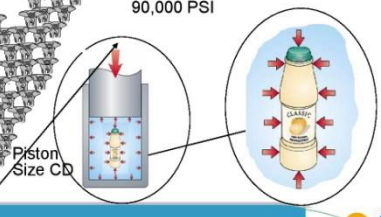
- Global HPP food production estimated in 2014 : + 500 millions Kg

Source: Hiperbaric

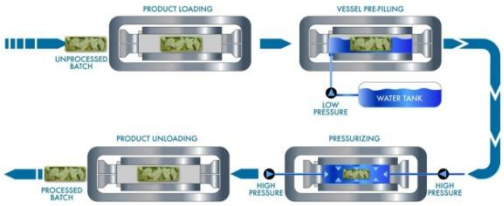
How does it work?



200 elephants weighing 3000 kg each standing on a piston with a diameter of a CD, create a static pressure of 600 MPa, 6000 bar or 90,000 PSI



How does HPP work – process steps



Industrial HPP machines

160 L vessel MULTIVAC

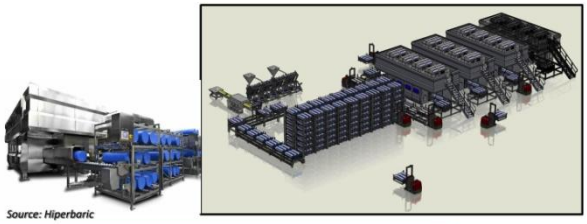
Hiperbaric 420 L vessel

Avure Technologies
350 L vessel

Trends in HPP equipment

Example of automatic processing of big pouches (1):

- Fully automatic line with 3 x 420 L machines
- Automatic transport of carriers with Automatic Guided Vehicles (AGV)
- Maximum production: 97.5 Millions lbs – 45 000 tons/ year



Source: Hiperbaric

Videoclips

HPP systems at CSIRO

- 2 mL kinetic, (700 MPa) and temp
- 300 mL, pressure (800 MPa) and temp
- 2 L, pressure (500 MPa)
- 3L, pressure (800 MPa) and temp
- 35L, pressure (690 MPa) and temp

Current HPP processors in Australia

HPP Meat Value-Adders

New Trends – Wet Salads

http://www.youtube.com/watch?v=BBnNxJ2DV2o

HPP Dairy Products

- Shelf life increase
- Destruction of pathogens
- Retaining bioactivity of functional components

Source: Carole Tonello, Hiperbaric

Wellness Drinks

New Fruit/Veg RTE

Packaging requirements

- Flexible packaging (>15% volume contraction)
- Extra tight seals
- Rounded & reinforced edges
- Minimal head space
- MAP possible
- Tear strength, puncture resistance, surface smoothness generally not affected by HPP
- Often flexible pouches or bottles are inserted in secondary cardboard containers or sleeves after processing

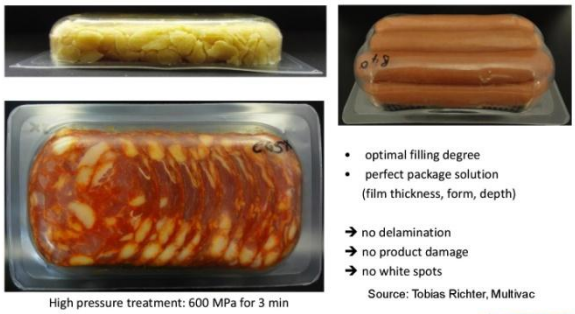
Conventional HPP processing of typical MAP products

Damages could occur when insufficient packaging and processing is used

→ In particular modified atmosphere packs (MAP) have been critical.

Source: Tobias Richter, Multivac

Examples for a suitable HPP packaging concept



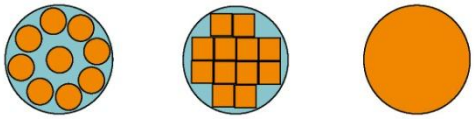
- optimal filling degree
- perfect package solution (film thickness, form, depth)

→ no delamination
→ no product damage
→ no white spots

Source: Tobias Richter, Multivac

High pressure treatment: 600 MPa for 3 min

Optimise packaging



Poor Design Better Design Best Design

HPP packaging and presentation formats

Estimating Costs of HPP

Factors to consider

- Processing conditions (pressure, temperature, time)
- Cycle time
- Capital Costs (size of plant, manufacturer)
- Depreciation period (note: number of cycles is limited)
- Vessel filling efficiency
- Labour costs
- Energy/water costs
- Factory overheads
- Exchange rates

COST FACTORS	VALUE	UNITS
Exchange rates		
EUR:USD	1.331824 [a]	$/€
AUD:USD	1.05045 [a]	$/AUD
JPY:USD	0.011094 [a]	$/¥
General factors		
Electric power	0.11	AUD/kWh
Water	2.74	AUD/m³
Factory overheads	13	%
Depreciation period	10	years
Interest rate per period	10	%/a
Production parameters		
Process pressure	600	MPa
Starting temperature	5	°C
Yearly days of production	216	d/a
Production hours per day	24	h/d
Cycle time	9.0	min
Pressure come up time	3.0	min
Vessel filling estimate	60	%
Product density [b]	1.0	kg/L
Labour		
Engineer(s) per shift	0.1	-
Worker(s) per shift	2	-
Annual costs per Engineer(s)	113000	AUD/a
Annual costs per Worker(s)	90000	AUD/a
Hours per shift	8	h

Costs and Benefits

- **Costs**
- HPP additional processing - $0.20 - $0.50/kg

- **Benefits**
- New product/category opportunity and value add
- Seasonal primal utilisation
- General quality attributes – juiciness and tenderness
- Reduced yield/cook loss
- Extension of product shelf life reducing product returns
- Manufacturing efficiencies due to larger and shorter production runs

Conclusions

Consumers: HPP is a consumer acceptable, environmental friendly, scientifically recognised method to achieve higher quality in certain foods

Processing: Pressure transmission is instantaneous and uniform (not heat transfer controlled, no 'shadow', depth, or uneven distribution effect)- **rapid**, short processing times, assured safety in whole pack, suitable for solids and liquids

Quality: retains flavour and nutrition

Environmentally: safe and no process by-products, no emissions

Packaging:

Package design, geometry and format should be tailored for HPP, Packaging films and laminate structure generally survive HPP well, but MAP and HPP at high temperature can cause delamination and defects

OTR and WVTR can be affected by HPP

Thank you

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HPP Research Outcomes – Meat Quality, Shelf-life and Safety

Anita Sikes
27 November 2014

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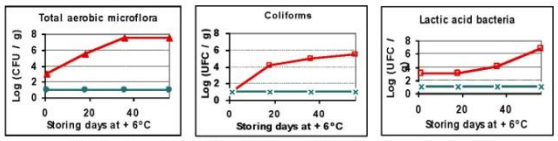
Research Outcomes:

Shelf-life and Safety

Why does the meat industry use HPP ?

Efficiency

- Non- thermal post packaging pasteurization (approved by FSIS in USA)
- Safest alternative for sliced meat products
- Significant shelf life extension
- No size / volume effect : whole, sliced, stripped & diced meat products
- Suitable for vacuum-packed or MAP



HPP treatment of sliced cooked ham at 500 MPa for 8 min at + 8ºC

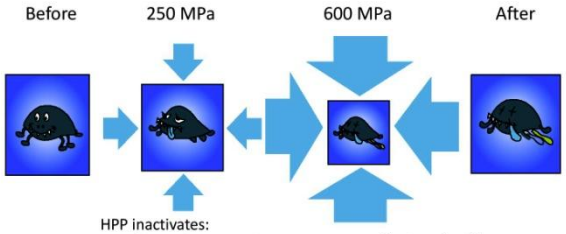
Shelf-life extension

- Cold pasteurisation in the final package
- Increased shelf life
- Destruction of pathogens – Listeria, Salmonella, coliforms
- Stabilisation of preservative-free or low salt content products

Country	Year	Products
Spain	1998	Sliced cooked ham and "tapas"
USA	2001	Sliced cooked products and prosciutto ham
USA	2001	Poultry products
USA	2002	Pre-cooked chicken and beef strips
Spain	2002	Sliced cooked meats products, Serrano cured ham
Italy	2003	Prosciutto ham, salami & pancetta
Germany	2004	Cured and smoked sliced and diced ham
Japan	2004	Nitrites-free bacon, sausages and sliced meat
USA	2005	Ready-to-eat meat based products
Spain	2005	Cured meat products & Serrano ham
Canada	2006	Cured & cooked meat products
USA	2006	Whole roasted chicken
USA	2006	Sliced cooked turkey and chicken
Canada	2006	Ready-to-eat meat meals
USA	2007	Chicken sausages
USA	2008	Cooked pork & beef sliced products
USA	2008	Pet food
Canada	2008	Sausages and bacon
Canada	2009	German style cooked meat products
USA	2009	Sliced RTE meats
Canada	2010	Prosciutto ham and cured meats
Australia	2010	Sliced and diced preservative free poultry products
Switzerland	2011	Cooked pork sliced products and sausages
USA	2011	Prosciutto ham and cured meats
USA	2011	RTE sliced meats
Rumania	2011	RTE pork products
Spain	2011	Serrano ham and cured meats

Source: Carole Tonello, Hiperbaric

Effect of pressure on micro organisms



High pressure can kill microorganisms by interrupting their cellular function without the use of heat that can damage the taste, texture, and nutrition of the food.

HPP inactivates:
- spoilage micro organisms – yeasts, moulds, Lactobacilli
- toxigenic pathogens – S. aureus, Cl. Botulinum
- infectious pathogens – Listeria, Salmonella, E. coli

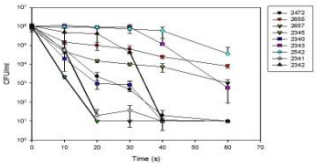
Challenge for HPP:
- inactivation of bacterial spores

In-pack pasteurisation by HPP

Ready-to-eat meats processed at 600MPa for 180s

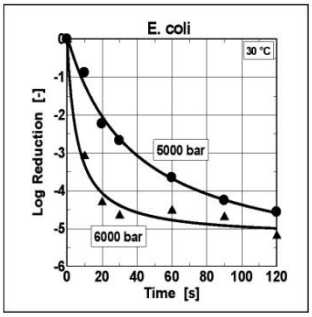
Extension of refrigerated shelf-life from 45-50 days to >98 days

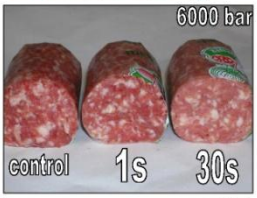
Approx. 4-log reduction of *L. monocytogenes*



Hayman *et al.* 2004

Inactivation of *E.coli* in fresh fermented sausage

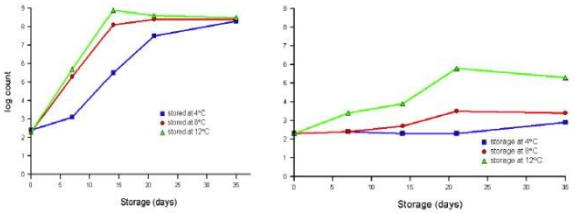




Effect of high pressure & storage temperatures on the microbiological quality of cooked poultry meat

400 MPa/1 min/20°C

600 MPa/10 min/20°C



(Patterson, 2011)

Research Outcomes:

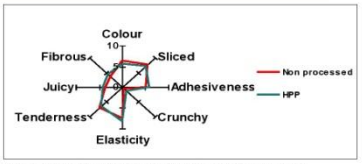
Meat quality

Why does the meat industry use HPP ?

Quality

- No effect on sensorial quality
- Keep fresh taste
- Maintain nutritional value
- Remove chemical preservatives

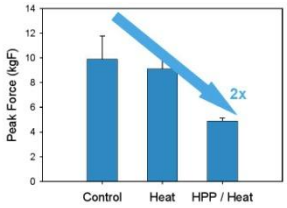
Improved tenderness
Modified functionality



HPP treatment of sliced cooked ham at 500 MPa for 8 min at + 8ºC

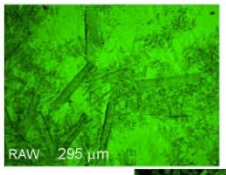
Pressure-heat treatment – neck muscle

- 200 MPa / 60°C / 20 min
- improvement in texture

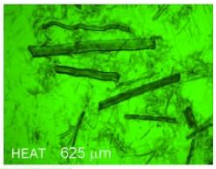


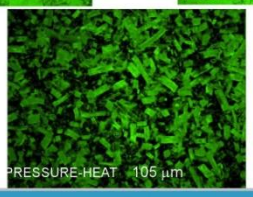
Beef neck muscle (tongue root)
M. Sternomandibularis
High connective tissue content muscle

Pressure and heat effect on muscle fibres



Tough





Tender

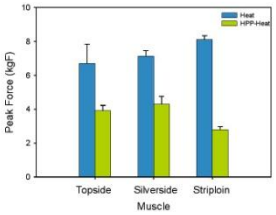
Tenderisation at high temperature – retail muscles

- 200 MPa / 60°C / 20 min
- varying connective tissue content

Raw

Heat treatment
60°C, 20 min

P-H treatment
200 MPa, 60°C, 20 min

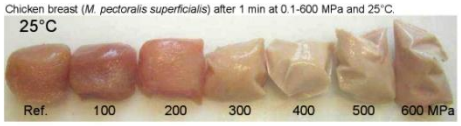


200 MPa / 60°C / 20 min ⟹ 70°C / 30 min ⟹ tender meat

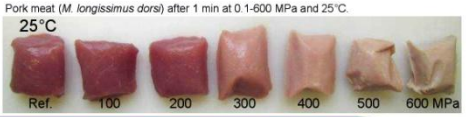
Effect of high pressure on meat colour

Turkey breast (*M. pectoralis superficialis*) after 1 min at 0.1-500 MPa and 25°C.

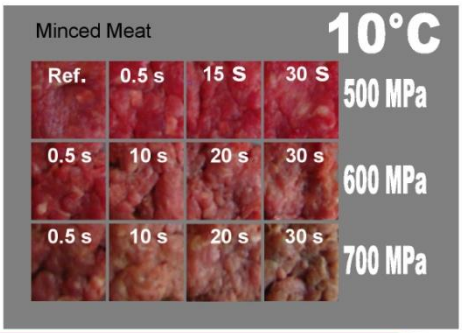
Chicken breast (*M. pectoralis superficialis*) after 1 min at 0.1-600 MPa and 25°C.



Pork meat (*M. longissimus dorsi*) after 1 min at 0.1-600 MPa and 25°C.



Colour change in minced meat

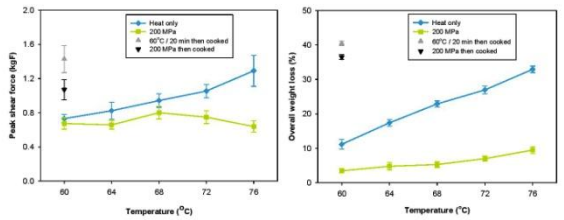


One-step pressure-heat process

- Topside ≈ 150 g, 20 mm thick steak
- One-step P-H process
- 200 MPa for 20 min at 60 – 76°C
- No further cooking
- Measure texture and yield

Texture and yield of P-H treated steaks

One-step process



200 MPa / 76°C / 20 min ⟹ tender meat + increased yield

HPP has potential for assuring quality

hang (AT, TS)	TS
sex (M, F)	M
epbi (est %)	0
hump (cm)	5
cwt	260
uoss	120
MFV? (Y, N)	N
umb	200
days.aged	21
ribfat	8
pHu	5.5
HGP? (Y,N)	N
amc	2
saleyard? (Y,N)	N

cut	muscle	GRL	
spinalis	SPN081	79	5
tenderloin	TDR034	81	5
tenderloin	TDR062	76	4
tenderloin	TDR063	71	4
cube roll	CUB045	72	4
striploin	STA045	67	4
chuck	CHK068	--	
chuck	CHK074	64	4
chuck	CHK078	57	3
chuck	CHK081	--	
chuck	CHK082	--	
thin-flank	TFL051	--	
thin-flank	TFL052	--	

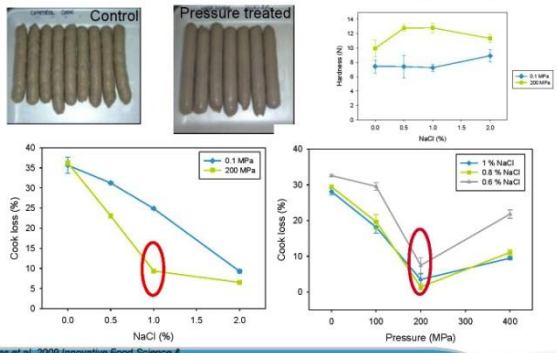
Assured for eating quality by MSA

Not assured by MSA, HPP can move these to 'assured'

Research Outcomes:

Salt reduction in processed meats

Effect of HPP and salt content on quality



Sikes et al. 2009 Innovative Food Science & Emerging Technologies 10:405

Conclusions

- HPP combined with heat can tenderise low-value whole meat cuts
  - one-step process can significantly improve yield
- HPP at low temperature improves the functional properties (binding, texture) of meat batters using reduced salt content
- HPP provides opportunities for the meat industry
  - extension of shelf life
  - ready-to-eat (RTE) meat products : sliced/diced cooked meat products, ready-to-eat meals, marinated meats, dry cured products
  - enhance meat quality of low-value cuts
  - provide healthy, convenient, alternative processed meat products

Thank you

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