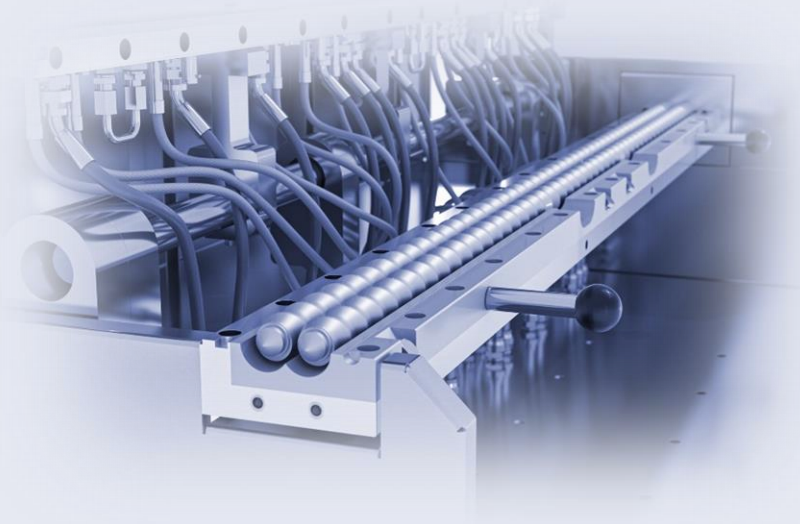


LAB SCALE EXTRUSION
ALTERNATIVE PROTEINS AND MEAT ANALOGUES

Anton Paar

Brabender becomes part of Anton Paar. Two pioneers, one mission.

Great people | Great instruments

FACTS & FIGURES

ESTABLISHED IN
1922

HEADQUARTERS
IN GRAZ / AUSTRIA

4,400+
EMPLOYEES

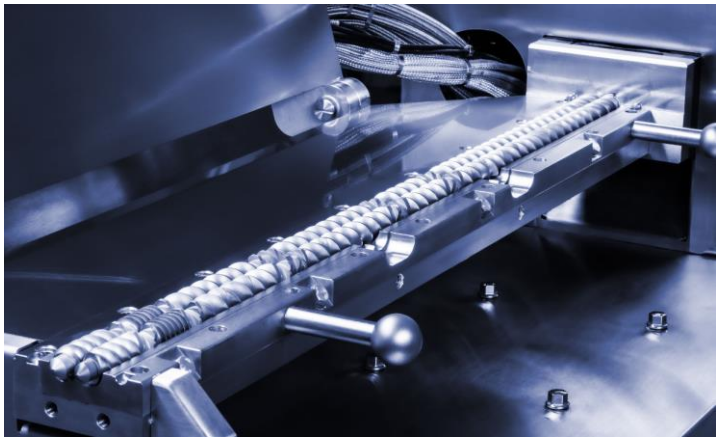
OWNED BY THE CHARITABLE
SANTNER FOUNDATION

14.5 % INVESTMENT
IN RESEARCH AND DEVELOPMENT

FROM ANNUAL TURNOVER
ANTON PAAR GMBH

ALL CRITICAL COMPONENTS
MANUFACTURED IN-HOUSE

BRABENDER HAS BEEN INTEGRATED AS A BRAND OF ANTON PAAR



BRABENDER PRODUCT LINE

- SERVING INDUSTRY & RESEARCH SINCE 1923
- PART OF THE ANTON PAAR GROUP SINCE AUGUST 2023

PRODUCT PORTFOLIO

- MODULAR TORQUE RHEOMETERS
- MEASURING MIXERS
- FLOUR, DOUGH & STARCH ANALYZERS
- VISCOMETERS
- MOISTURE, DENSITY, OIL ABSORPTION & RELAXATION ANALYZERS
- LAB-SCALE EXTRUDERS & PERIPHERY
- LAB MILLS
- PROCESS SENSORS
- LABORATORY SOFTWARE

… AND IS NOW SERVING INDUSTRY AND RESEARCH WITH NUMEROUS APPLICATIONS

FOOD & FEED

PLASTICS & RUBBER

OTHERS

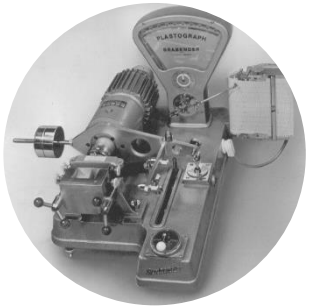
THE BRABENDER HISTORY

1923

Company foundation by Carl Wilhelm Brabender. Corporate purpose: **Major repairs of electric motors and transformers.**

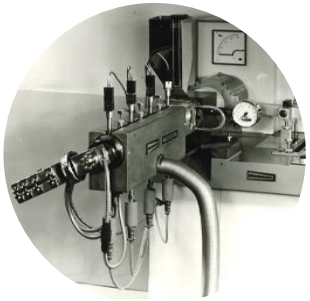
1928

Invention of the **Farinograph** as world's first torque measuring instrument for determining the **quality of flour.**



1936

Development of the **Plastograph**, based of the Farinograph's measuring principle. First measuring mixer on the market for determining **plastics and rubber quality.**



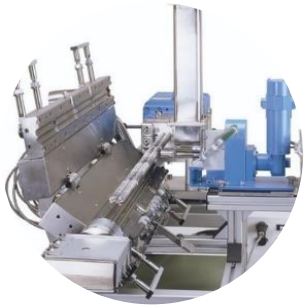
1965

Brabender enters the extrusion market with **single screw extruders for realistic process simulation at laboratory scale.**

1970

Carl Wilhelm Brabender's wife **Martha Brabender** takes over the company after the death of her husband.

THE BRABENDER HISTORY



2001

Brabender develops the market's **first twin-screw extruder with hinged and openable liner**, optimized for process monitoring and cleaning.

2012

Brabender's first rheological instrument for **rapid quality testing: The GlutoPeak** was developed to measure gluten quality.

2015

First devices equipped with **MetaBridge software,** allowing customers to retrieve measurement readings from any device and location.

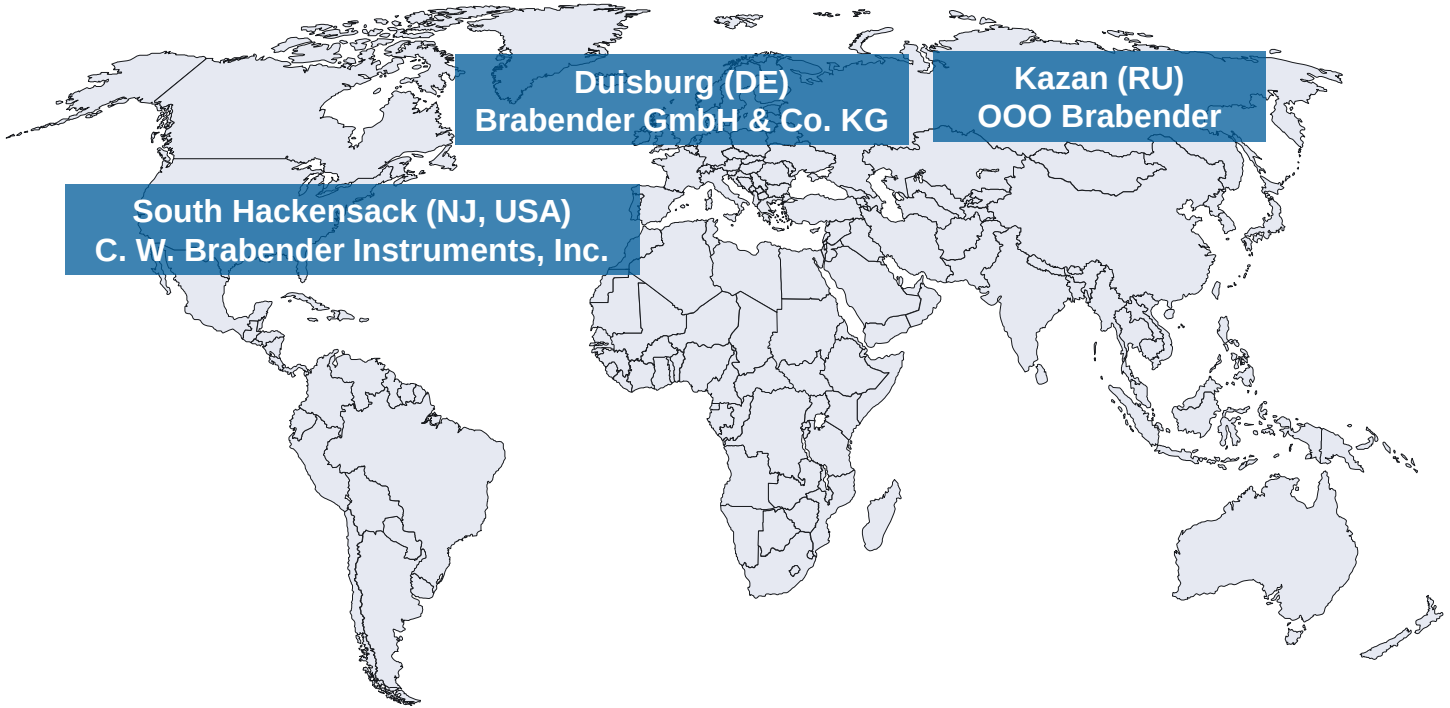
2018

ViscoQuick – **first universal viscometer** developed by Brabender. Measures starch-based products and fluids with different viscosities.

2023

Brabender celebrates its **100th anniversary** and is integrated into the **Anton Paar Group**

OUR PRODUCTION FACILITY IN DUISBURG, GERMANY



GLOBAL BRABENDER LOCATIONS

BRABENDER PRODUCT LINE FOOD & FEED

Flour & Dough Analyzers

ICC, AACCI, ISO standard methods:

- **FarinoGraph:** Flour water absorption and kneading characteristics of dough
- **ExtensoGraph:** Dough elasticity and processing properties
- **Amylograph-E:** Enzyme activity and baking properties of flour

Rapid method:

- **GlutoPeak:** Aggregation properties and strength of gluten in flour (rapid method)

Starch & Gluten Analyzers

Starch analyzers:

- **Viscograph-E:** Starch gelatinization and enzyme activity (ICC, AACCI, standard method)
- **ViscoQuick:** Starch gelatinization and enzyme activity (rapid method)

Gluten analyzers:

- **GlutoPeak:** Vital gluten aggregation properties and strength (rapid method)
- **Glutograph-E:** Gluten elasticity

Mills & Moisture Analyzers

Equipment for sample preparation

Lab Mills:

Break mills and separators at laboratory scale for preparing samples for further analyses

Moisture analyzer:

- **MT-CA:** Automated oven drying method with integrated balance and capacity for testing 10 samples at once (based on ICC and ISO standard method)

BRABENDER PRODUCT LINE FOOD

Lab-scale Extruders

- Stand-alone single-screw extruders
- Stand-alone twin-screw extruders
- Single and twin-screw extruder attachments for modular torque rheometers
- Application-specific dies and screws
- Downstream equipment for conveying, cooling and cutting of extrudates

Applicable for e. g. snackfood, pasta, flatbread, meat analogues, feed pellets

Laboratory Software

MetaBridge: Browser-based standard instrument software

- Touch-screen optimized operation
- Compatible with all desktop or mobile terminal devices
- Compliance with standard and individually defined methods
- Comparisons via reference and correlation add-on functions
- Measured values transfer to other Brabender devices and 3rd party systems

SINGLE SCREW AND TWIN SCREW EXTRUDERS AND ACCESSORIES

Single screw extruders

Complete systems and attachments for the rheological drive units with 19 and 30 mm screw diameter

Twin-screw extruders TwinLab Series

12/36 attachment
20/40 system and attachment
30/40 system

SINGLE VS. TWIN SCREW EXTRUDERS

When to use a single-screw extruder?

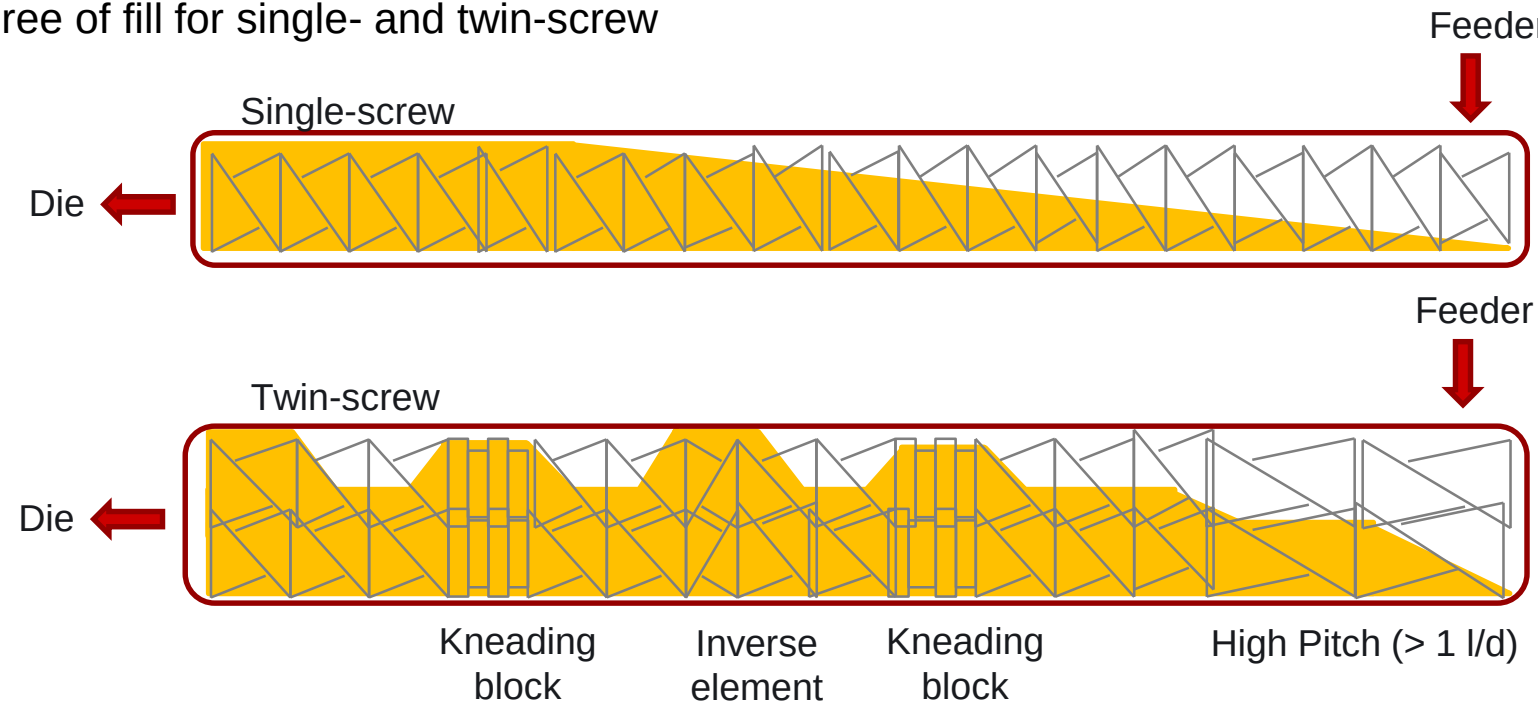
- Customer only has one material or premix/compound
- Customer does not want to actively adapt the recipe during the process
- Customer requires a higher maximum process pressure (700 bar)
- Save money with simplified setups

When to use a twin-screw extruder?

- Required if you want to mix more than 2 material
- Throughput greater than 20 kg/h required
- Future-proof and flexible solution when money is no issue

SINGLE VS. TWIN SCREW EXTRUDERS

Degree of fill for single- and twin-screw

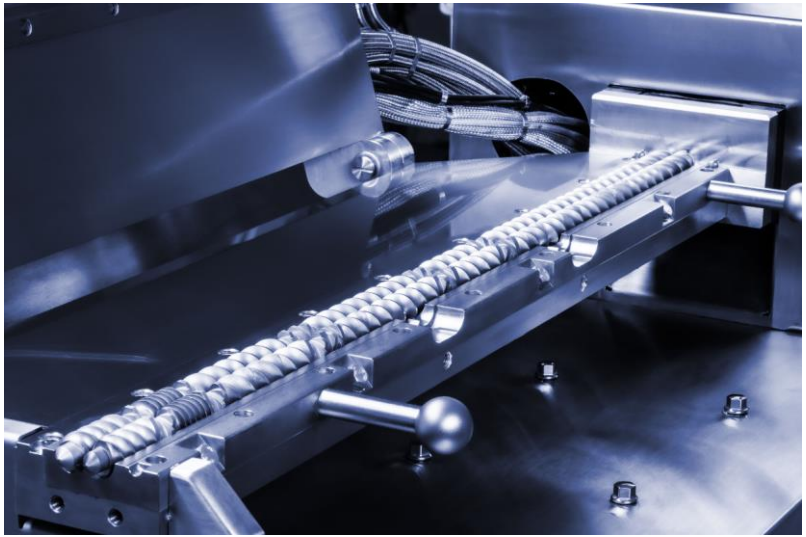


Schematic!

CLAM SHELL DESIGN

User-friendly design of Brabender twin-screw extruders

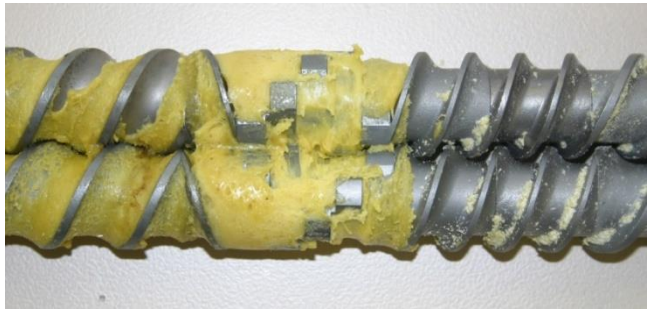
- Openable liner
- Easy cleaning
- Process transparency



Liner opening for screw design optimization

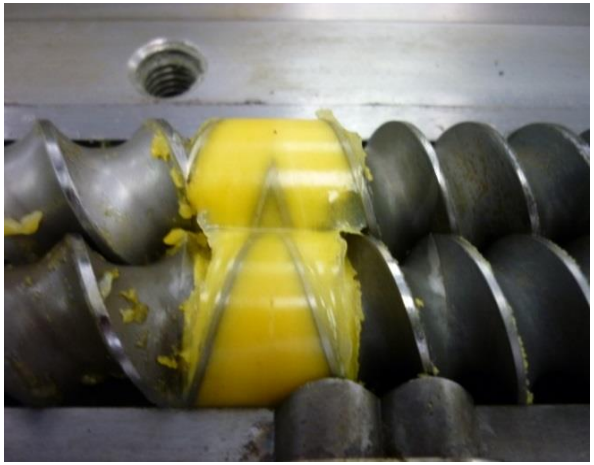
- **Opening of the liner enables the operator to have a look insight the process.**
- **Further benefit: cleaning process much easier**
- Identification of fully and half-filled zones
- Influence of temperature on the raw material
- Determination of the degree of mixing

⇒ **Optimization of screw design**

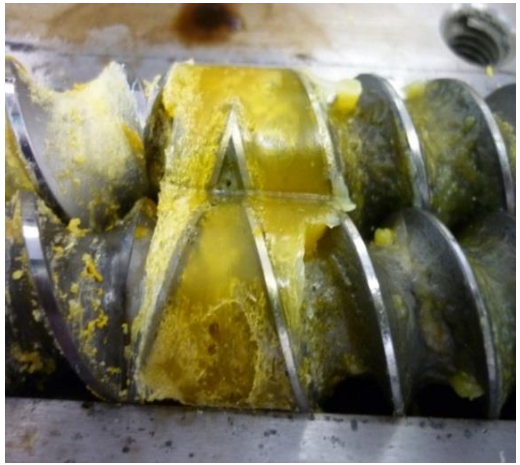


Impact of screw elements on raw material

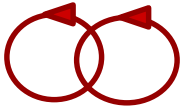
Mixture/ cold forming



Gelantinization/ plastification



Starch destruction



Co-rotating,
intermeshing,
twin-screw

Extrusion processing… what about meat analogues?

CCO public domain/ pixabay

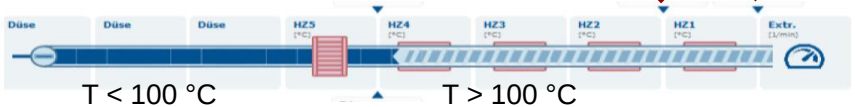
Most meat analogues are extruded products…

Extrusion process - HME

meat analogue – extrusion process & modular cooling die

80 – 40 % Water

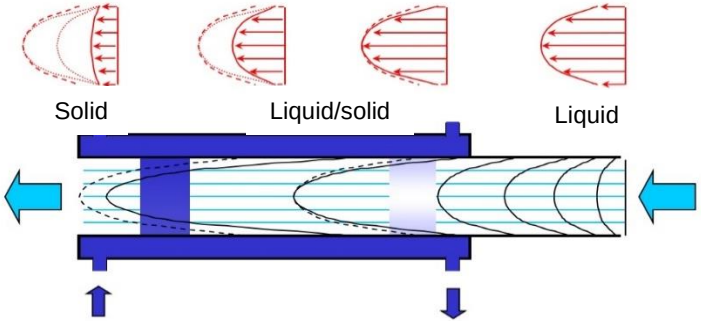
20 – 60 % Protein



T < 100 °C

T > 100 °C

lamination



Extrusion process - HME

meat analogues – HME

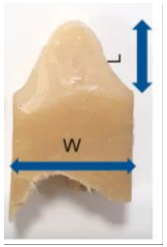
Starting procedure	Parameter determination	Sample production	Stopping procedure
Low shear + heat	Increase: shear + heat stepwise	Optimal conditions	Low shear + heat

Under cooked

Over cooked

$$Relative\ fibre\ length = \frac{L}{W}$$

$L = Fibrelength$
$W = Fibrewidth$



meat analogues – LME

Starting procedure	Parameter determination	Sample production	Stopping procedure
Low shear + heat	Increase: shear + heat stepwise	Optimal conditions	Low shear + heat

Under cooked

Over cooked

Soy chunks

Set up & equipment

Marel demo center facilities:

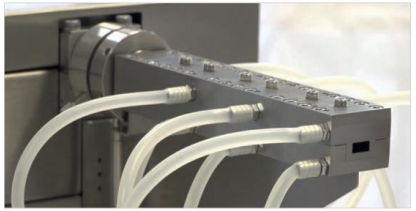
marel

Set up & equipment

Brabender extrusion line:

Twin screw extruder TwinLab-F 20/40
+ application-specific screws

Round dies for LME



Modular cooling die for HME

Cutting device for LME

Conveyor belt for HME

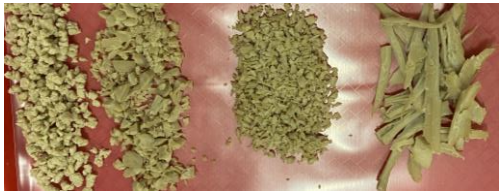
Formulations & products

- **LME:**
- soy protein concentrate: „alpha-8“ (Solae), 67% protein content
- water
- **HME:**
- soy protein concentrate: „alpha-8“ (Solae), 67% protein content
- water
- **Burger patty mix: „vegan burger mix“ (DP&S):**
- emulsion
- binding system
- spice mixture
- **Schnitzel mix: „vegan chicken schnitzel“ (DP&S):**
- emulsions
- binding system
- spice mixture
- coating system

Processes:
burger patties, chicken-type burgers, schnitzels & chicken-type pieces

extrusion line

LME extruded products of different size



HME extrusion

Process: Application 1 burger patties – tasting

Comparison of the marel-Brabender-products to commercially available products:

	marel-Brabender (soy based)	Vegetarian Butcher (soy + wheat based)	Albert Hein (soy based)	Garden Gourmet (soy based)	Beyond meat (pea based)
raw					
fried					

→marel-Brabender patty was smooth texture in comparison to other products
→marel-Brabender patty and Garden Gourmet patty showed best results at the tasting

Process: Application 2
chicken-type burgers, schnitzels & chicken-type pieces

fried schnitzels

fried chicken-type filet products

Research & Applications
Pulse flour Extrusion

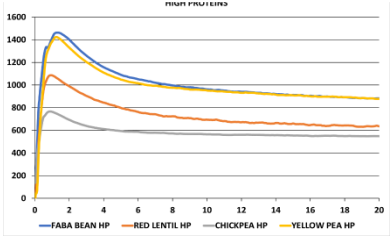
RQ: Is it possible to produce a whole BURGER made from HME stripes?

Setup:

- twinscrew extruder
- modular cooling die

Raw materials:	Protein content	Carbo-hydrates	Fibre	Fat
Soy protein concentrate (supplier: Solae)	67 %	data not available	data not available	8 %
SMART PRO Faba bean (supplier: Müller‘s Mühle)	58,3 %	7,4 %	14,3 %	4,6 %
SMART PRO Yellow pea (supplier: Müller‘s Mühle)	48,4 %	17 %	16,2 %	4,3 %

water absorption of different pulse flours analyzed in advance



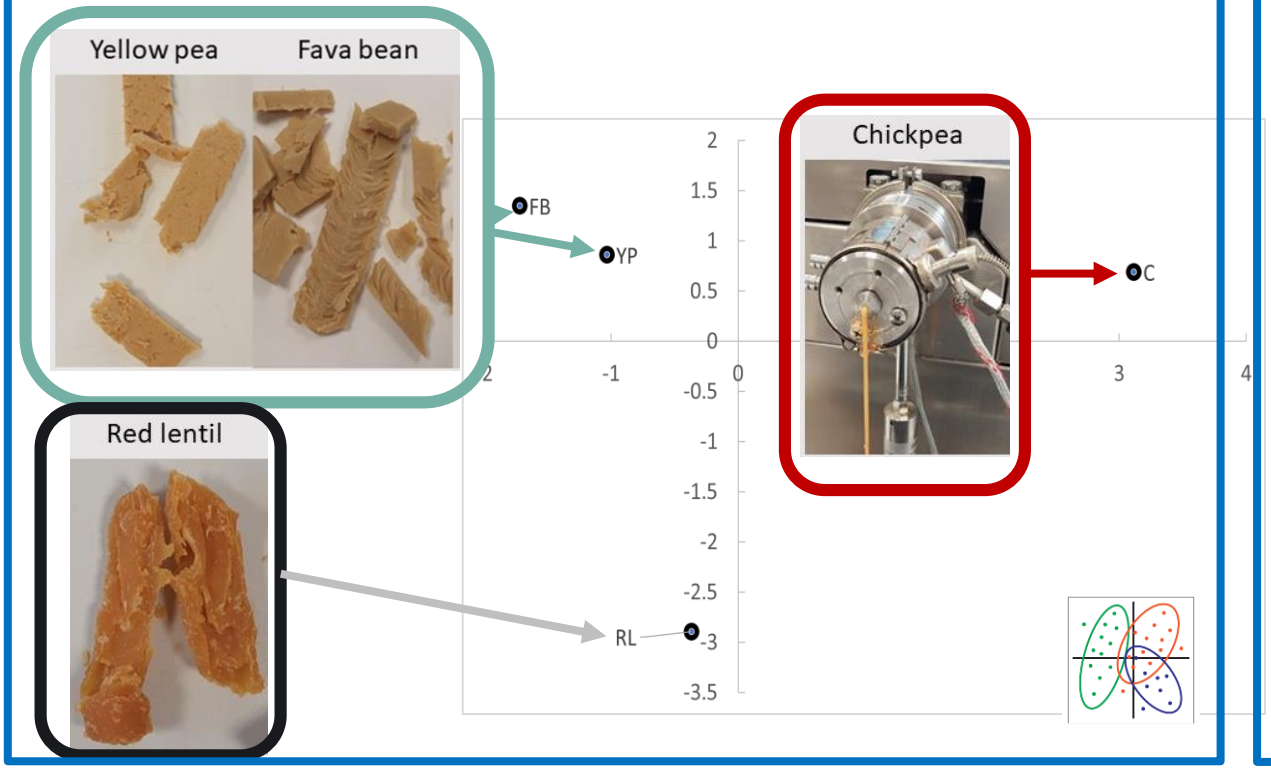
Extrusion process (HME; faba bean):

- total moisture content: 50%
- temperature profile: 40-70-80-110 °C
- cooling die temperature: 20°C
- screw speed: 100 rpm
- throughput: 2Kg/h

Results:

- pure faba bean → low texturization, ‚beany‘ taste
- mixtures with good texturization and sensory properties:
  - faba bean + y. pea
  - pea + oat

Selection of pulses for HME and TVP extrusion



Chickpea:
- No texturization and/or expansion
- due to low protein and high-fat content

Red Lentils:
- No texturization through HME
- TVP performed well

Yellow Pea:
- Suitable for HME

Fava Bean:
- Good behavior for HME
- The best results due to the formation of texturized proteins
- Pure: beany taste

(Bresciani et a

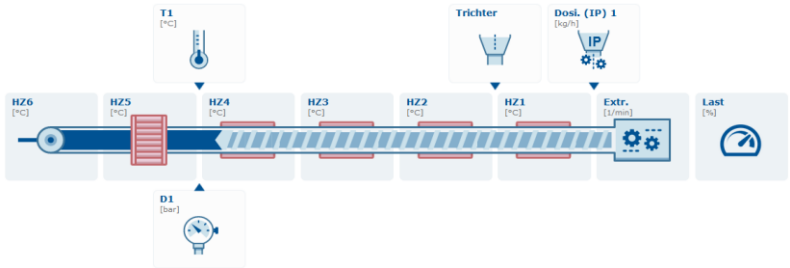
Extrusion of pulse-based pasta

SMART PRO Chickpea			
Protein content	Carbo-hydrates	Fibre	Fat
36,8 %	24,5 %	15,0 %	11,7 %

Setup:

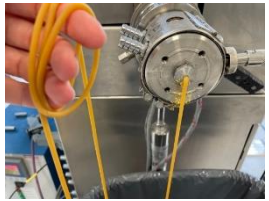
- twinscrew extruder
- round die
- extrusion process:
  - temperature profile [°C]:

  HZ1 – HZ5: 50-80-100-120-130
  - total moisture content [%]: 25
  - throughput [kg/h]: 2
  - screw speed [U/min]: 700



Results:

extruded



dried

cooked

Further optimization: using a degassing unit

Sidestream utilization

Stale bread

The amount of bread thrown away is far too high.

Brewer´s spent grains

Brewer‘s spent grain is a byproduct of the brewing industry. Due to its high protein content, it is often used for animal feed.

Olive Stone Powder

Many olive are needed for nutrition and producing of olive oil. But the olive stones are discarded

Sidestream utilization

Setup

- Specially configurated screw for High Moisture Extrusion
  - High shear
  - Different kneading blocks
  - Tooth element
  - Reconveying

Sidestream utilization

Setup

Parameter	SPC [%]	Side stream [%]	Moisture content [%]
Breadcrumbs	70	30	8,04
Olive stone powder	70	30	7,85
Brewer‘s spent grains	70	30	27,2
Soy protein concentrate	100	0	7,44

Sidestream utilization

Soy protein concentrate

Stale bread

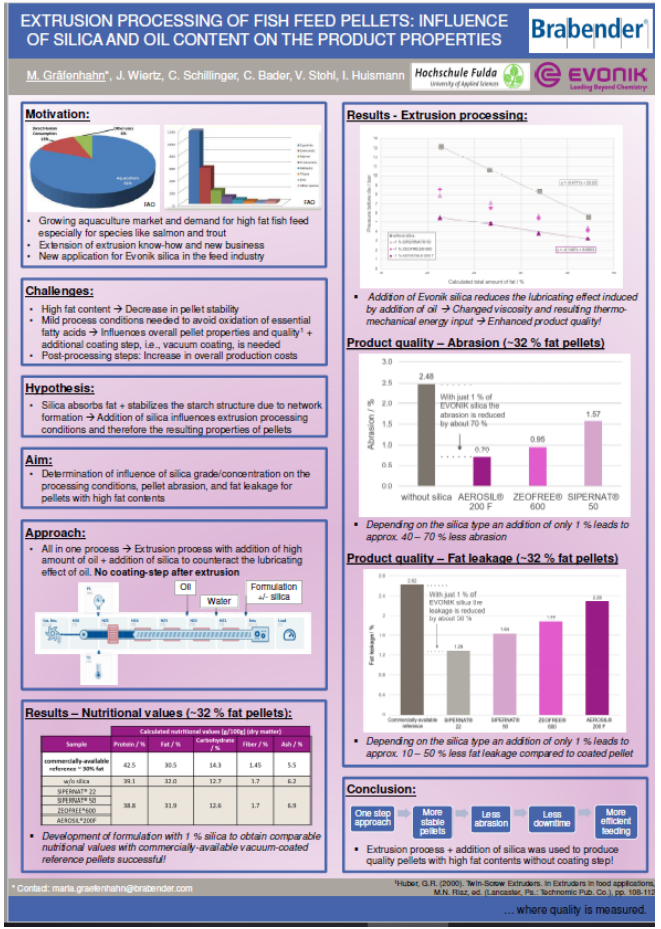
Brewer´s spent grains

Olive Stone Powder

AquaFeed extrusion

- Optimization of fish feed formulations
- Substitution of fish meal by insect meal
- Increasing fat content by
  - changing process parameters
  - adding different silica types
- Exhibition + poster presented at…
  - Aquaculture Europe 2021 (Portugal)
  - VICTAM 2022 (Utrecht)
- Presentation at Aquafeed Extrusion Conference 2022 (Utrecht)

- Silica project to be continued
- Exhibition + poster (+ presentation) at Aquaculture Europe 2022 (Italy)



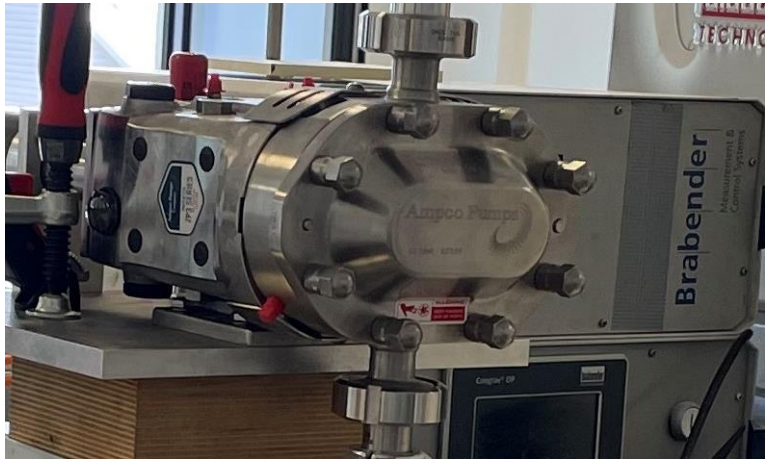
Confectionary

- It's hard to imagine confectionery shelves without the very common fruit laces,
- which come in a wide variety of shapes and colors with various surface treatments to be offered.
- From waxed, or sprinkled with sugar, to a sour sprinkling with a sugar-acid mixture, a lot is possible.
- Products filled with sugar pastes are just as varied on offer as products made from liquorice, which often also come with a sugar coated surface
- No matter how great the variety of products, there is one manufacturing process behind it: extrusion.

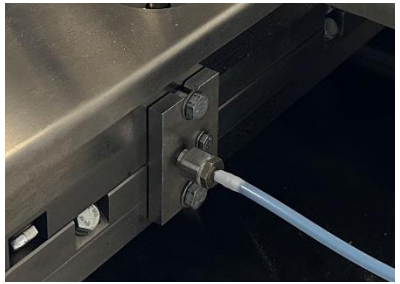



Confectionary

- Challenges:
  - Dosing of high viscous slurry
  - Dosing low amounts of colour and flavor



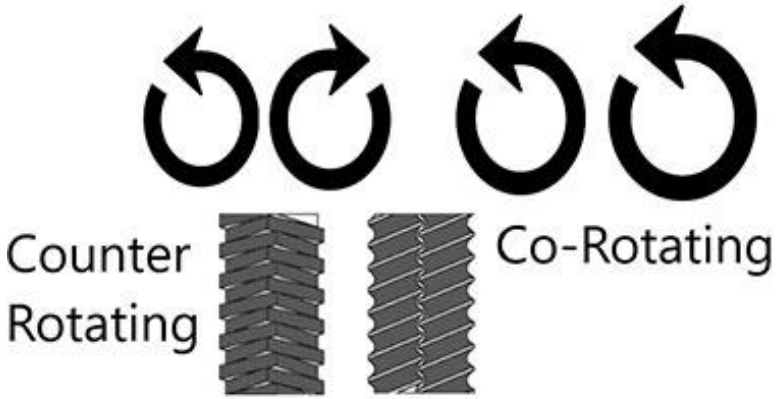
Rotary Piston Pump for high viskos mass (up to 2 million mPas)



Confectionary

Co-Rotating vs. Counter-Rotating

- Benefit Co-Rotating:
  - very flexible regarding the application
  - 2 uniform screws
  - High shear possible
- Benefit Counter-Rotating:
  - Very low shear possible



Arlington Machinery (www.arlingtonmachinery.com), 29.06.2023

Confectionary

- Complete Setup with
  - Slurry Pump (Rotary Piston Pump)
  - Colordosing
  - Flavordosing
  - Degassing Station
  - Round Die Head

Confectionary

Process Parameter

- Temperature Profil:
  - HZ1 – HZ5: 90-135-110-90-90
- Total throughput:
  - 4 – 5 kg/ h

Screwspeed:

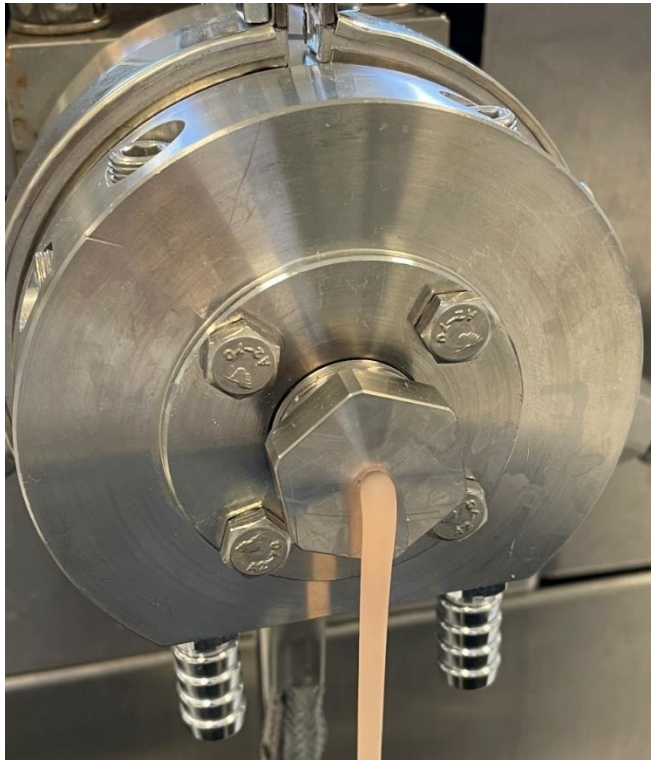
- 100 rpm

Vakuum:

- -0,35 bar

Schmelzetemperatur:

- Approx. 110 °C



REFERENCES R&D INSTITUTIONS

Hochschule Düsseldorf
University of Applied Sciences
HSD

Hochschule Fulda
University of Applied Sciences

Nofima

TDU
The University of Trans-Disciplinary Health Sciences & Technology

African Milling School

vg
versuchsanstalt für getreideverarbeitung

Università degli Studi di Milano

AIMPLAS
PLASTICS TECHNOLOGY CENTRE

China Agricultural University
1905

Washington State University

NDSU North Dakota State University

RI.SE Research Institutes of Sweden

Wageningen University & Research

NASA

UCC
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

Kansas State University

Universidad Nacional de Colombia

REFERENCES FOOD





REFERENCES FOOD

APPLICATION LABS

Get support from experts in quality control and R&D

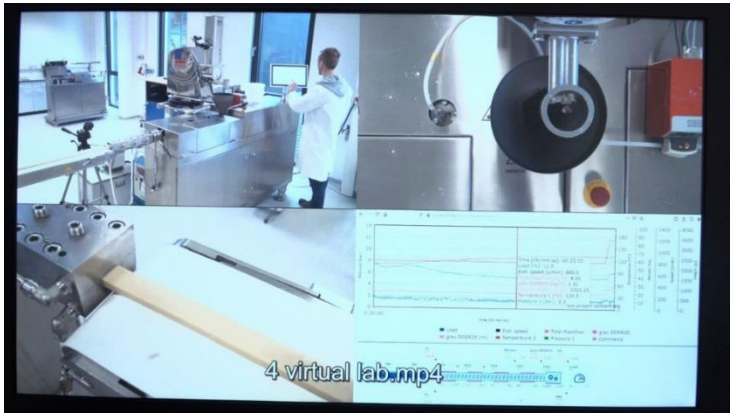
Run trials with equipment for rheological and other measurements, extrusion and more

APPLICATION LABS – remote lab

- Lab tours
- Device demos
- Material analysis
- Extrusion trials
- Product & process development

Benefits

- No travel restictions
- Limited costs
- Customers from different subsidiaries can attend
- Recording
- Live interaction with applic. team



CUSTOMIZATION

Custom-tailored solutions

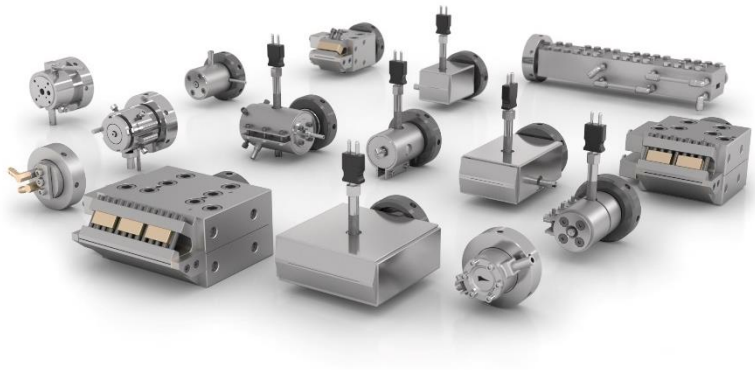
- Experts in technology and application
- Customized components and systems

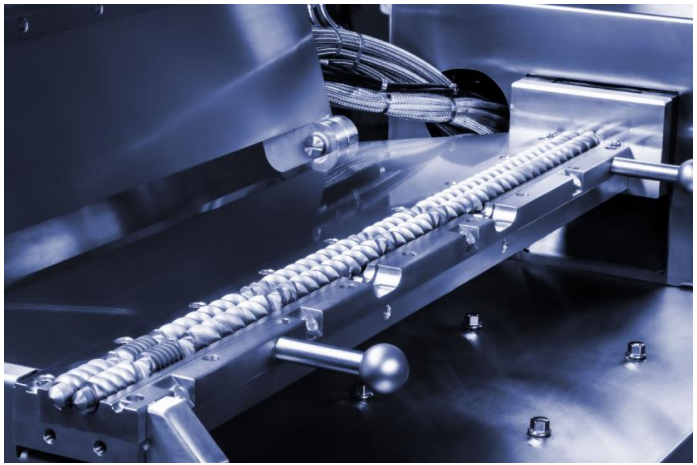
Get in touch

www.anton-paar.com

EXTRUDER DIE HEADS AND SCREWS

- Application-specific dies for the production of extrudates with different shapes
- Screws for single screw extruder tailored to specific applications
- Modular screws for twin screw extruders





EXTRUDER DIE HEADS –EXAMPLES

- Round die head
- Ribbon die head
- Multi-strand die head
- Modular cooling die