Shock wave meat tenderization

Identification

Key words
shock wave, beef, pork, meat, convenience food, ripening, maturation, hydrodynamic, tenderness, tenderization, shelf life, texture, lower salt content, electrohydraulic, electrodetonative, electrothermal, electromagnetic, piezoelectric

Latest version 2012/07/17
Completed by DIL

How does it work?

Primary objective
- Shortening of meat maturation time by tissue disintegration and weakening of mechanical stability of biological materials e.g. in meat processing a tenderization
- Grinding or fractionation of biological or inorganic material
- Fragmentation of nephroliths and sediments

Working principle
Shockwave application is based on underwater acoustic energy delivery to food products. For shock generation electric energy is converted into mechanical energy making use of electro-thermal, electro-detonative, electro-magnetic or piezo-electric energy conversion. Due to higher energy propagation water is used as a transmitting media, required a packaging of products in most cases [1, 2]. At present, mainly electro-thermal systems, based on an underwater discharge of electrical energy between two electrodes, are used.

For electro-detonative shock generation an exploding wire is applied, which is melted and vaporized by electric energy. As a result of thermal expansion and release of the chemical energy, a shock wave is generated. As an alternative to electro-thermal and electro-detonative shock generation in particular, an electro-magnetic energy conversion could allow high energy efficiency as well as an improvement of equipment stability. By a high current pulse through a coil an instantaneous displacement of a metal plate placed under water (actuator) can be achieved.

Figure 1: Pressure-time-profile of a shockwave (Mayer et al. 2009)
**Additional effects**

Accelerating meat tenderization and reducing maturation time will allow the production of a higher amount of high quality beef cuts and provide significant economic benefits and a more sustainable use of beef carcasses. By a reduction of maturation times the requirement for chilled storage capacities, energy costs as well as fixed capital costs can be reduced. For liquid systems such as beer the potential to increase colloid stability has been investigated (source to be added by FRIP). Besides the evaluation of fundamental interactions between process and product, the impact on sensorial properties during maturation will have to be investigated.

Negative aspects are hot spots with very high shock intensity or splintering of the exploding wire, which result in possible partial damages of treated product or packaging material. Dependent on chamber geometry, interference may cause addition or substraction of shock waves. This may require additional efforts to improve treatment homogeneity or product transport within the treatment area.

**Important process parameters**

Voltagess of electric energy and treatment rate have been shown as most important processing parameters.

Others:
- capacitor charger (voltage, average power), and energy storage (max. capacity)
- chosen distance of multiple electrodes
- wire thickness and length
- working area size
- spatial distribution of the shock wave intensity leads to maximum treatment
- homogeneity leads to treatment intensity distribution

**Important product parameters**

Protein content, conjunctive tissue content, proteoglycan content, pH value, content of lipids, salt and water. These contents depend on varying attributes of raw materials: different beef primal cuts, maturity level, breed and age of animal to be slaughtered.

**What can it be used for?**

**Products**

Solids and products with solid components in a final or processing package are meaningful applications for this technology. Especially meat products, but also, fish or seafood can be treated.

For Oysters a shucking of > 90 % of samples treated has been achieved. Fruit and vegetables could be disintegrated by shockwave applications, but for such products other disintegration techniques (grinders, cutters, mills) are available.
A pre-treatment by shock waves could be used to tenderize meat pieces and make better use of cuts with low tenderness. This tenderness improving effect is based on physical impact on myofibrillar structures and the increase of intra-myofibrillar space as well as a potential release of endogenous enzymes. The extent of tenderization is dependent on the shock intensity. Since shock wave are impacting on the myofibrillar structure, it might be possible to use the technique as a pre-activator of the meat before sausage production; Improving tenderness; cooked sausages with higher yield or better texture; reduced amount of NaCl; enhance meat maturation [3,4].

Figure 2: Source: Claus et al. 2002

**Solutions for short comings**

- Improving tenderness, enhance meat maturation, reduction of processing time, reduction of salt content.
- By shockwave application a structure modification of meat tissue is possible.
- A reduction of cutting energy was observed after a shockwave treatment.
- A potential to reduce aging time from 14 to 7 days was identified

**What can it NOT be used for?**

**Products**

Inflexible packaging materials, modified atmosphere packages

**Operations**

Not applicable for mechanically sensitive products

**Other limitations**

- If applied as a batch process, capacity is limited
- On the one hand shorter storage and maturation time, but on the other hand additional investment costs and maintenance costs
- Choice and adaptation of appropriate packaging geometry and material required.
- Undesired changes of functional and technological properties of proteins because of varying attributes of raw materials (different beef primal cuts, maturity level, breed and age of animal to be slaughtered) are possible

**Risks or hazards**

In case of damages of packaging, product gets into contact with process water, which could be contaminated with microorganisms. Furthermore, protection against by electrical discharge induced heat, resp. splintered wire is no longer ensured
Implementation

Maturity

At present, no industrial, continuously operable shock wave equipment for disintegration of biological materials is available. In the US the so-called Hydrodyne process was developed in technical scale, using underwater shock waves generated by explosives [4, 5, 6, 7, 8, 9]. A reduction of the maximum shear force of beef in a range of 30 to 59% was reported [4, 7, 8, 9]. Though the applicability of explosives for shock generation and meat tenderization has been proven, its use in food industry is mainly due to safety reasons. As an alternative, electrical energy can be used to generate underwater shock waves. Four principle mechanisms can be applied to convert electrical into mechanical energy: electrothermal, electrodetonative, electromagnetic and piezoelectric. A continuous operability will be a key requirement for a successful implementation of the technique into industrial practice. RTD will be required to develop a suitable meat handling system as well as to improve treatment homogeneity by increasing the effective working area with high shock wave intensity.

Modularity /Implementation

Short processing times allow a simple implementation of the technique, but often high efforts for loading/unloading and packaging of products are required. Treatment with shock waves in combination with anterior maturation and especially after-ripening could promote and accelerate maturation. Towards fourteen days lasting conventional maturation, an advantage in time of circa seven days would be possible.

Consumer aspects

No declaration required. Consumers could perceive the technique as if old or low quality meat is processed to food.

Legal aspects

As a mechanical treatment the process can be applied. EU: Novel food legislation to be observed, but at present results do not indicate substantial changes of product composition.

Environmental aspects

Waste free technique, energy efficient.
Facilities that might be interesting for you

<table>
<thead>
<tr>
<th>Title</th>
<th>Institute/company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous microwave heating system with conveyor - SP</td>
<td>SP</td>
</tr>
<tr>
<td>Continuous tubular microwave heating system - SP</td>
<td>SP</td>
</tr>
<tr>
<td>HIGH STATIC ELECTRIC FIELD FREEZER</td>
<td>ONIRIS-GEPEA</td>
</tr>
<tr>
<td>Microwave heating labscale IRTA</td>
<td>IRTA</td>
</tr>
<tr>
<td>Microwave heating pilot and industrial scale IRTA</td>
<td>IRTA</td>
</tr>
<tr>
<td>Microwave system 2450 MHz FBR</td>
<td>Wageningen UR - FBR</td>
</tr>
<tr>
<td>Microwave system 915 MHz FBR</td>
<td>Wageningen UR - FBR</td>
</tr>
<tr>
<td>Radio Frequency heat treatment pilot system - KEKI</td>
<td>NAIK EKI</td>
</tr>
<tr>
<td>Radiofrequency heating semi-industrial scale IRTA</td>
<td>IRTA</td>
</tr>
<tr>
<td>Shockwave - DIL</td>
<td>DIL</td>
</tr>
</tbody>
</table>

Further Information

Institutes
- DIL

Companies
- DIL, PROMATEC

References

Patents: