Heating mechanisms in Shaka™ processing

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Nofima - The Norwegian Institute of Food, Fisheries and Aquaculture Research

Nofima is a business oriented research group working in research and development for the aquaculture, fisheries and food industry in Norway.

- Established on 1 January 2008
- About 470 employees.
- Turnover in 2008 NOK 470 million.
- Main office is located in Tromsø
- Research divisions in: Ås, Stavanger, Bergen, Sunndalsøra, Averøy and Tromsø.
- Owned by Ministry of Fisheries (56.8%), the Agricultural food research Foundation (33.2%) and Akvainvest (10%)

Contents

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- Conclusions
- On-going research on agitated thermal processing at Nofima

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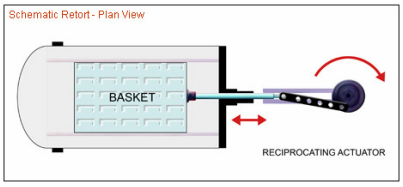
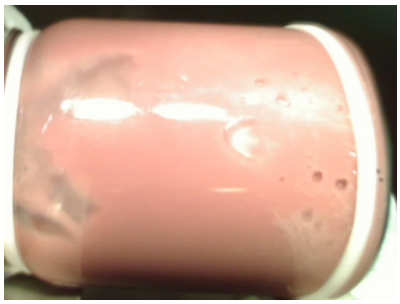
Principle

Patented process by Richard Walden / Zinetec



The autoclave basket is pushed back and forth to obtain forced convection and, thus, much more effective heat penetration than for static processing.



Walden, R., 2008. In-pack processed foods. CRC Press, 86–101.

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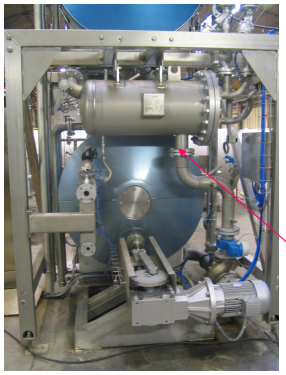
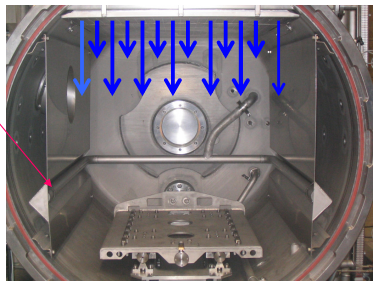
Heating and cooling in Steriflow Shaka-autoclave

Direct steam injection

Cascading water system





Heat exchanger for cooling with cool and / or chilled water

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Pre heating system

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Potential of for agitated products

- Sterilised foods without gross over-processing
- Heat preserved foods without pre-cooking and/or mixing prior to autoclaving
- Heat preservation of foods too sensitive for static processing
- Pasteurised foods which looks and tastes like restaurant meals
- Targeted heat load for food components in multiple compartment trays

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Examples of packaging materials used with success

- Plastic trays
- Pouches
- Cans (round, square)
- Glass jars

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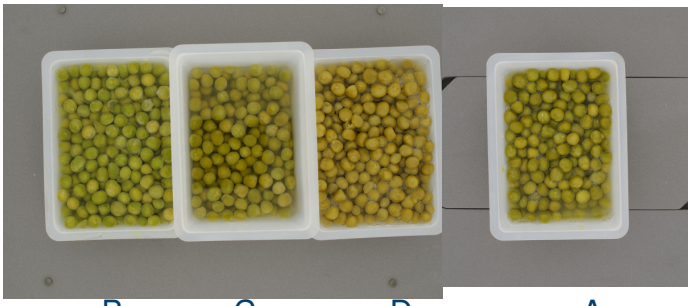
Food example: Green Peas processed at 121°C

Quiz: Which of the beakers are A, B and C?

Sample	Sterilisation time (min)	Sterilisation temperature (°C)	F_0-value (min)	Speed of agitation (rpm)
A (2 w storage)	4	121	4.8	150
B	4	121	4.8	150
C	9	118	4.5	140
D	15	118	4.0	0



B C D A

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Fish Soup:

Sensory analysis: Significant difference between Shaka and static processed soup with respect to colour, taste, texture of fish and carrots and dryness of fish

Comparison of required times for processing of fish soup

Processing Method	Come up time	Hold time (min)	Time to achieve $P_{90°C}$=10 (min)	Total process time until cooled to 70°C
Shaka	7	4	11	15
Static	10	53	67	87
Reduction (min)	3	49	56	72
Reduction (%)	30	92	84	83

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Nutritional effects: Theoretical example for fish soup

- Example: Inactivation of Thiamin (Vitamin B_1) in carrots
  - Static: 49 % loss
  - Shaka: 7 % loss
- Further optimisation (e.g. higher processing temperature) may lead to even better nutrient retention for the Shaka process

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Other products successfully shaken

- Baby food (8 formulas – 4 main courses, 4 deserts)
- Plums
- Ground Mackerel in tomato ("only" 50 % reduction in process time)
- Whole brisling in tomato
- Potatoes (10 kg can)

- Foods pasteurised without pre-cooking/mixing:
  - Rice porridge
  - Sauerkraut

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Products difficult or unsuitable for agitation

- Trout patè – gel forming below 60°C and little to gain with agitation
- Liver patè (cod liver, cod roe) – no gel after end of process, liquid. However, dramatic reduction in processing time and further experiments without shaking after come up may be considered
- Pet food (cont.)

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Pet food

400 g

800 g

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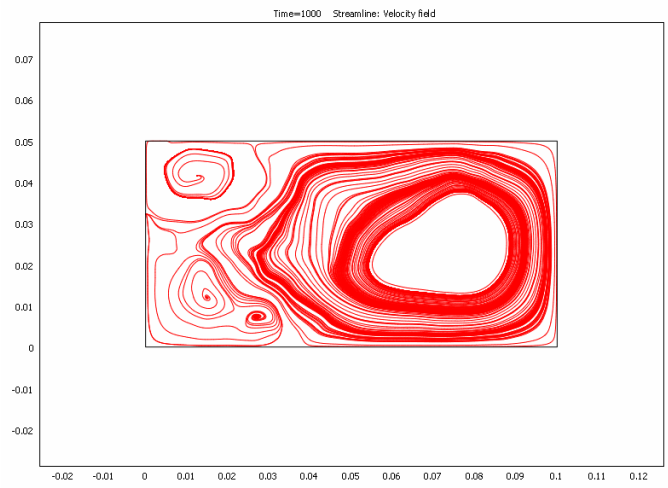
Modelling



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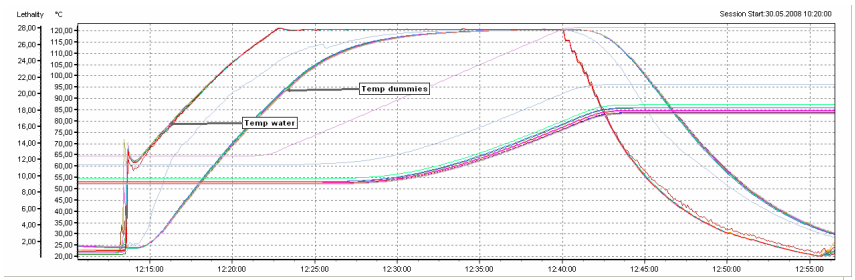
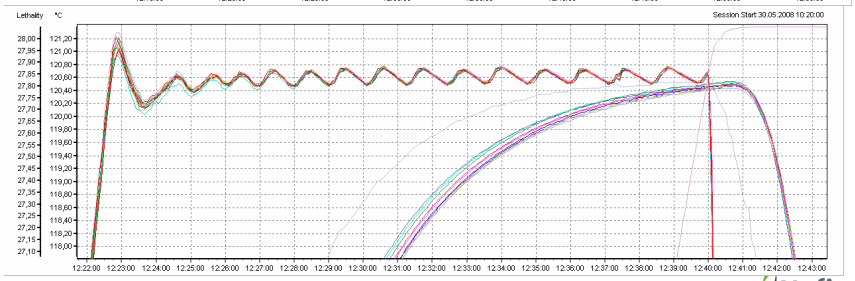
Temperature distribution





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Pitfalls with respect to safety

- Heat inactivation of Shaka process is not equal to static process even if F_0 of core is equal for the two processes
- Unexpected heating patterns
- Viscosity extremely important

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Heat penetration experiments on model product

- Experiments with Bentonite suspensions as model food
  - Dehydrated Bentonite (clay) was mixed with sterile water in concentrations 2.5 % (thin sauce), 5% (creamy soup) and 10% (thick but pumpable slurry)
  - Shaking at 0, 20, 40, 60 ….120 rpm for all three suspensions and pure water
  - Headspace 2, 4 and 8 %
  - Core temperature measurement and calculation of F_0

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Results from bentonite experiments

- Heating behavior is strongly dependent on viscosity and rate of agitation
- 2.5% bentonite solution show an order of magnitude higher heating rate than a static process
- High concentration bentonite solutions (5 and 10%) are highly viscous and heat by conduction. At slow agitation they show relatively less effect, while agitation rate of 120 rpm still results in 2-2.5 times faster heating rate
- In all experimental cases studied, higher agitation rate increases heat transfer rate

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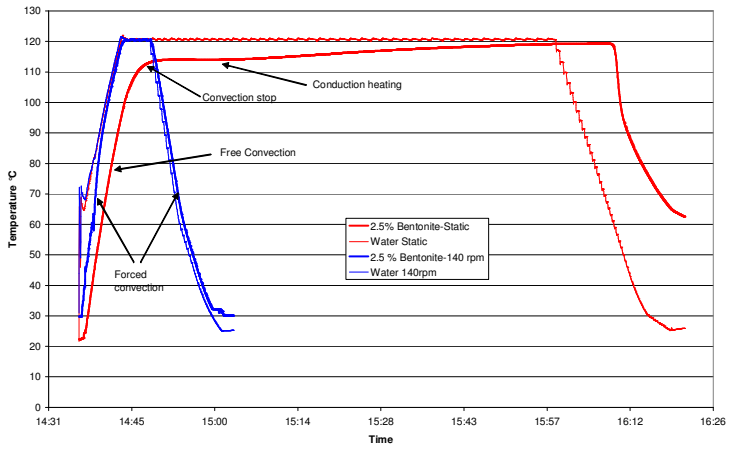
Unusual heating pattern



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Conclusion -Limitations

- Required processing time increases exponentially with increasing viscosity at lower frequencies
- Strict control of product fill and viscosity at all process temperatures necessary
- Excessive agitation (> 80 rpm) required for products of medium or high viscosity
- Limitations in size of autoclaves
- Temperature distribution should be documented for a industry size autoclave
- Further documentation on heat distribution within product and microbial inactivation is needed
- Further documentation of nutritional improvement also under storage conditions is desired

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Conclusions – Improvements in thermal processing by Shaka-technology

- Up to 92% reduction in required processing time gives:
  - Extremely high capacity per volume and processing area
  - Major reduction in heat load on product
    - High nutrient retention (proteins, vitamins)
    - High retention of colour, flavour, texture and fresh appearance
    - Non or significantly reduced problems with browning
  - Reduced steam consumption
- New products
- Products without pre-cooking/pre-mixing

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Projects at Nofima

- Completed:
  - Shaka investment – Advanced scientific equipment funding (AVIT), Norwegian Research Council
- Ongoing:
  - Shakin' – Branch/Norconserv Foundation – 2.5 years left – 1 PhD-student
  - Shaop – Food industry commissions (product development)
  - PU 97 – Product development network – Food Industry/Ministry of Agriculture
- Project proposals:
  - Sha-kin – Proposal to the Norwegian Research Council by 3 companies and Nofima
  - Gourmet canning – Norwegian Centre of Expertise on Culinology

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Acknowledgement

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