FORSCHUNGSKREIS DER
ERNÄHRUNGSINDUSTRIE E.V.

HIGHLIGHTS DER FEI-GEMEINSCHAFTSFORSCHUNG

Vegane Vielfalt mit IGF: Stoffliche und verfahrenstechnische Konzeption pflanzenbasierter Alternativen mit Brühwurst- und Rohwurstcharakter (AiF 18622 N)

Dr. Nino Terjung
DIL Technologie GmbH

DIL
FACTS AND FIGURES

FOUNDED **1983**

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- **BERLIN (GER)**
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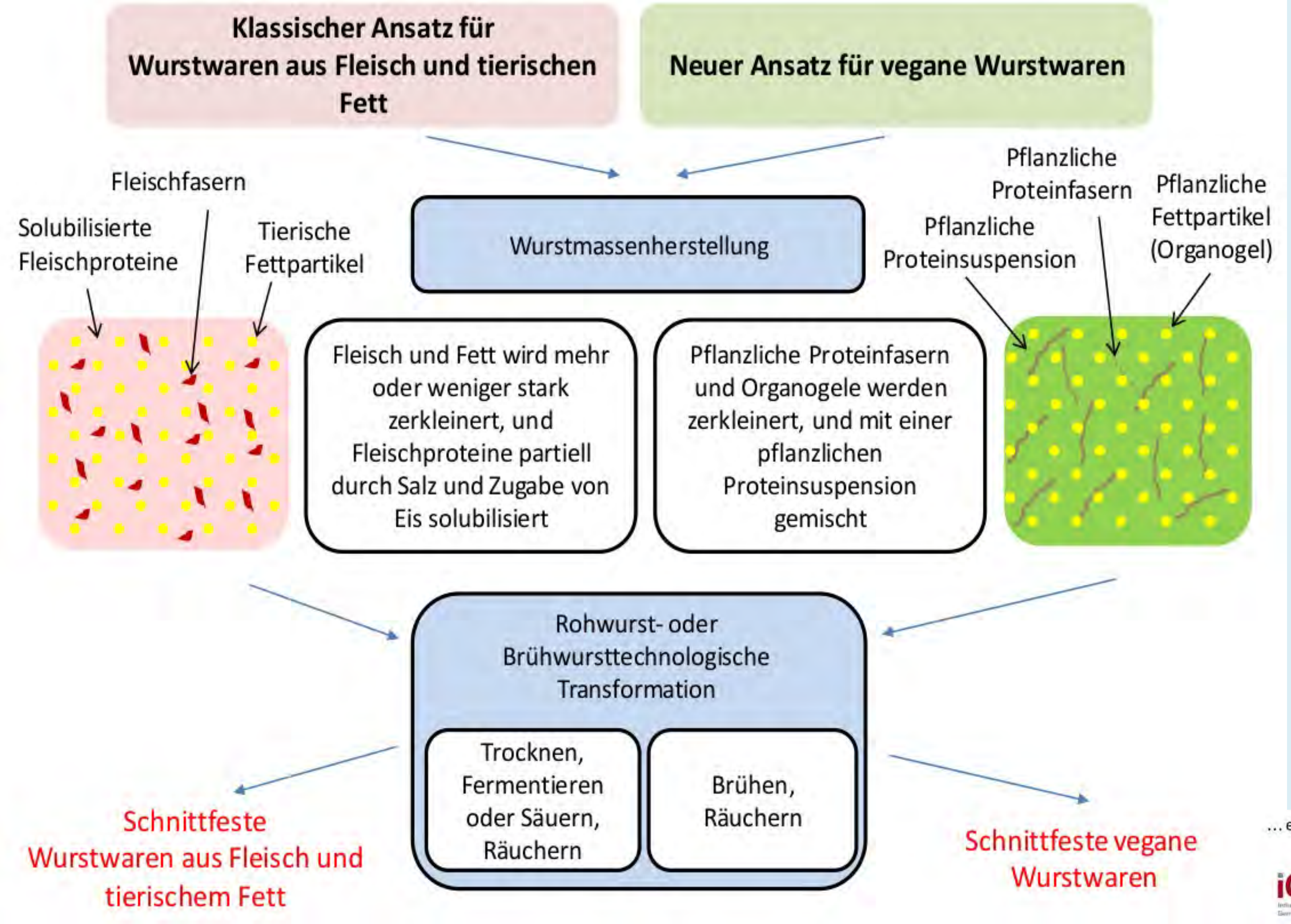
VEGANE WURST
GRUNDLEGENDE IDEE



… ein Projekt der *Industriellen Gemeinschaftsforschung (IGF)*
gefördert durch/via

VEGANE WURST

RAW MATERIAL CHARACTERIZATION

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Survey of aqueous solubility, appearance, and pH of plant protein powders from carbohydrate and vegetable oil production

Sandra Ebert[a], Monika Gibis[a], Nino Terjung[b], Jochen Weiss[a,*]

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The technofunctional properties vary depending on the manufacturer and extraction/processing method

Table 3
Protein classification of the tested plant protein genera based on literature values and Osborne (1907).

Osborne fraction	Albumin	Globulin	Prolamin	Glutelins	Reference
Suitable solvents	Water/Dilute saline solutions	Dilute saline solutions	Aqueous alcohol solutions	Acid/Alkali	Osborne (1907)
Pea	20%	65%	–	15%	Chéreau et al. (2016)
Wheat	4%	7.5%	45%	35%	Schormüller (1965)
Rice	5%	13%	3%	80%	Ju, Hettiarachchy, and Rath (2001)
Potato[a]	50 – 60%	25 – 26%	2 – 4%	9%	Peksa et al. (2009).
Canola	50%	25%	5%	10%	Chéreau et al. (2016)
Sunflower	20%	60%	5%	15%	Chéreau et al. (2016)
Pumpkin	14%	20%	4%	49%	Pham, Tran, Ton, and Le (2017)

[a] Alternative classification available into acid-soluble and -coagulable proteins.

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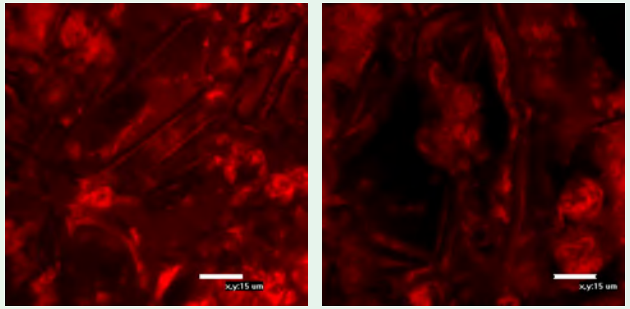
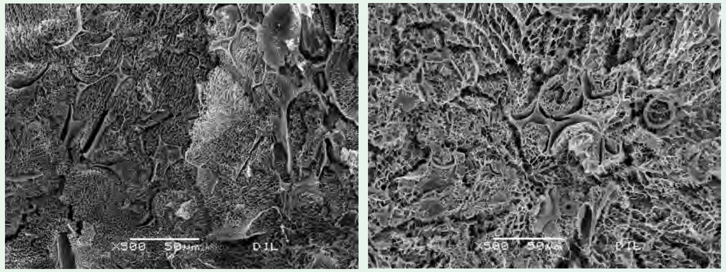
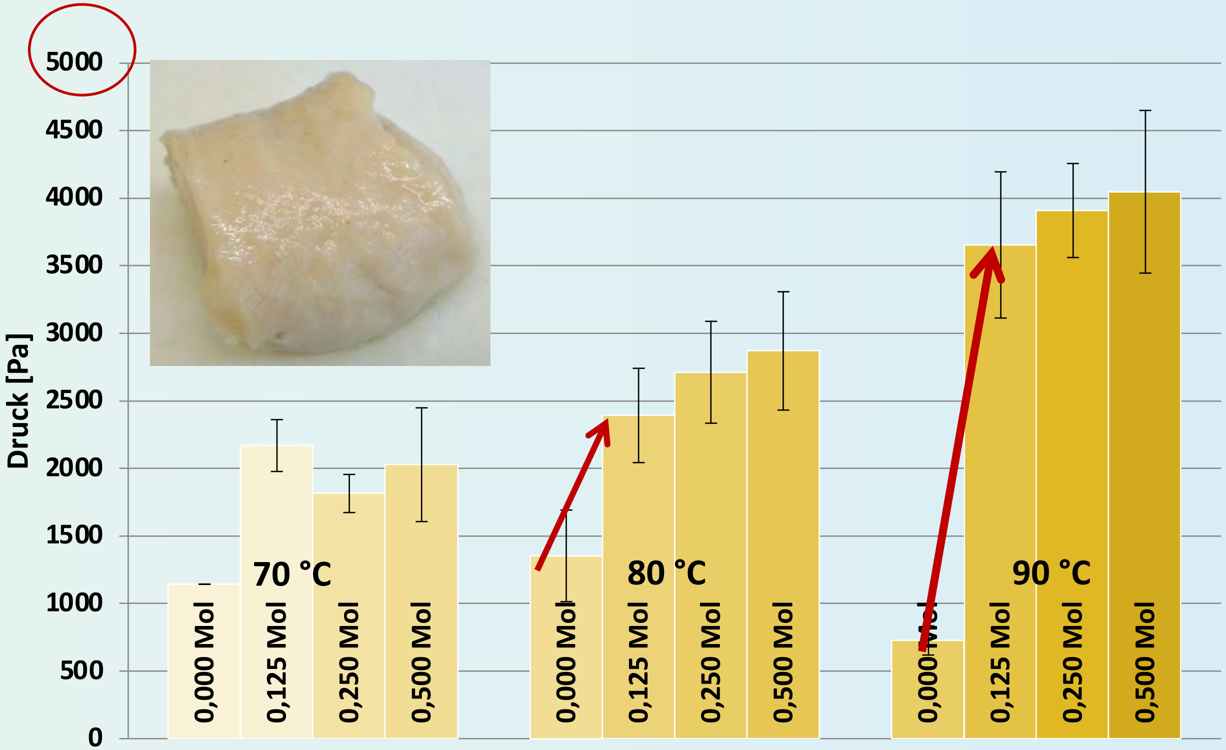
SOJAPROTEINKONZENTRAT



90 °C

0.0 Mol 0.5 Mol Salz





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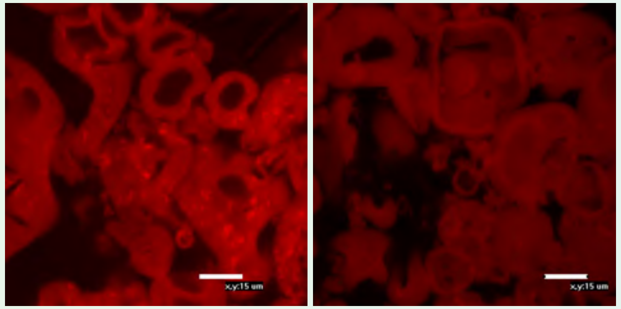
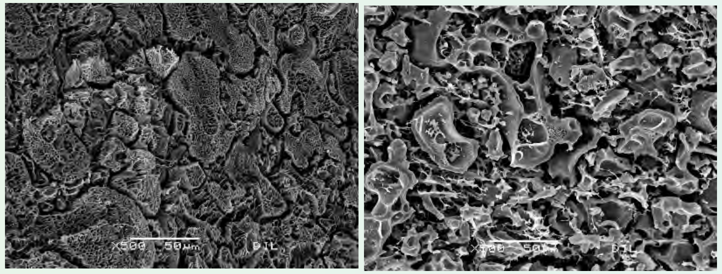
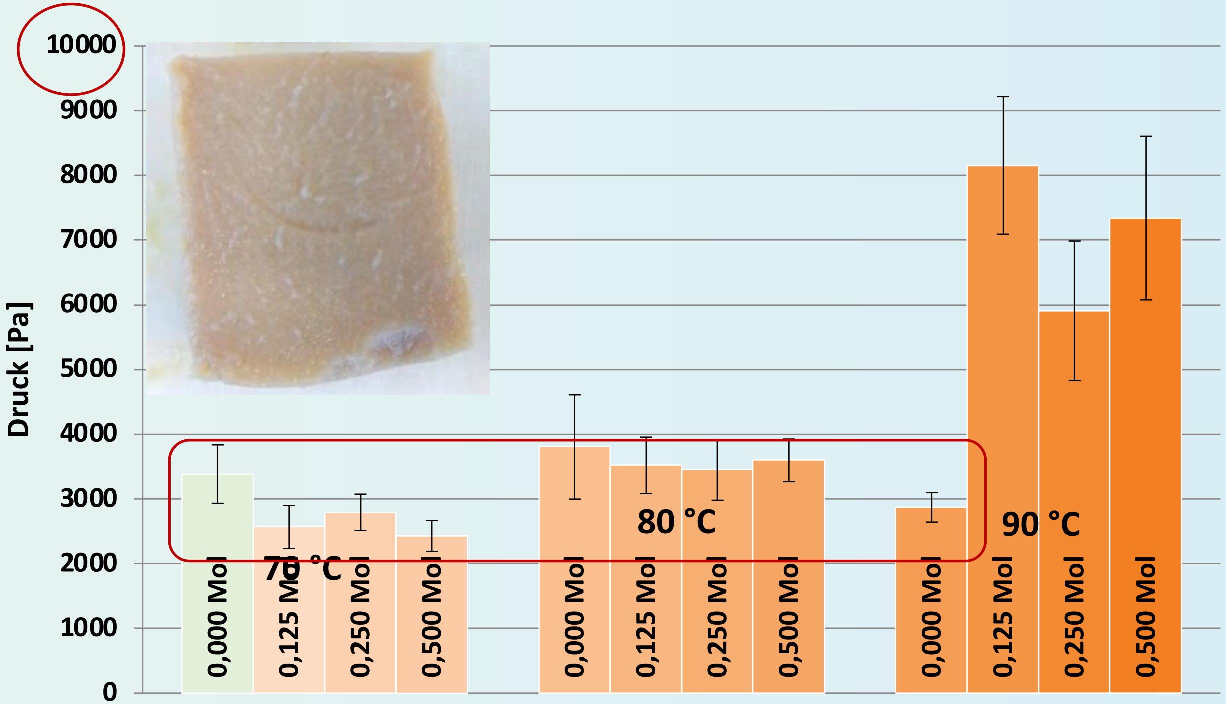
LUPINENPROTEINISOLAT



90 °C

0.0 Mol 0.5 Mol Salz



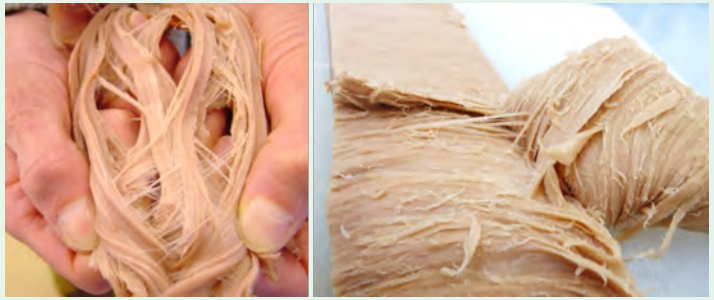


MEAT HYBRID
TEXTURIZATION

High moisture extrusion

High moisture extrudate (HME)

- Moisture content > 40%
- Filamentous, meat-like texture
- No rehydration



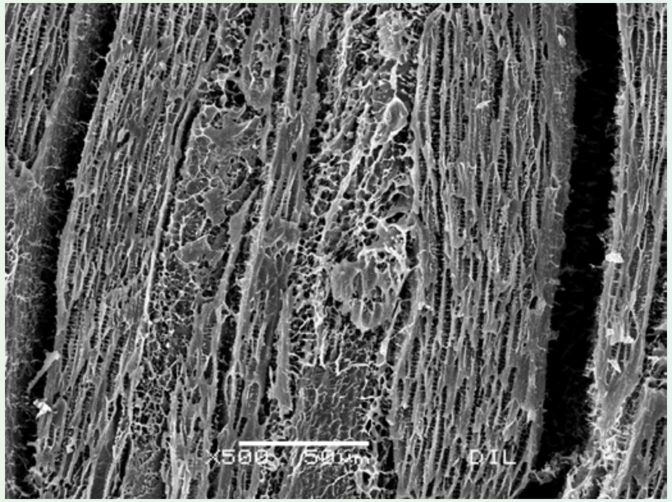
Low moisture extrusion

Textured vegetable protein (TVP)

- Moisture content < 35%
- Sponge-like texture
- Rehydration prior to application

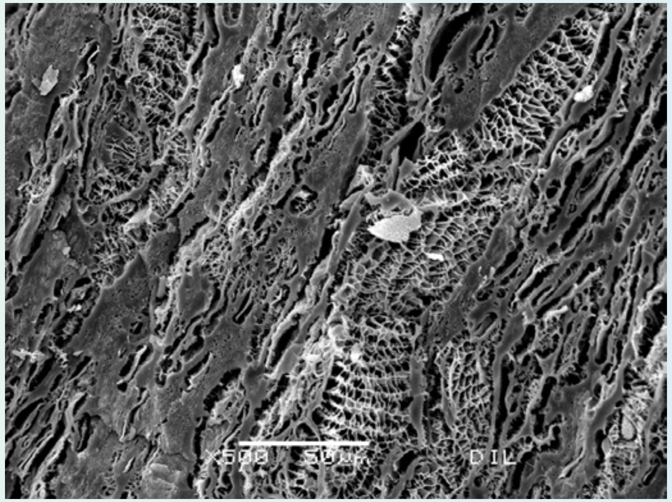
VEGANE WURST
IDEA OF TEXTURIZATION

Ubiquitous structure of meat
(beef top sirloin)



Structuring of plant proteins

Structure of Soy-HME



→ Organoleptic properties
→ Functionality of proteins (gelling, water and fat binding)

→ Anisotropic fibrous structure
→ Still shows functionality

Hypothesis:

In comparison to protein powder, structured plant proteins will improve the organoleptic properties of hybrid meat products.

In comparison to TVP, HME will improve the bite and texture due to its meat-like structure

In comparison to HME, TVP will decrease the water loss due to its high water-binding ability

VEGAN WURST
TEXTURIZATION

Pea protein isolate

Sunflower seed flour

Pumpkin seed flour

MEAT HYBRID
GRINDING

Pea | Sunflower | Pumpkin

Meat Grinder, 10 mm

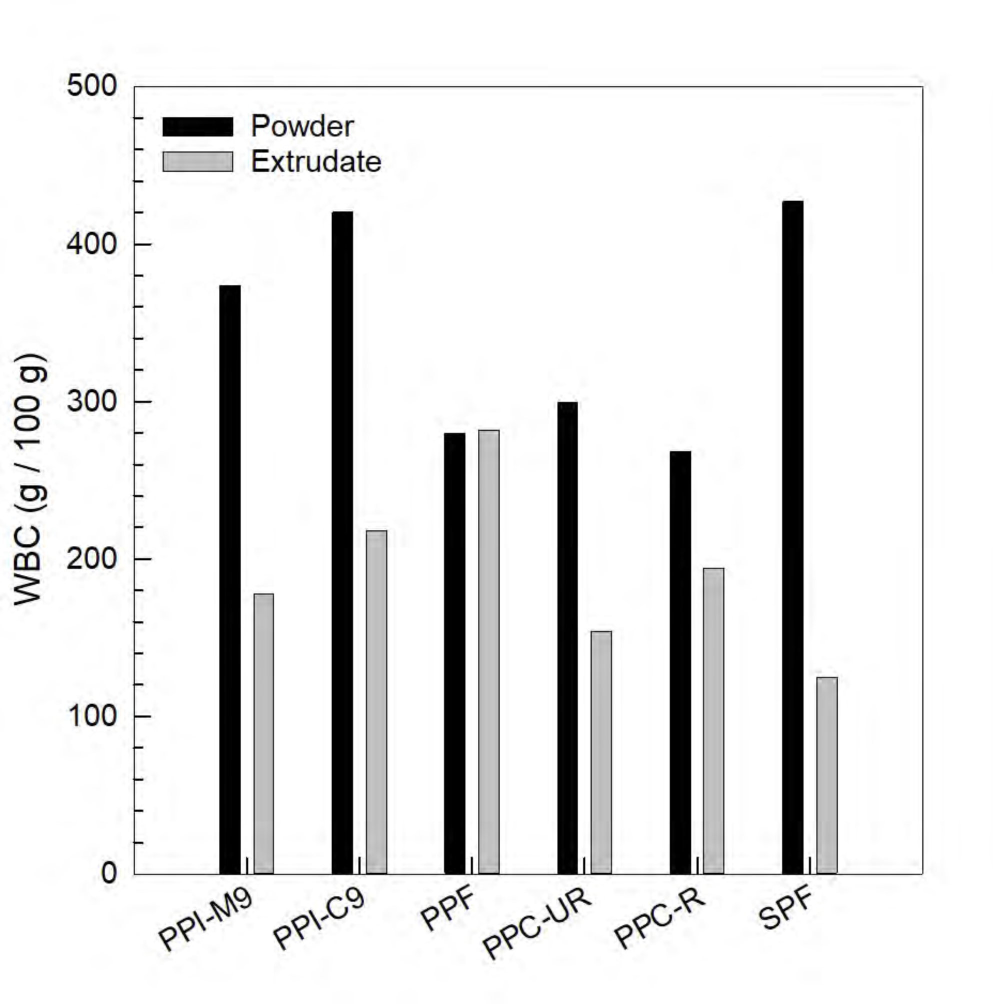
Soft HMEs are only pressed through the punched disk destroying the structure

Vacuum Bowl Chopper

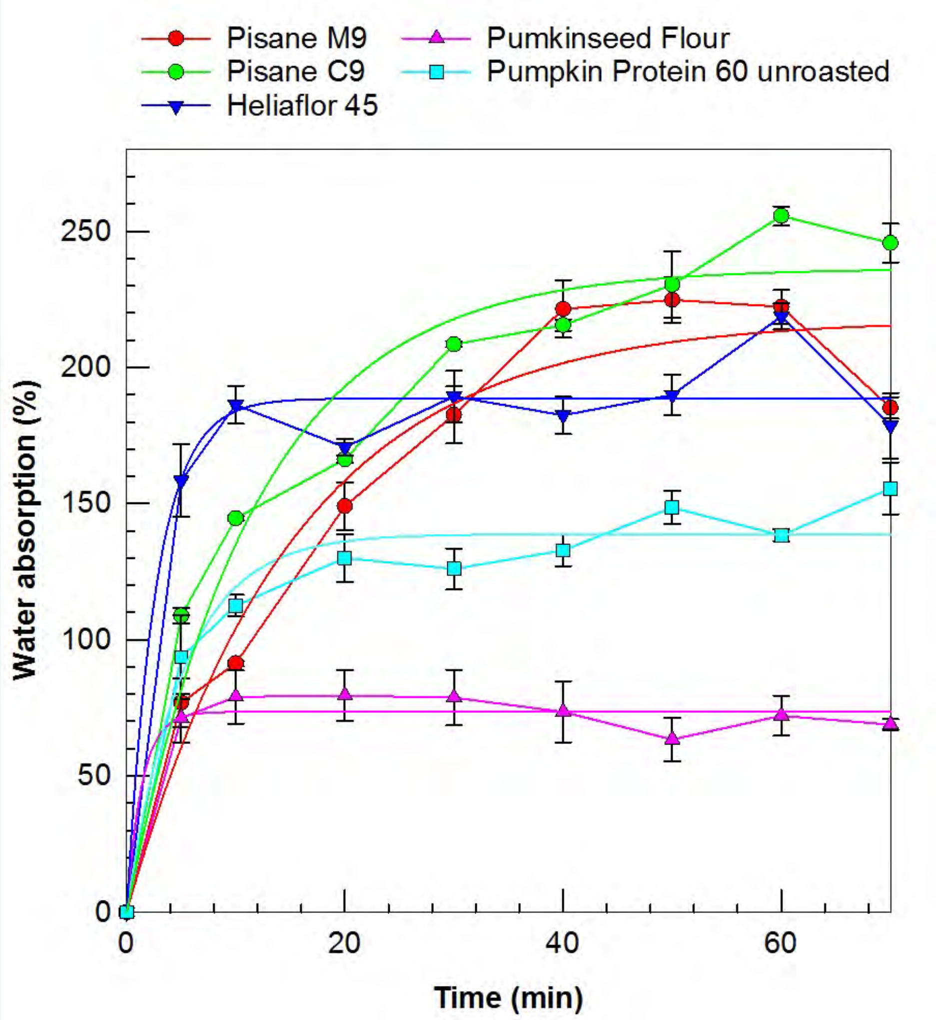
The bowl chopper suits better for mincing

VEGANE WURST
WASSERBINDUNG

HME (20°C)



TVP (80°C)



VEGANE WURST
GELLING VARIOUS PLANT PROTEINS

- least gelation concentration (LGC) of the protein powders and HMEs was determined, (gel induction 90°C, 10 min)

Protein	LGC (% protein)		Firmness (kPa)		Effect of Salt on Firmness		Soluble Protein (%)		Effect of Salt on Solubility		Effect of T (20, 90°C) on Solubility	
	Powder	HME	Powder	HME	Powder	HME	Powder	HME	Powder	HME	Powder	HME
Soy	**8.8**	10.9	1.6 ± 0.1	**6.9** ± 1.3	↑	↓	**37.5** ± 2.2	15.1 ± 2.4	↓	↔	↑	↑
Pea	**12.2**	17.6	2.8 ± 0.2	**7.8** ± 0.5	↑	↓	**36.3** ± 1.3	35.6 ± 1.8	↓	↔	↑	↑
Pumpkin	18.9	**11.9**	**9.4** ± 0.6	3.8 ± 0.2	↓	↔	13.4 ± 0.2	12.9 ± 0.4	↑	↔	↑	↑
Sunflower	11.5	11.8	**4.6** ± 0.4	2.8 ± 0.2	↓	↔	**19.8** ± 1.0	12.3 ± 1.2	↑	↔	↑	↔


Soy

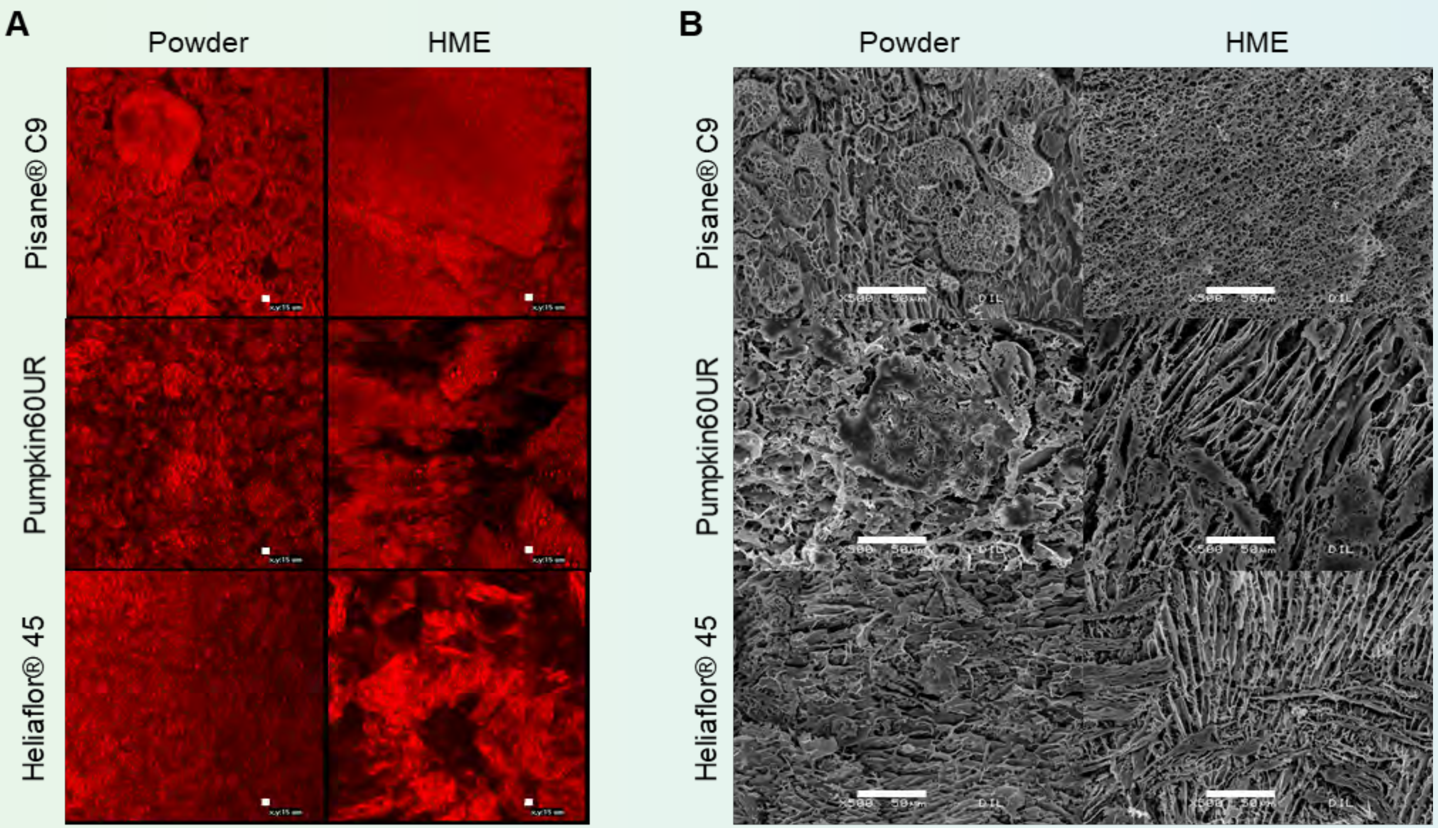

Pea


Pumpkin


Sunflower

- products posses different structures, protein concentrations, functional and sensory properties
- even after high moisture extrusion gelling ability of the proteins is given → basis for a hybrid protein network
- texture and firmness of the final product can be modified by protein and salt concentrations

VEGANE WURST
MICROSCOPIC GEL STRUCTURE



CLSM

- particle structure of powder gels vanished after extrusion,
- Pisane®C9 HME-gels: very dense
- Pumpkin 60UR HME-gels: more swollen, directed structure
- Pumpkin powder gels: less swollen and denser
- Sunflower HME gels: lumps of unswollen completely denatured protein and well swollen areas

REM:

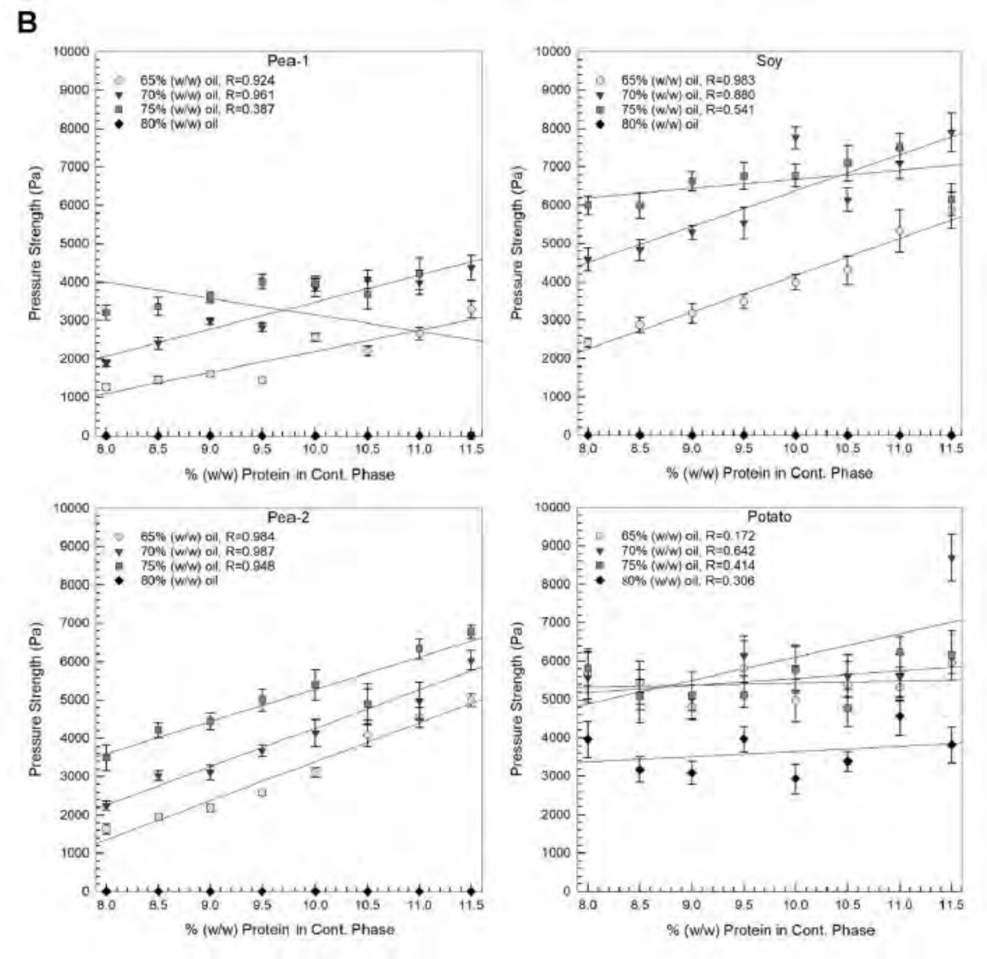
- directed structures (pumpkin and sunflower HME)

  → gel structure of both proteins was improved

  → positive sensorial impact?
- Powder gels: dense structures of non-protein solids
- Pea HME-based gels: more homogenous structure and much smaller mesh → indicates a higher WBC

VEGANE WURST

ENTWICKLUNG DER VEGANEN FETTKOMPONENTE



- ➢ 75% oil: structure weakening most likely coalescence

- ➢ With increasing oil content the protein content is reduced

- ➢ With increasing oil content the viscosity increases
- ➢ With increasing protein content, aggregate formation is enhanced
- ➢ Both reduce protein diffusion to the interface

- ➢ Soy: highest ability to form hydrophobic protein-interface bonds and protein–protein interactions → protein aggregate formation

- ➢ Potato: no dependency → emulsion-filled protein gel, hybrid gel with 11.5% protein + 70% oil

(I) Increasing oil content: increase in interfacial area and interface-interface interactions

(II) Increasing protein content: increase in interactions between protein and interface (electrostatic, hydrophobic) and between protein subunits (electrostatic, hydrophilic)

→ results in the formation of protein aggregates that additionally contribute to structure reinforcement

VEGANE WURST
ENTWICKLUNG DER VEGANEN FETTKOMPONENTE

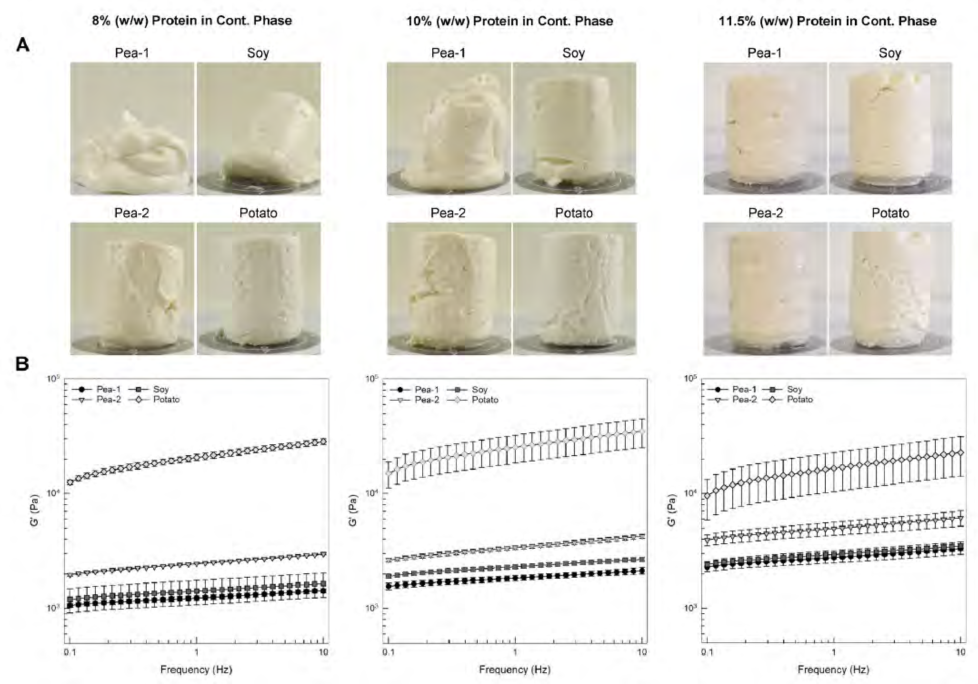
Journal of Food Measurement and Characterization
https://doi.org/10.1007/s11694-020-00767-9

ORIGINAL PAPER

Analysis of protein-network formation of different vegetable proteins during emulsification to produce solid fat substitutes

Marie-Christin Baune[1] · Sarah Schroeder[1] · Franziska Witte[1] · Volker Heinz[1] · Ute Bindrich[1] · Jochen Weiss[2] · Nino Terjung[1]

Emulsion gel appearance and molecular firmness



Protein denaturation behaviour as function of temperature

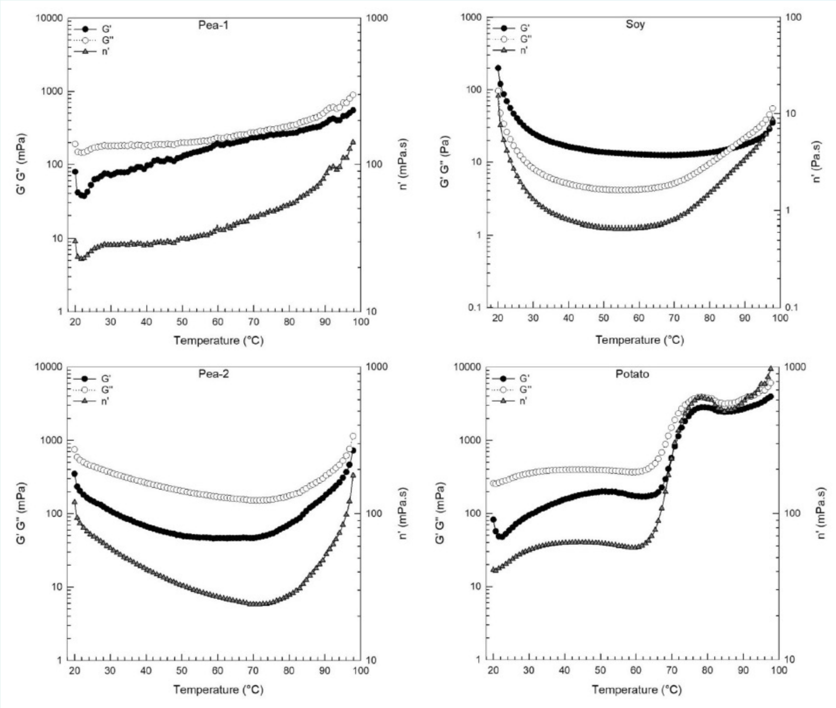


Table 2 Interfacial tension of the plant proteins

Heating Tempera-ture (°C)	Interfacial Tension (mN/m)			
	Pea-1	Pea-2	Soy	Potato
65	28.8 ± 0.9	36.3 ± 1.1	33.1 ± 5.3	29.1 ± 1.9[1]
72	30.3 ± 1.1[w]	36.9 ± 2.8[x,y]	29.8 ± 3.2[x,z]	24.1 ± 1.7[1,w,y,z]

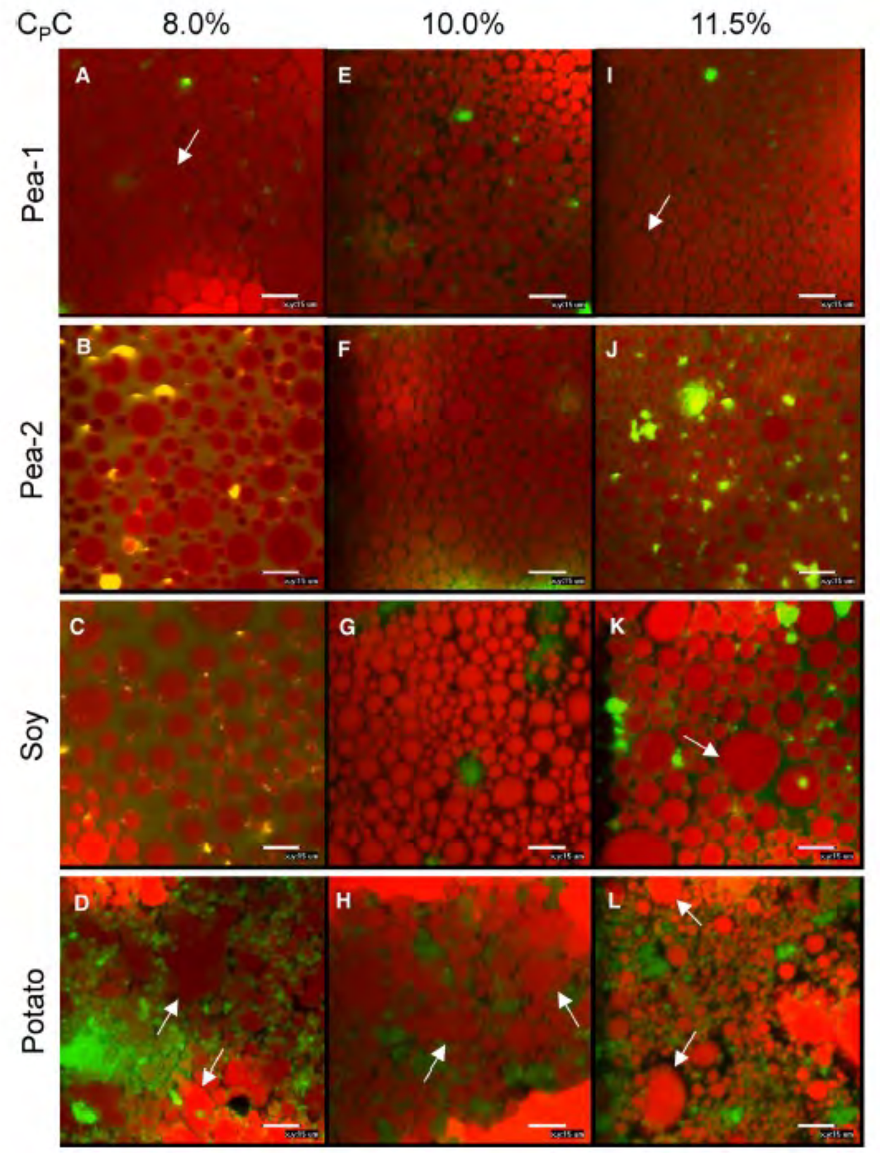
Higher G' value: more cross-linking due to protein denaturation and interaction of subunits

Potato strongly denatures at 60-70°C → emulsion-filled protein gel formation

Potato shows the lowest interfacial tension → indicates good emulsification behaviour

VEGANE WURST

ENTWICKLUNG DER VEGANEN FETTKOMPONENTE



Potato emulsions
1) strong coalescence = instable 2) protein network 3) low surface charge density 4) high extractable fat content

Table 3 Droplet surface area and calculated surface charge density

	SSA (m^2/g)	φ(0 mL) (mV)	V(0 mV) (mL/g)	σ (mC/m^2)
Pea-1	$1.337 \pm 0.058^{1,2}$	$-1314.74 \pm 87.42^{1,2,}$	2.74 ± 0.17^{1}	$197.73 \pm 20.67^{1,2}$
Pea-2	$1.547 \pm 0.127^{3,4}$	$-1634.25 \pm 56.76^{1,3}$	$2.78 \pm 0.09^{2,3}$	$173.39 \pm 20.02^{3,4}$
Soy	$0.501 \pm 0.103^{1,3,5}$	-1655.50 ± 467.37^{4}	$2.36 \pm 0.32^{2,4}$	$453.54 \pm 154.50^{1,3,5}$
Potato	$0.906 \pm 0.114^{2,4,5}$	$560.50 \pm 132.32^{2,3,4}$	$0.93 \pm 0.04^{1,3,4}$	$98.51 \pm 17.12^{2,4,5}$

Listed are the specific surface area (SSA) of the creamed emulsion droplets in m^2/g, the initial charge φ(0 mL) in deionized water (0.1 g/10 g) in mV and respective electrolyte volumes added up to the inflection point V(0 mV) in mL/g cream, as well as the calculated surface charge density σ in mC/m^2. Emulsions were prepared with C_PC of 10.0% (w/w) and oil mass fraction of 70%

For SSA means ± standard deviation were determined by triplicate analysis. For *φ(0 mL) and V(0 mV)* means ± standard deviation were determined by quadruplicate analysis. σ ± Δσ was calculated using Eqs. 5 and 6. Different superscripts within one parameter indicate significant differences between proteins ($P < 0.05$)

Table 4 Extractable fat content of emulsions

C_PC (%)	EFA (g/100 g fat)			
	Pea-1	Pea-2	Soy	Potato
8.0	$1.37 \pm 0.33^{v,w}$	$0.47 \pm 0.15^{x,y}$	$4.64 \pm 1.65^{v,x,z}$	$19.44 \pm 8.00^{1,2,w,y,z}$
10.0	$2.01 \pm 0.40^{v,w}$	$0.29 \pm 0.06^{x,y}$	$6.35 \pm 0.80^{v,x,z}$	$24.69 \pm 2.35^{1,3,w,y,z}$
11.5	$1.87 \pm 0.46^{v,w}$	$0.56 \pm 0.16^{x,y}$	$5.62 \pm 2.79^{v,x,z}$	$34.36 \pm 2.53^{2,3,w,y,z}$

Listed is the extractable fat amount (EFA) of the emulsions in g/100 g fat in dependence of the protein type, and C_PC (8.0, 10.0, 11.5% (w/w)). Emulsions were prepared with oil mass fraction of 70%

Means ± standard deviation were determined by nine single values. Different superscripts indicate significant differences ($P < 0.05$): [1,2,3] within the same protein at different concentrations, and [v–z] between different proteins at the same concentration

VEGANE BRÜHWURST
HERSTELLUNG EINER VEGANEN WURST

70 %

ZERKLEINERUNG VON 80 % **SOJA-EXTRUDAT** MIT WASSER (20 %)

+

30 %

ZUGABE DES „FERTIGEN“ **EMULSIONSGELS**
(70 % ÖL + 30 % SUSPENSION MIT 11,5 % ERBSEN- ODER SOJAPROTEINISOLAT)

↓

HOMOGENISIERUNG

↓

ABFÜLLUNG

↓

ERHITZUNG AUF 72 BZW. 85 °C

Proteingehalt

Im Nassextrudat:	21,0 %
Im Extrudatgel:	16,8 %
70 % in der Wurst:	**11,8 %**
In der Suspension:	11,5 %
In der Emulsion:	3,45 %
30 % in der Wurst:	**1,04 %**
Gesamt	**12,8 %**

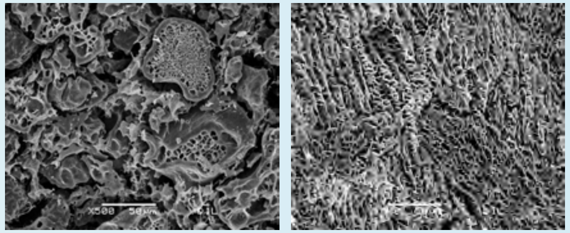
VEGANE BRÜHWURST

KOMBINATION VON PULVER- UND EXTRUDAT

Pulver- + Extrudatgelen → Stabilität ↑ Mischung mit weiteren Rohstoffen

Erbse

Kürbis



Pulver- + Extrudatgel (Erbse)

Rezeptur:

36 % Proteingel (50 % Extrudat (ca. 25 % TM)

+ 50 % Pulvergel, darin 50 % TM

40 % Weizen-Pulvergel (1:1)

20 % Emulsionsgel

4 % Erbsenfaser

1 % Salz

90 °C

Keine Elastizität

Proteingel:
100 % Pulvergel

Proteingel:
100 % Extrudatgel

VEGANE BRÜHWURST
TEST ANDERER FETTE

- Einarbeitung Öl
  - →Keine Einbindung → keine Verbesserung
- Einarbeitung Festfett (Salfett)
  - →Bei 7 °C feste, eher plastische Gele
  - →Separation des Fettes
- Bindung Fett/Öl über Fasern
  - →Keine Verbesserung

Es wird auf den Einsatz von Emulsionsgel, Fett oder Öl verzichtet.

Die Kombination im Proteingel reicht für elastische Gele nicht aus.

- Weizengluten = Elastizität ↑, aber „brot“-ähnlich, Allergen und viel verwendet
- Fasern = Festigkeit ↑, aber vergleichbar mit Proteinpulver

VEGANE BRÜHWURST
POLYSACCHARIDE

Elastizität durch Polysaccharide? ≠ Forschungshypothese (Schwächung des Proteinnetzwerkes)

Stärke = Festigkeit ↑, teilweise Verbindung, teilweise Separation; plastisch (+ E-Nummer)

Sehr stark wasserbindende Mehle
- →stabiles, verformbares Netzwerk
- →Festigkeit + Elastizität ↑
  - -Leinsamenmehl
  - -Flohsamenschalen

➔ Untersuchungen zum Verhältnis Leinsamenmehl zu Flohsamenschalen (1:1, 1:2, 1:3, 1:4, etc.)
- ➔ größer 1:3 nötig
- ➔ Maximal 16 % total

6 % Leinsamenmehl

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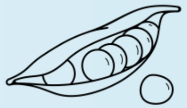
HERSTELLUNG DER WURSTMASSE

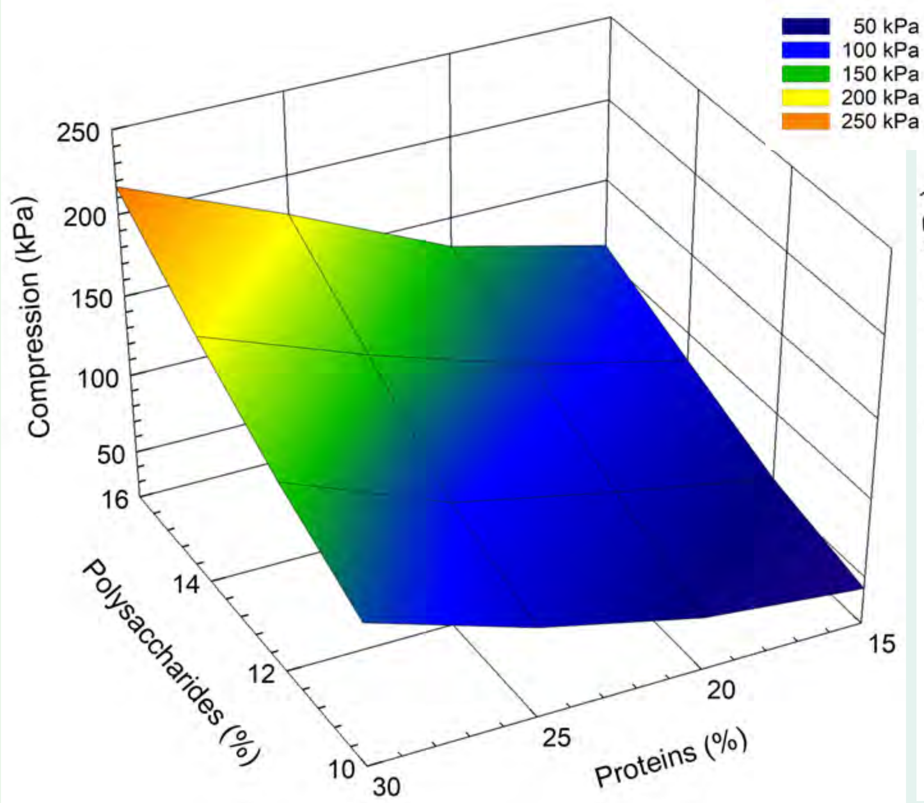


1. Zerkleinertes Nassextrudat (50 % des Proteingels)
2. Vermengen der Trockenstoffe
    - Erbsenproteinpulver: 50 % des Proteingels; insgesamt: 15, 20, 25, 30 %
    - Flohsamenschalen: 6, 8, 10, 12, 14 %
    - Leinsamenmehl: 2 und/oder 4 %
3. Salz (1 %) wird in nötiger Menge Wasser gelöst
4. Zugabe von Trockenstoffen + Salz-Wasser in Küchenmaschine → Vermengen → Abfüllen
5. Erhitzen auf 90 °C Kerntemperatur für 15 Min
6. Durchkühlen über Nacht
7. Untersuchungen:

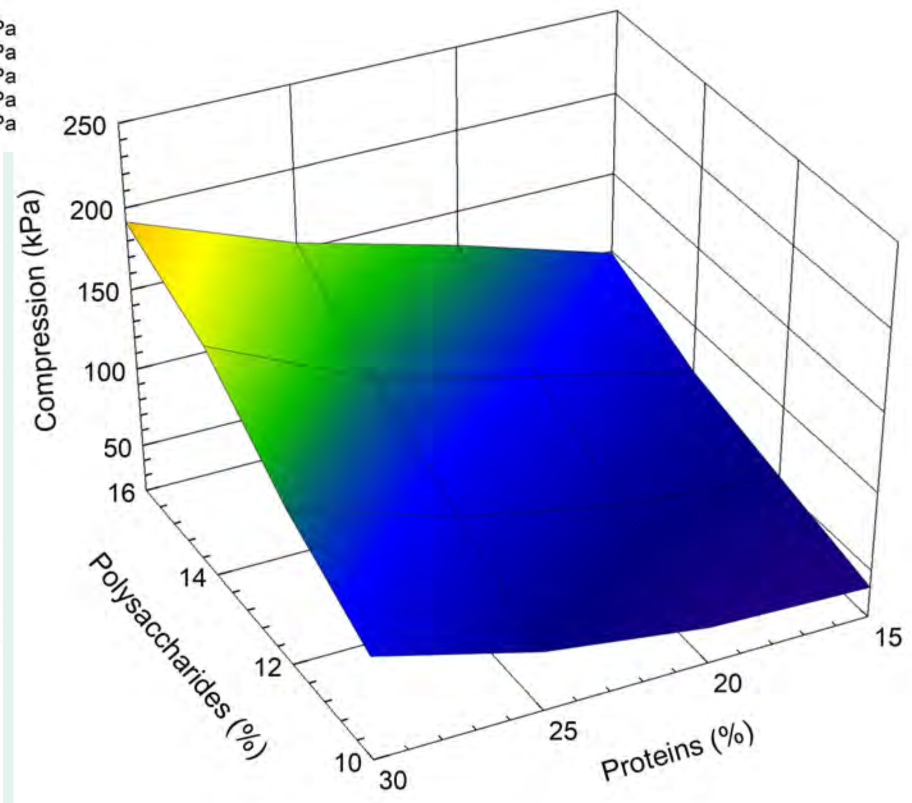
Kompression | Schnittfestigkeit | Klebrigkeit | Elastizität

VEGANE BRÜHWURST
KOMPRESSIONSANALYSE

2 % Leinsamenmehl



4 % Leinsamenmehl



Protein ↑ = Widerstand/Gegendruck ↑

Flohsamen ↑ = Widerstand ↑

Widerstand bei 2 % Leinsamen > 4 %

→ Flohsamen bewirken mehr Widerstand als Leinsamen

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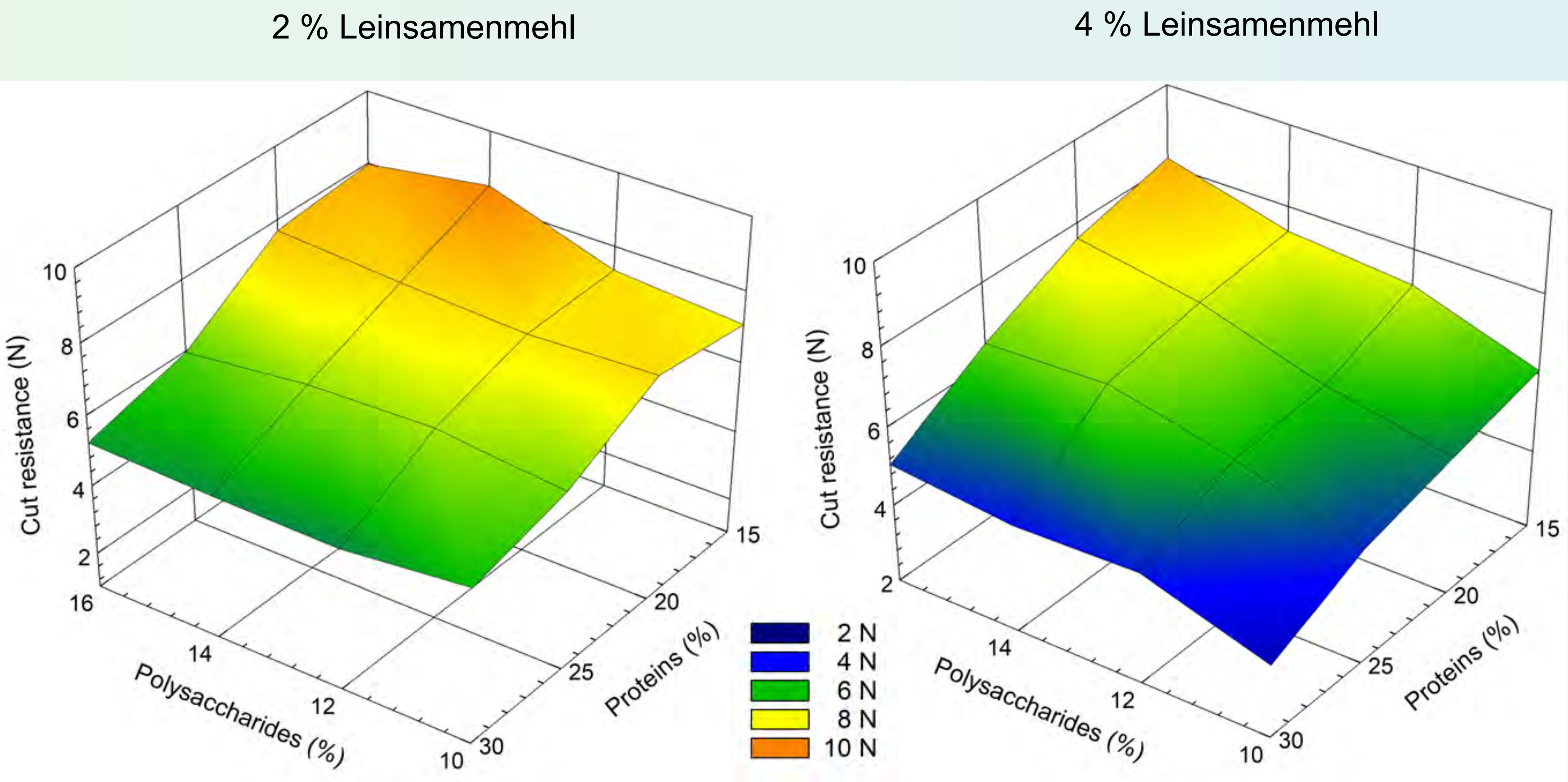
SCHNITTFESTIGKEITSANALYSE



Protein ↑ = Widerstand gegen Klinge ↓

Flohsamen ↑ = Widerstand ≈↑

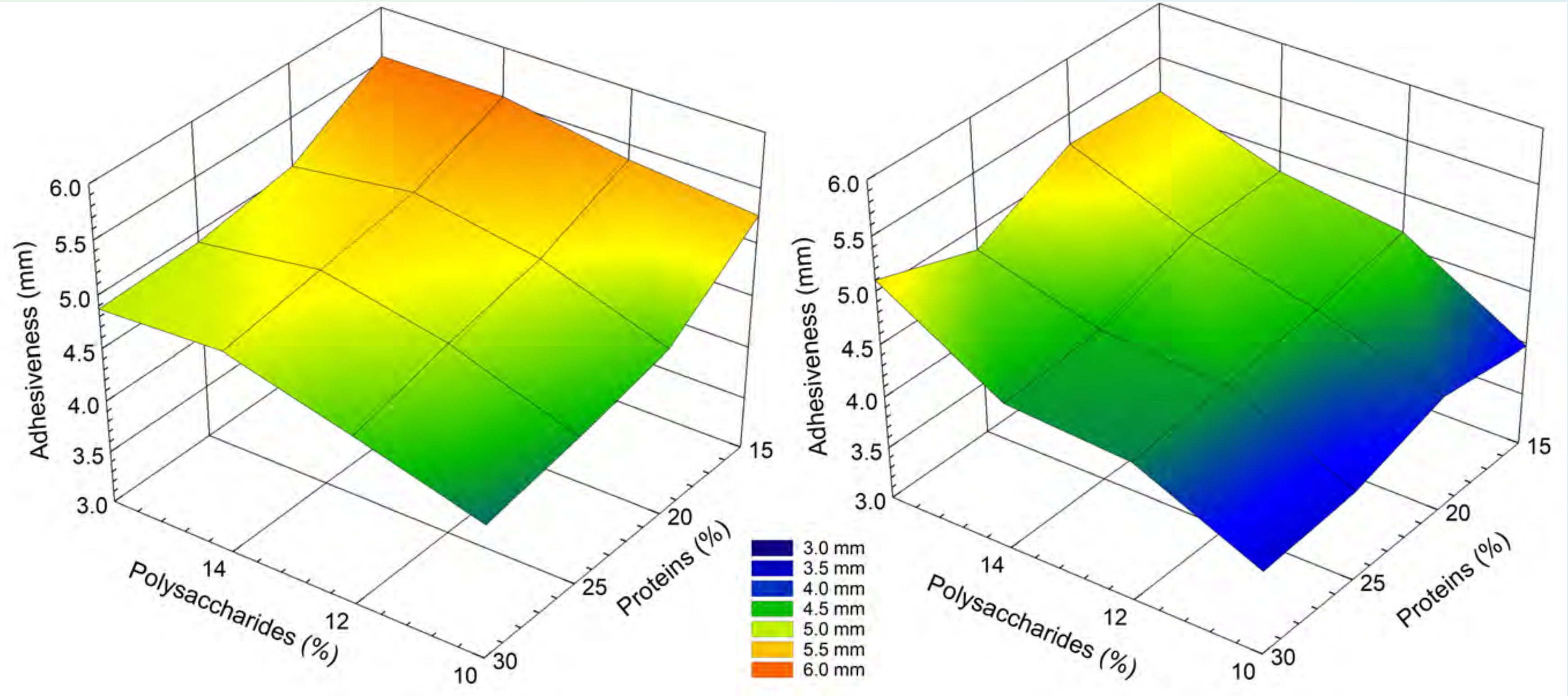
Widerstand bei 2 % Leinsamen > 4 %

→ Flohsamen bewirken mehr Widerstand als Leinsamen

VEGANE BRÜHWURST
ELASTIZITÄTSANALYSE

2 % Leinsamenmehl

4 % Leinsamenmehl



Protein ↑ = Elastizität ≈↓

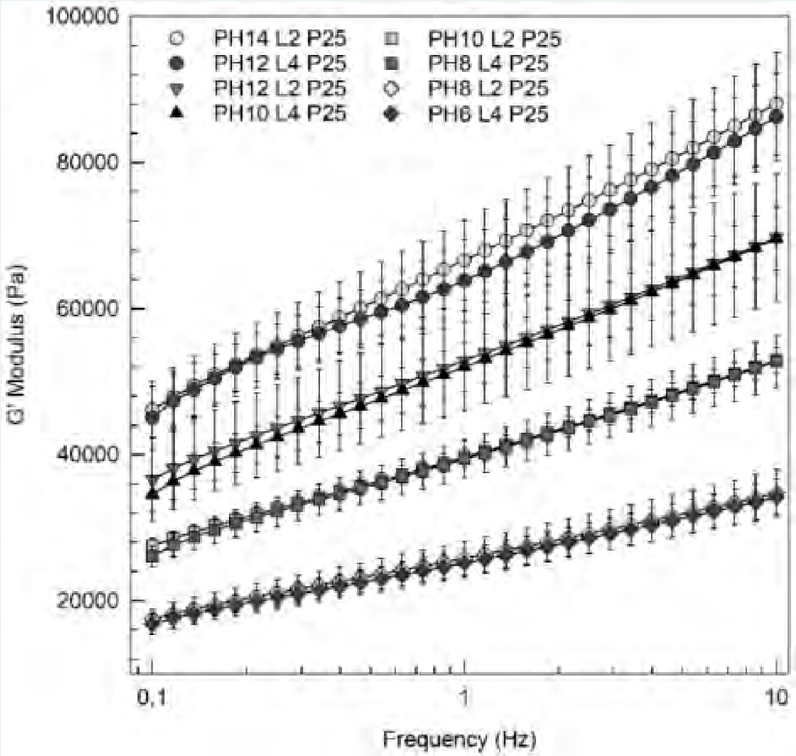
Flohsamen ↑ = Elastizität ≈↑

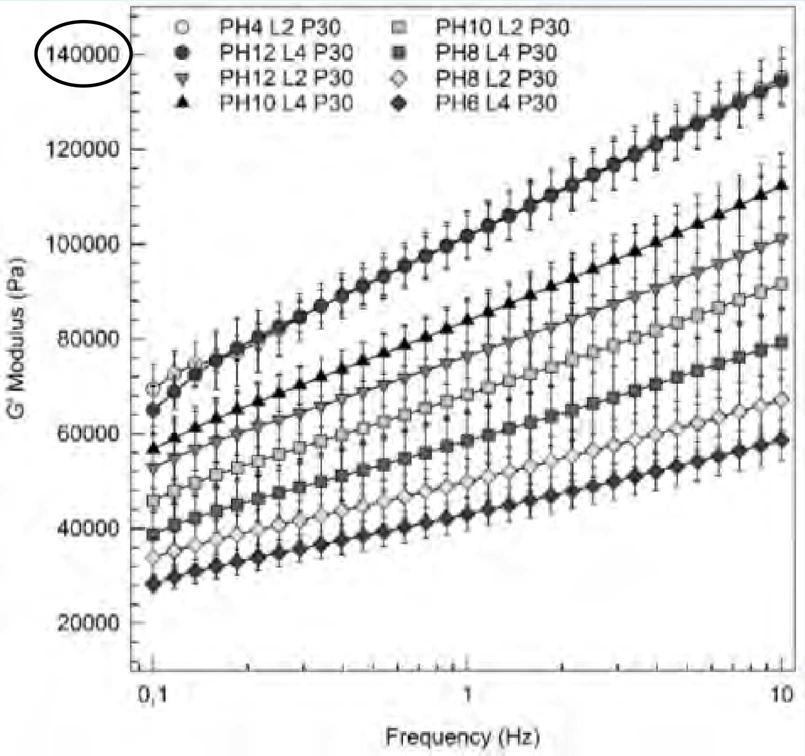
Elastizität bei 2 % Leinsamen > 4 %

→ Flohsamen bewirken mehr Elastizität als Leinsamen

VEGANE BRÜHWURST

ELASTIZITÄTSANALYSE





Protein ↑ = Elastizität ↑

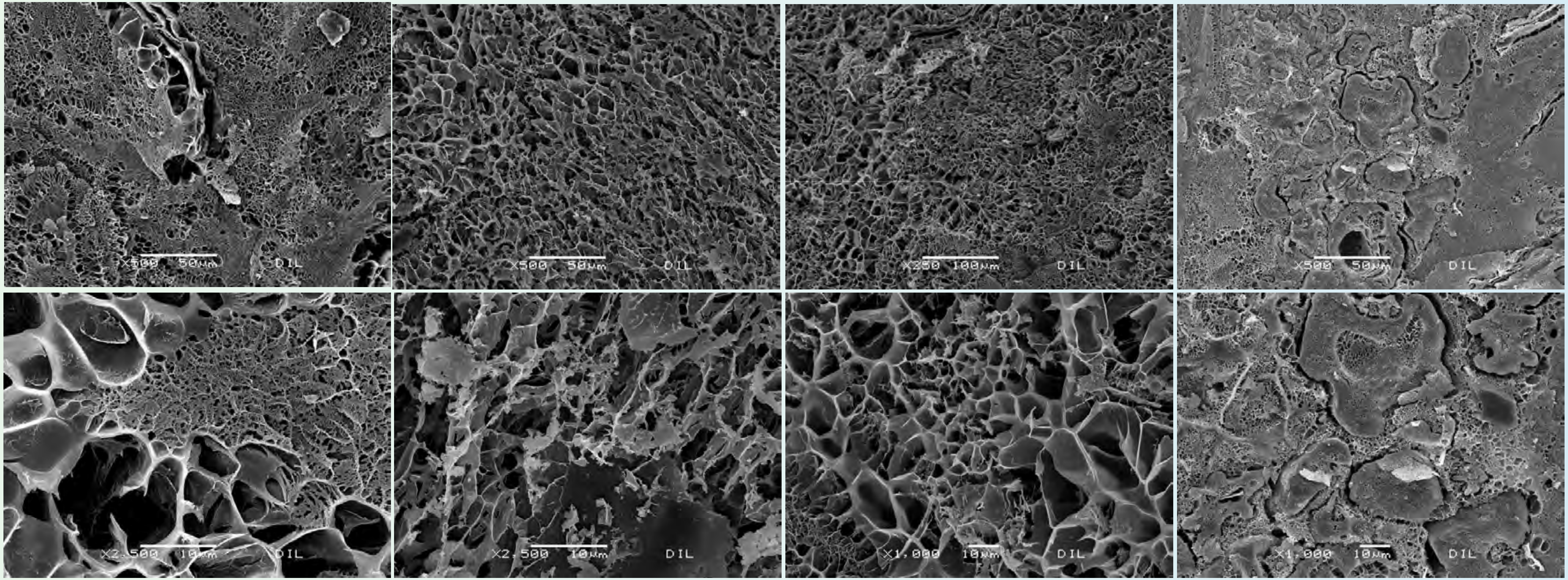
Flohsamen ↑ = Elastizität ≈↑

Elastizität bei 4 % Leinsamen > 2 %

→ Flohsamen bewirken mehr Elastizität als Leinsamen

VEGANE BRÜHWURST
UNTERSCHIEDE DER NETZWERKE

Flohsamenschalen (10 %)	Leinsamenmehl (10 %)	8 % Flohsamen + 4 % Leinsamen	+ 30 % Protein + 1 % Salz



heterogenes Netzwerk	homogenes Netzwerk	gemischtes Netzwerk	
Sehr feine, dünne + sehr grobe, dicke Maschen	Sehr feine regelmäßige Maschen Teilweise unverknüpft	Feine, dünne + grobe, dicke Maschen	Vernetzung über → Protein (runde Strukturen) → Feine Maschen (Floh) → Gröbere Maschen (Lein)

VEGANE BRÜHWURST
SCHLUSSFOLGERUNGEN

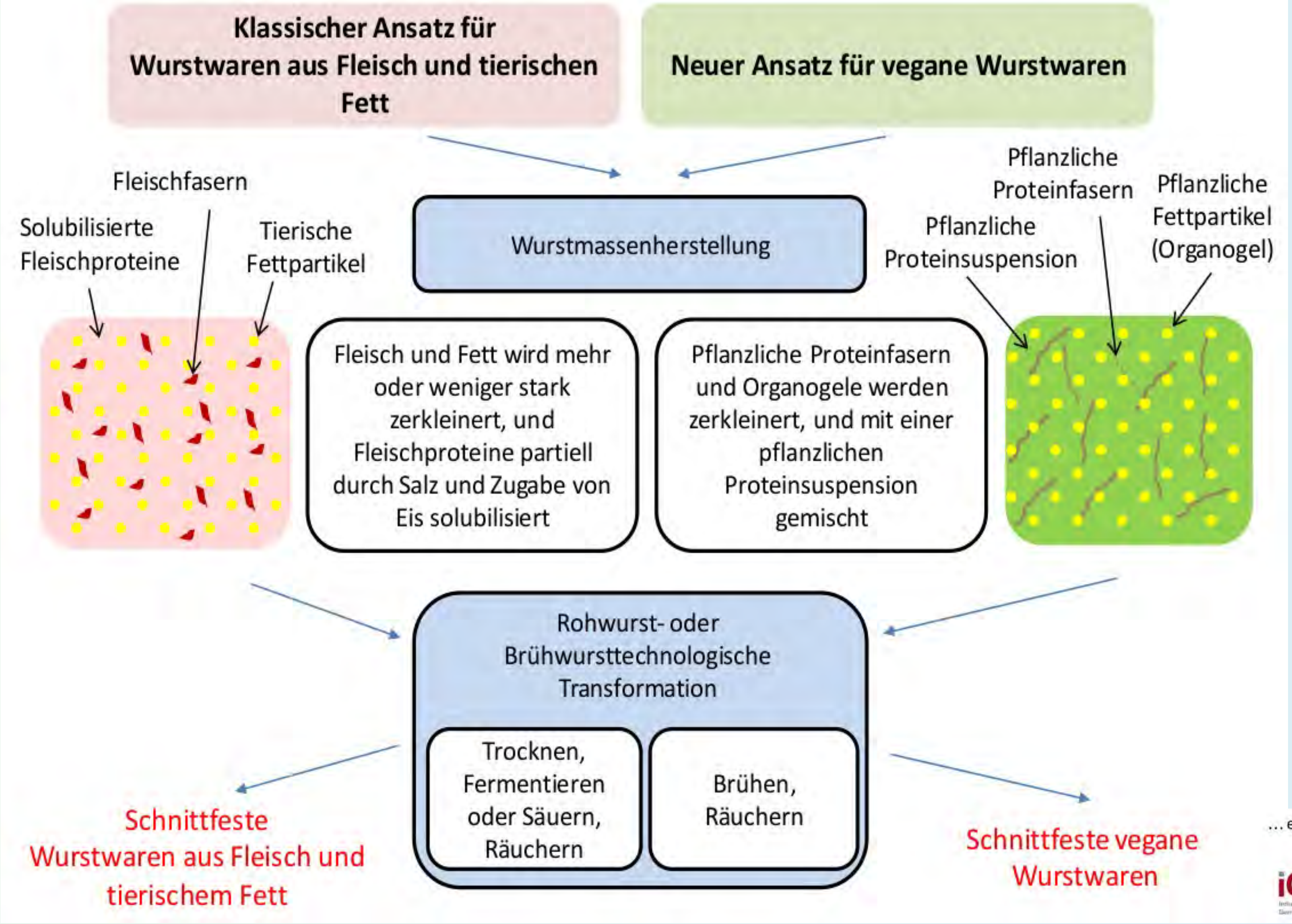
Nötig für vegane brühwurst-ähnliche Massen

- Erhitzung > 90 °C für > 50 Min
- Salzzugabe < herkömmlicher Brühwurst, ca. 1 %
- pH-Einstellung abhängig vom Proteinpräparat und dessen isoelektrischen Punkt
- Mischung aus Pulver und zerkleinertem Extrudat
- Netzwerkausbildung mit Protein und Polysacchariden empfehlenswert
- Emulgierung von Öl/Fett „schwierig“ → nötig?

Mögliche Modifikationen

- Lyoner und Wiener Art
- Färbung
- Aromatisierung

VEGANE WURST
GRUNDLEGENDE IDEE



… ein Projekt der *Industriellen Gemeinschaftsforschung (IGF)*

gefördert durch/via

Thank you for your attention

… ein Projekt der **Industriellen Gemeinschaftsforschung (IGF)**

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

AiF Forschungsnetzwerk Mittelstand

FEI FORSCHUNGSKREIS DER ERNÄHRUNGSINDUSTRIE E.V.

iGF Industrielle Gemeinschaftsforschung

Das o. g. IGF-Vorhaben der Forschungsvereinigung Forschungskreis der Ernährungsindustrie e. V. (FEI), Godesberger Allee 125, 53175 Bonn, wird/wurde über die AiF im Rahmen des Programms zur Förderung der Industriellen Gemeinschaftsforschung (IGF) vom Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages gefördert.

DIL

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