How does it work?

Primary objective
Continuous production of products with e.g. meat-like structure or crunchy, aerated structure

Working principle
In food processing mostly twin-screw extruders are used to process different kinds of foodstuffs, e.g. breakfast cereals, snacks, noodles of meat analogues. Two types are available: co-rotating and counter-rotating twin screw extruders. Main difference is the very high shear rate using a co-rotating twin screw extruder and the build up of a high pressure working with a counter rotating twin screw extruder.

High moisture extrusion, the process to produce meat analogues is realized using a co-rotating twin screw extruder (8). Cooking extrusion for expanded snacks and breakfast cereals mainly is realized using a corotating twin screw extruder (1, 2)

The mode of working is: At the material charge of the extruder usually a powder mixture is added. In the extruder, the premix is mixed and compressed. Furthermore some water is added using a dosing pump. The mass is homogenized and conveyed by the screws, treated by adjusted special temperature and pressure profile up to 170°C and 90 bar (maximum values for meat analogues). In this way, starch and protein are disrupted and the water is bound. Depending on the application at the end of the extruder, product outlet is realized by a long cooling die for meat analogues or a hole type nozzle to produce e.g. snacks by cooking extrusion. (3, 6, 8, 9) Finally a cutting device at the outlet determines shape and size of the end product.

Important process parameters
The most important parameters are temperature, pressure, rotation speed, throughput and dwell time, screw profile, screw rotation and die profile.

Important product parameters
Product parameters are starch, protein and water content.

Images
Sterilization by high temperature in extruder, mixing, kneading, moulding
Starch gelatinization Protein denaturation Structure- modification , structure generation

Additional effects
Sterilization by high temperature in extruder, mixing, kneading, moulding
Starch gelatinization Protein denaturation Structure- modification , structure generation
What can it be used for?

**Products**
For the cooking extrusion:
The big range of expanded products like breakfast cereals, flat bread and snack products e.g. peanut puffs products. Furthermore many pet food products.
For the high moisture extrusion: Restructured meat or fish products with meat-, poultry or fish like structure based only on vegetable components (8, 10)

**Operations**
Generation of structure and mould, under pressure, high shear rate and high temperature

**Solutions for shortcomings**
Need for continuous processing in food industry; need for characteristic products with special structure, need for adding value to secondary raw materials

What can it NOT be used for?

**Products**
Special needs to raw materials (for cooking extrusion starch content of 45...70 % (applied to dried matter), for high moisture extrusion protein content <50 % (applied to dried matter)) otherwise characteristic structure of end products can not be generated (degree of expansion, stability of shape, ...)(1, 2, 3, 7, 8)
Standard treatment for different products, extrusion needs adaption of recipe, process and apparatus configuration. No end product with coarse and lumpy materials; lumpiness of raw materials restricted to a size in the filed of dp < 5...10mm Generating meat-like structures without vegetable proteins.

**Operations**
Production based on extrusion technology requires a lot of experience; a need of trained employee, trouper for running this very sensitive apparatus resp. process

**Other limitations**
High investment cost

**Risks or hazards**
Extrusion, especially cooking extrusion and high moisture extrusion, leads to thermal demands of the material. The high temperature can destroy vitamin, colour and flavours

Implementation

**Maturity**
Available in the pet food industries are the largest and most powerful extruders through rates of up to 16t/h are possible and in the cereals industry are throughput rates up to 12 t / h. Depending on the application, the extruder can be adapted to the various processes.
Also is it possible to work with small extruders in a laboratory scale (throughput to 40 kg/h) e.g. in the pharmacy industry

**Modularity**
The continuous mode of working can be easily integrated into existing processes and can undertake tasks of batch processes

**Consumer aspects**
Consumers perceive the technique as environmental friendly and are positive to naturalness of the product.

**Legal aspects**
Extrusion is a long time an established technology in the food industry, no need of special certifications in new applications

**Environmental aspects**
The extruder combines different process types and thus can work more effectively. Concluding other equipment is saved.
## Facilities that might be interesting for you

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<tr>
<th>Title</th>
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<tr>
<td>BC 21, Nano 16- Extruder-HES-SO Valais-HEI</td>
<td>University of Applied Sciences and Arts Western Switzerland Valais</td>
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## Further Information

### Institutes
- DIL, TU Berlin, Gaziantep University, Wageningen UR - FBR
- Coperion, KraussMaffei Berstorff, Clextral, Buhler, Leistritz Extrusionstechnik GmbH

### Companies
- Coperion, KraussMaffei Berstorff, Clextral, Buhler, Leistritz Extrusionstechnik GmbH

### References

Books:
- Mian N. Riaz: Extruders in Foo, CRC Press, 2000
- Robin Guy: Extrusion Cooking, Technologies and Applications; CRC Press, 2000
- Medeni Maskan: Advances in Food Extrusion Technology, 2011