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IAOM Meeting – Nairobi, 2018

New methods for raw material characterization

29TH ANNUAL IAOM MIDEAST & AFRICA CONFERENCE & EXPO

Food Division │ Food Application Lab │ Alexandra Petz , Jessica Wiertz, Ulrike Ito

…where quality is measured.

New methods for raw material characterization
Agenda

- Company profile
- Current food trends
- New methods

Company profile

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Brabender® GmbH & Co. KG
Part of the Brabender® Group

Brabender® GmbH & Co. KG
(1923)

OOO Brabender®
(2015)

C.W. Brabender® Instruments Inc.
(1955)

Brabender Messtechnik® GmbH & Co. KG
(1961)

Brabender Technologie KG
(1957)

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Brabender® GmbH & Co. KG
Facts and figures

3 companies headquartered in Duisburg (Germany)

100 % family-owned

6 subsidiaries abroad

450 employees

98 international sales agents

80-85 % export

Present in 129 countries.
Steadily growing.

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Brabender® GmbH & Co. KG
Portfolio

- Laboratory mills for sample preparation
- Instruments for grain reception tests (e. g. moisture testing)
- Instruments for flour quality tests
- Rheological equipment for dough quality testing
- Starch quality testing instruments
- Laboratory extruders

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Brabender® GmbH & Co. KG
Facilities

- Food Rheology Application Lab
- Food Extrusion Lab
- Bakery Lab

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Current food trends

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Current Food Trends
Market trends & customer requirements

Nutritional trends / technologies

- Gluten-free
- Low-carb
- Alternative protein sources
- Vegan food
- Ancient grains
- Whole meal products
- Superfood
- Algae
- Insects
- 3d-printed food

Customer wishes

- Automatisation
- Quick methods
- Cost savings
- Independence from operator

Conditions

- Legislation on fertilisation
- Hygienic requirements

New methods

…where quality is measured.

Co. KG, 30.10.2018

New methods
Analysis of gluten-free raw materials

- Raw materials: corn flour, rice flour, flour made from pulses, etc.
- Initial situation: gluten-free raw materials cause doughs with non-elastic behaviour
- Solution: Farinograph-TS + Farino-Add S30

  Adaption of standard methods

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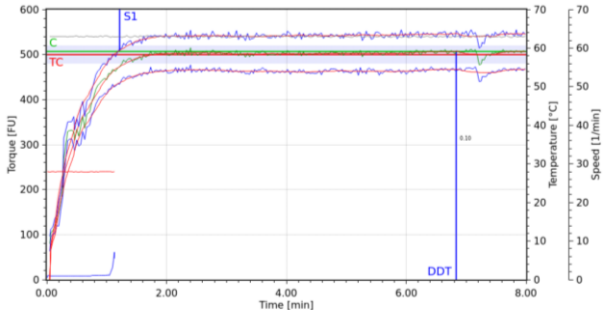
New methods
Analysis of gluten-free raw materials

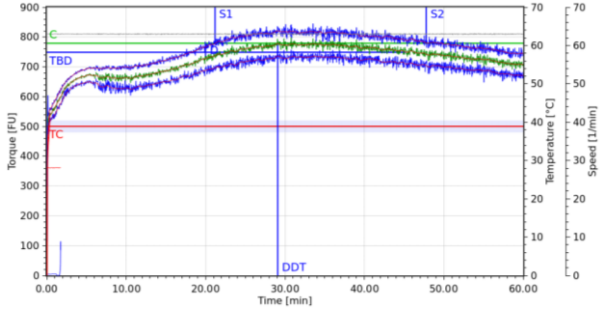
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

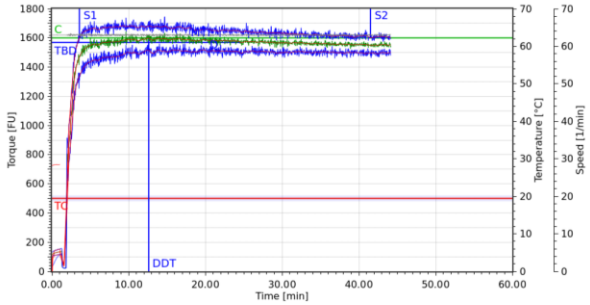
Wheat

Buckwheat

Soy







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New methods
Analysis of gluten-free raw materials

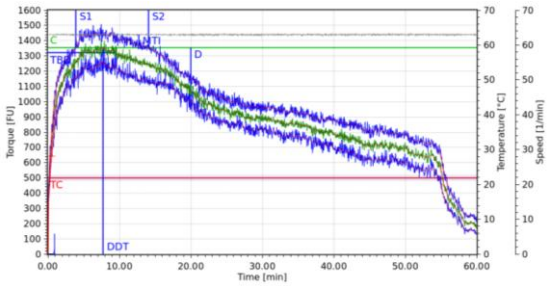
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

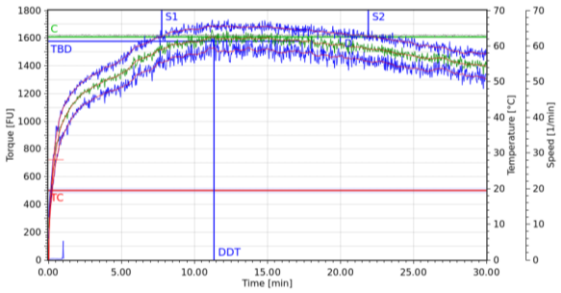
Gluten-free

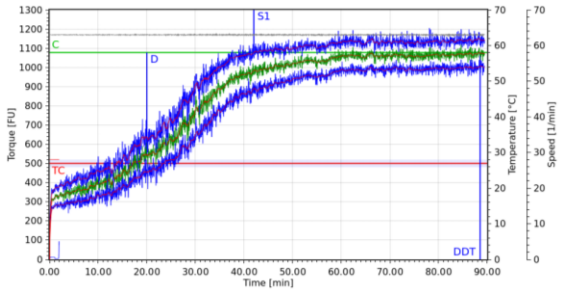
Rice

Brown rice

Corn







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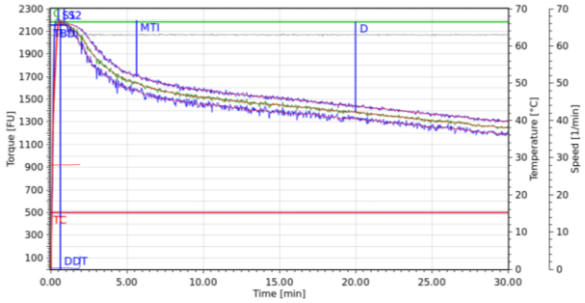
New methods
Analysis of gluten-free raw materials

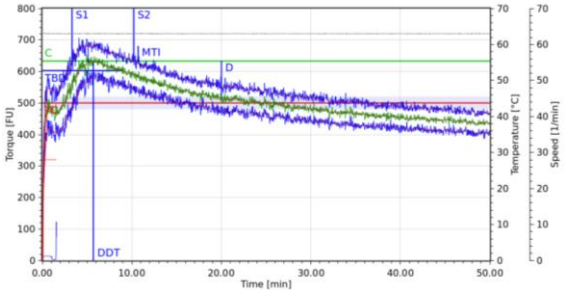
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

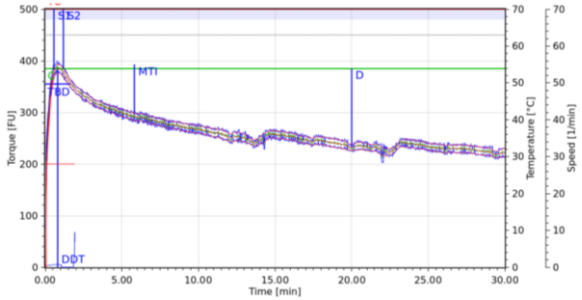
Quinoa

Sorghum

Chickpea







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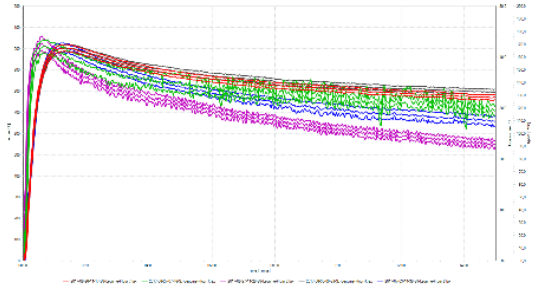
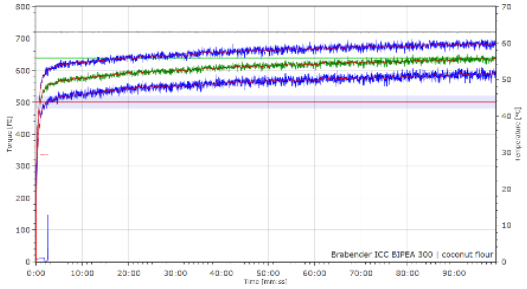
New methods
Analysis of gluten-free raw materials

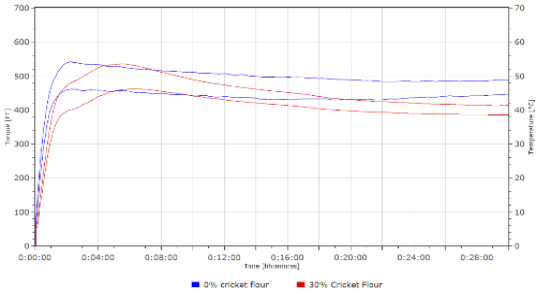
Red lentil

Coconut

Cricket







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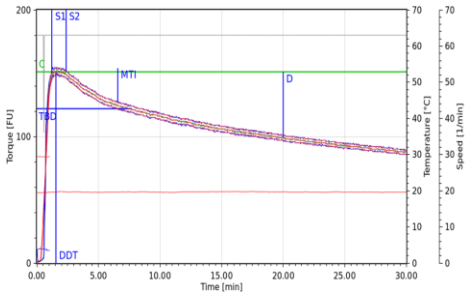
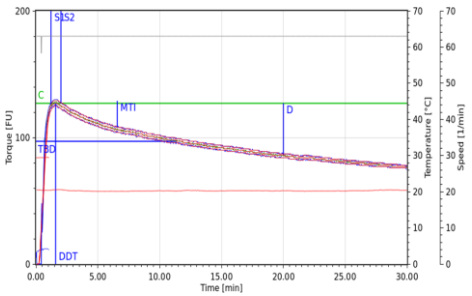
New methods

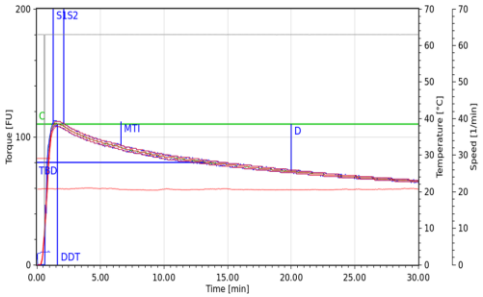
Analysis of gluten-free raw materials

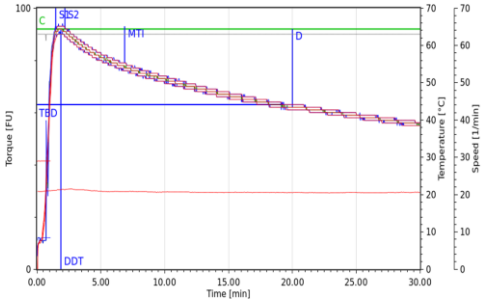
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Corn flour + 2% HPMC









100	105	110	115
Consistency: 151 FU	Consistency: 127 FU	Consistency: 110 FU	Consistency: 92 FU
Stability: 70.2 s	Stability: 48 s	Stability: 49.8 s	Stability: 43.2 s
Drop-off: 52 FU	Drop-off: 41 FU	Drop-off: 37 FU	Drop-off: 30 FU

New methods
Brabender GlutoPeak

- Raw materials: wheat flour, whole wheat flour, dried gluten
- Initial situation: requirements for quick methods at raw material receiption
- Solution: GlutoPeak

  Adaption of standard methods

Method	
Amount of sample	9 g
Amount of liquid (dest. water)	9 g
Temperature	36 °C
Speed	2.750 rpm
Time	5 min

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New methods
Brabender GlutoPeak

Principle:

- Rheologic measurement
- High-speed-mixing
- Torque measurement
- Gluten aggregation

Target group:

- Grain breeders & traders
- Mills and bakeries
- Starch producers
- Research institutes

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New methods
Brabender GlutoPeak

Which advantages does the GlutoPeak provide?

- Time saving due to quick methods
- Quick raw material control at grain or flour receiption
- Limited dependence from operator due to easy handling
- Cost saving due to quick decisions regarding quality
- Easier silo management

Brabender GlutoPeak
successfully used by our reference customers

wiesneth mühle gmbh

KRÖNER STÄRKE
... die ganze Stärke der Natur!

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New methods
Analysis of dried vital gluten

- Project: **Development of a method to analyze dried vital gluten quality**
- Target: Being able to differenciate among qualities at raw material receiption

  Having a measurement system independent from the operator
- Institution(s): Brabender, ttz Bremerhaven, CSM Deutschland GmbH, Blattmann Schweiz AG
- Result: RGC – Rapid Gluten Check*

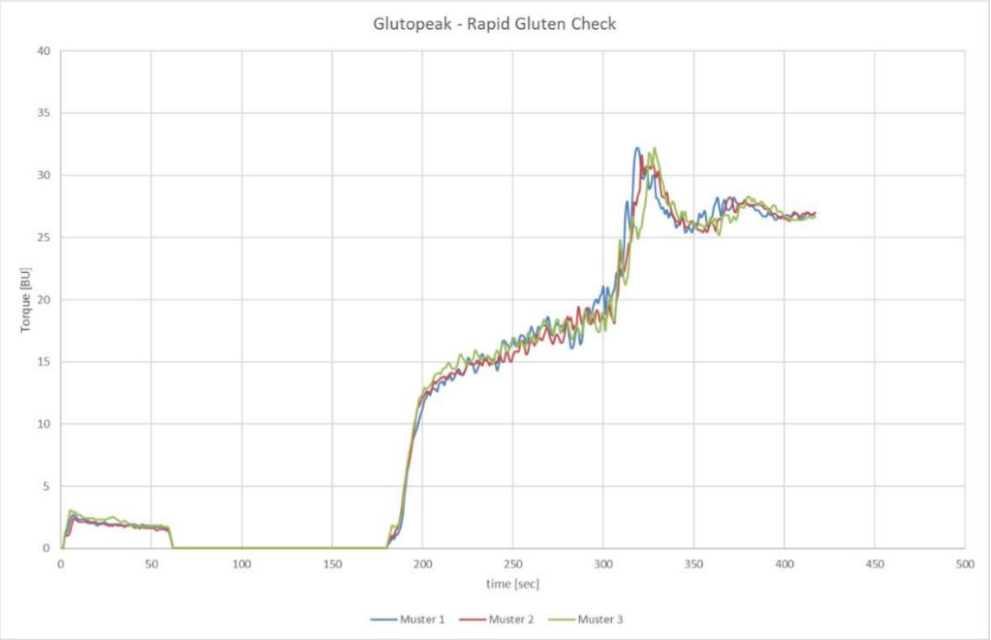
Das Gluten-Netzwerk

csm | ttz Bremerhaven | Brabender … where quality is measured. | Blattmann Schweiz AG

*Gall, S. et. al. (2018)

New methods
Analysis of dried vital gluten

Method*	
Amount of sample (dried gluten)	2,1 g
Amount of liquid (dest. water)	4,4 g
Temperature	36 °C
Speed	500 rpm (1min) 0 rpm (2 min) 3.300 rpm (10 min)
Time	13 min



*Gall, S. et. al. (2018)

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New methods
Analysis of dried vital gluten

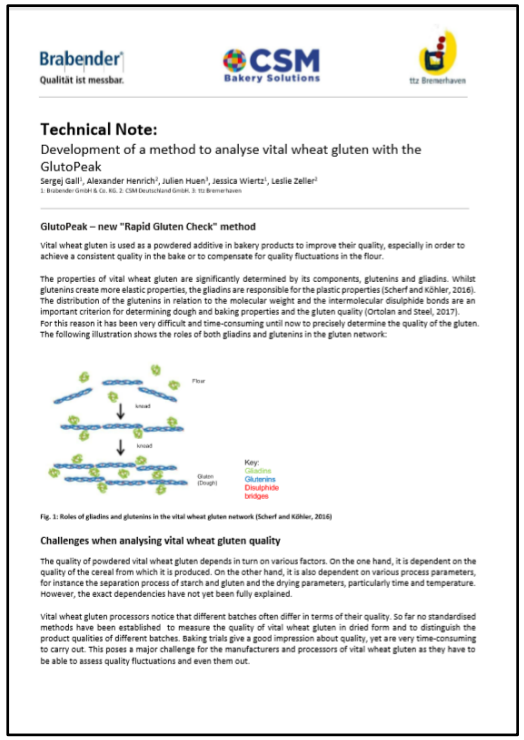
Target groups:

- Gluten producers
- Starch producers
- Gluten processors (bakery ingredients, baking mixtures, meat analouge producers)

Application:

- Raw material quality check
- Final product check
- Process control during starch/gluten manufacturing
- Proof of heat damage

Technical Note:*



Brabender® Qualität ist messbar. CSM Bakery Solutions ttz Bremerhaven

Technical Note:
Development of a method to analyse vital wheat gluten with the GlutoPeak

Sergej Gall[1], Alexander Henrich[2], Julien Huen[3], Jessica Wiertz[1], Leslie Zeller[2]
1: Brabender GmbH & Co. KG, 2: CSM Deutschland GmbH, 3: ttz Bremerhaven

GlutoPeak – new "Rapid Gluten Check" method

Vital wheat gluten is used as a powdered additive in bakery products to improve their quality, especially in order to achieve a consistent quality in the bake or to compensate for quality fluctuations in the flour.

The properties of vital wheat gluten are significantly determined by its components, glutenins and gliadins. Whilst glutenins create more elastic properties, the gliadins are responsible for the plastic properties (Scherf and Köhler, 2016). The distribution of the glutenins in relation to the molecular weight and the intermolecular disulphide bonds are an important criterion for determining dough and baking properties and the gluten quality (Ortolan and Steel, 2017).
For this reason it has been very difficult and time-consuming until now to precisely determine the quality of the gluten. The following illustration shows the roles of both gliadins and glutenins in the gluten network:

Fig. 1: Roles of gliadins and glutenins in the vital wheat gluten network (Scherf and Köhler, 2016)

Challenges when analysing vital wheat gluten quality

The quality of powdered vital wheat gluten depends in turn on various factors. On the one hand, it is dependent on the quality of the cereal from which it is produced. On the other hand, it is also dependent on various process parameters, for instance the separation process of starch and gluten and the drying parameters, particularly time and temperature. However, the exact dependencies have not yet been fully explained.

Vital wheat gluten processors notice that different batches often differ in terms of their quality. So far no standardised methods have been established to measure the quality of vital wheat gluten in dried form and to distinguish the product qualities of different batches. Baking trials give a good impression about quality, yet are very time-consuming to carry out. This poses a major challenge for the manufacturers and processors of vital wheat gluten as they have to be able to assess quality fluctuations and even them out.

*Gall, S. et. al. (2018)

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New methods
Analysis of whole wheat flours

- Project: **Development of a method to analyze whole wheat flour**
- Target: Having a quick method with saving time producing refined flour
- Institution(s): CWB, Wheat Marketing Centre, University of Minnesota, Washington State University, Anhui Agricultural University
- Result: Whole wheat method*

*Wang et. al. (2018)

…where quality is measured.

New methods
Analysis of whole wheat flours

Method	
Amount of sample (whole wheat flour)	8,0 g
Amount of liquid ($CaCl_2$ solution, concentration: 55,49 g/l)	10,0 g
Temperature	20 °C
Speed	3.000 rpm

paper:*

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GlutoPeak method improvement for gluten aggregation measurement of whole wheat flour

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ARTICLE INFO

Keywords:
Whole wheat flour
GlutoPeak
Flour particle size
Gluten aggregation
Dough rheology

ABSTRACT

A shear-based device, the GlutoPeak, was developed to measure the aggregation behavior of gluten. In this study, the GlutoPeak testing method was improved and applied for the gluten aggregation evaluation of whole wheat flour (WWF) of different particle size ranges. The sample/solvent weight ratio, mixing speed, and testing temperature were adjusted to different levels for obtaining more repeatable Peak Maximum Time (PMT) and Maximum Torque (MT) using two commercial WWF samples. The temperature had a greater effect on the repeatability of the PMT, while the sample/solvent weight ratio and mixing speed had lower impact on the repeatability of both PMT and MT. Another four commercial wheat samples were milled to WWFs of different particle size ranges. The gluten aggregation of the WWF was measured using the improved GlutoPeak parameters, which were 8 g WWF and 10 g 0.5 mol/L $CaCl_2$ solvent with a mixing speed of 3000 rpm and test temperature of 20 °C. The PMT significantly decreased (with the exception of SW) and MT significantly increased with a decrease of WWF particle size. Compared to the Mixolab and Farinograph tests, the GlutoPeak method took less time and provided significantly different ($p < 0.05$) results for WWFs of different particle size ranges.

1. Introduction

Whole wheat flour (WWF) is milled from the whole grain kernel that contains bran, germ, and endosperm, thus, it provides a highly nutritious and inexpensive source of protein, carbohydrates, dietary fiber, and various minerals. Considerable scientific research has confirmed the positive effects of WWF products intake on human health (Liu, 2007; Okarter & Liu, 2010). United States Department of Agriculture (USDA) recommends that Americans should consume at least half of their grains as whole grains (USDA, 2015), and outlines the whole grain-rich criteria for national school meals (USDA, 2016). Along with the increasing health awareness of consumers and recommendations of scientists, a large market demand for various WWF-based products is expected in the near future (USDA, 2015; Zong, Gao, Hu, & Sun, 2016).

One of the major challenges of WWF application is the influence of wheat bran, which results in changes in dough rheological properties, and further affects the qualities of food products (Cai, Choi, Hyun, Jeong, & Baik, 2014; Niu, Hou, Lee, & Chen, 2014; Sieglich, Bernin, Moldin, Topgaard, & Langton, 2015; Wang, Hou, Kweon, & Lee, 2016). Many studies have been conducted to reduce the influence of bran in products by adding vital wheat gluten, enzymes, and adjusting the particle size of bran (Katina, Salmenkallio-Marttila, Partanen, Forssell, & Autio, 2006; Pomeranz, Collar, & Huron, 2008). Compared to other methods, adjusting the particle size of bran is more natural and cost effective.

Several rheological instruments, such as the Mixograph, Mixolab and Farinograph, have been developed and applied to dough systems (Huang et al., 2010; Kokini, Kalopanos, Sastad, Osay, & Dubat, 2009; Mantey & Schoen, 2002; Vinitin & Dunchin, 2011). However, it is difficult for those instruments to detect meaningful differences in dough rheological properties for WWFs of different bran particle size ranges. Previous studies reported no significant effects of bran particle size regarding water absorption in the Farinograph (Noort, van Hunter, Hemery, Schols, & Hamer, 2010; Zhang & Moore, 1997), and dough development time in Mixograph (Cai et al., 2014) and Mixolab (Liu, Hou, Lee, Marquart, & Dubat, 2016) of WWFs.

Recently, a new technique has been investigated as a more efficient and rapid predictor of wheat flour functional quality (Chandi & Seetharaman, 2012; Marti, Cecchini, D'Egidio, Desiderio, & Pagani, 2014; Mehyar, Dreisoerner, Bonomi, Morcone, & Seetharaman, 2011).

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Effect of particle size:

- Particle size has got a significant effect on the analysis
- The method is more efficient when the particle size of the bran is smaller

*Wang et. al. (2018)

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New methods
Analysis of ancient grains

- Project: **Development of a method to analyze flour of ancient grains such as Einkorn, Emmer and Spelt**
- Target: Differenciation among standard wheat flours and ancient grain flours
- Institution(s): Leibniz-Institute for Food Systems Biology at the Technical University of Munich; Biotask AG
- Result: GlutoPeak can be used for*
  - Showing differences in aggregation behavior
  - Deriving conclusions on the baked product's quality

*Geislitz, S. et. al. (2018)

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New methods
Analysis of ancient grains

Method*	
Amount of sample (flour)	8,5 g
Amount of liquid ($CaCl_2$ solution, concentration: 55,49 g/l)	9,5 g
Temperature	34 °C
Speed	1.900 rpm
Time	7 min.

paper:**

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Journal of Cereal Science

journal homepage: www.elsevier.com/locate/jcs

Gluten protein composition and aggregation properties as predictors for bread volume of common wheat, spelt, durum wheat, emmer and einkorn

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ARTICLE INFO

Keywords:
Bread volume
Gluten
Glutenin macropolymer
Wheat

ABSTRACT

The technological properties of the ancient wheat species spelt, emmer and einkorn are considered inferior compared to common wheat and durum wheat, but there are only few comparative studies between ancient and modern wheat species. To help fill this gap, protein content and composition, gluten aggregation, dough and bread properties were determined in a unique set of eight cultivars each of common wheat, spelt, durum wheat, emmer and einkorn grown under standardized conditions at one location in the same year. Spearman correlations and principal component analysis (PCA) revealed that especially the contents of glutenins, high molecular-weight glutenin subunits and glutenin macropolymer were suitable to predict the volume of breads made from wholemeal flours of the five wheat species using microbaking tests. Based on their proximity to common wheat in the PCA, one cultivar each of spelt, emmer and einkorn was identified that had similar protein analytical, functional and baking properties to common wheat. Furthermore, the characterization of gluten aggregation behavior using the GlutoPeak test (GPT) enabled an estimation of dough properties and bread volume. Therefore, the fast and easy GPT may serve as an alternative to time-consuming and labor-intensive baking tests.

1. Introduction

In the 21st century, the production area of the "ancient" (hulled) wheat species einkorn (*Triticum monococcum* L., diploid), emmer (*T. dicoccum* L., tetraploid) and spelt (*T. spelta* L., hexaploid) is negligibly small compared to that of the "modern" (naked) wheat species common wheat (*T. aestivum* L., hexaploid) and durum wheat (*T. durum* L., tetraploid). Especially in the last decades ancient wheat species were replaced by modern wheat species due to higher grain yields (spelt 37%, emmer 55% and einkorn 62% lower yield compared to common wheat). Ancient species are hulled wheats with a though glume, which has to be separated from the grain in the mill (Longin et al., 2015). Because some consumers associate the consumption of ancient wheats with health benefits, ancient wheat species have been attracting attention in the last 20 years and special products such as bread, pasta and beer have been developed (Longin et al., 2015). Studies on the contents of bioactive components (e.g. dietary fiber components, phenolic acids, folates) in ancient and modern wheats revealed only small differences between modern and ancient wheat species. For example, even though emmer and einkorn contained more of the carotenoid lutein than common wheat, durum wheat had comparable contents of lutein due to its yellow color (Shewry and Hey, 2015). More studies on a wider range of genotypes of ancient and modern wheats grown under standardized conditions are currently needed to assess possible health benefits (Shewry, 2018). Further advantages of ancient wheats include their disease tolerance, adaptation to different climatic conditions, low requirement of fertilizers and potential to increase biodiversity (Longin et al., 2015). In addition, tetraploid and diploid wheat species may contain lower amounts of immunoreactive proteins and peptides compared to hexaploid species. For example, the celiac disease-active 33-mer peptide was not detected in emmer, durum wheat and einkorn samples due to absence of the D-genome, but spelt and common wheat had comparable contents of the 33-mer (Schalk et al., 2017).

The baking quality of wheat flours is mostly determined by gluten quality and quantity. Gluten proteins are storage proteins and divided into gliadins (GLIA) soluble in aqueous alcohol and glutenins (GLUT) soluble in aqueous alcohol only after reduction of disulfide bonds. Contents and composition of GLIA (α-, α1,2-, α- and γ-GLIA) and GLUT (sub-gliadins, high- (HMW-GS) and low-molecular-weight glutenin subunits (LMW-GS)) are typically analyzed by modified Osborne fractionation followed by reversed-phase high-performance liquid chromatography (RP-HPLC) (Wieser et al., 1998). One glutenin

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[1] Retired.

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0733-5210/

*Marti, A. et.al (2015); **Geislitz, S. et. al. (2018)

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New methods
Analysis of dough ingredients

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

- Project: **Analyzing dough ingredients (e.g. sour dough, fat, salt or yeast) with the GlutoPeak**
- Target: To be able to make the effect of ingredients and their amount visible;

  To show the ingredients effect on the dough and the gluten aggregation
- Institution: University College Cork, Ireland

- Result*: GlutoPeak can be used for product development
  - Definition of target curves for optimal receipts
  - Variation of single ingredients or their amount

*Heitmann, M. et.al. (2017b)

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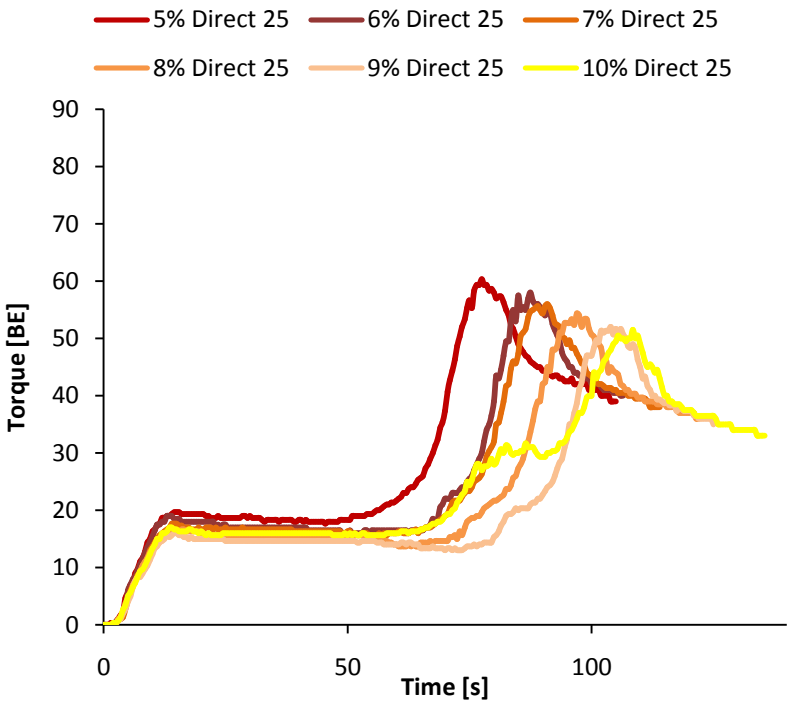
New methods
Analysis of dough ingredients

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Effect of sour dough



- Lowering the pH-value
- Weakening the gluten network

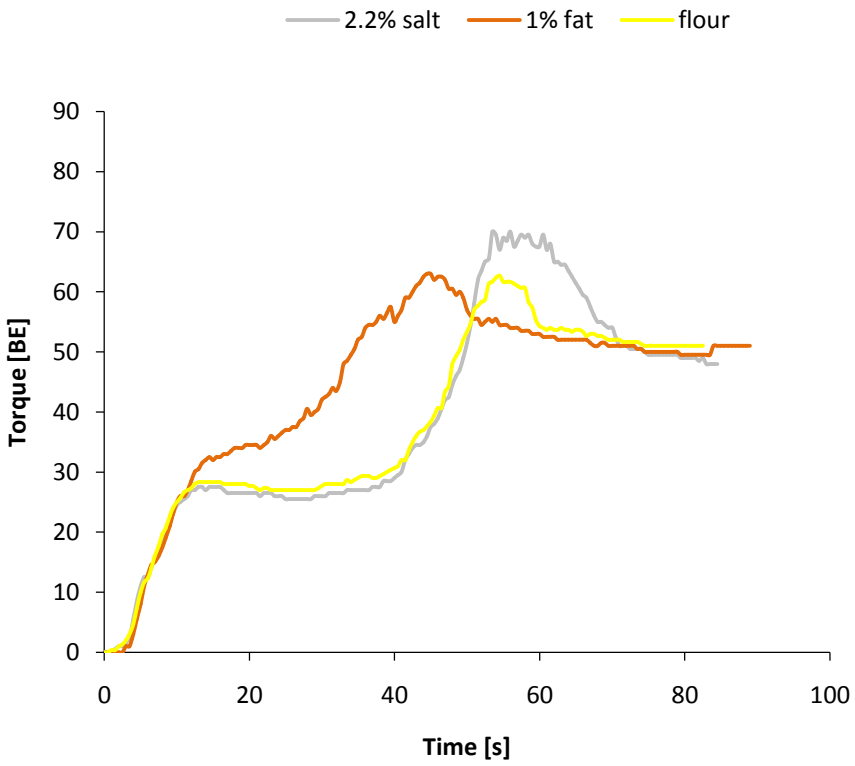
*Heitmann, M. et.al. (2017b)

…where quality is measured.

Brabender®

New methods
Analysis of dough ingredients

Effect of salt and fat



- Salt stregthes the gluten
- Fat plasticized the dough

*Heitmann, M. et.al. (2017b)

…where quality is measured.

New methods
How food extruders can contribute to product development

Extrusion & raw material analysis…. does that match??

Lab extruders for raw material control, product development and research

Torque measurement as Farinograph & Co.

Analysis of material properties unter certain conditions (shear stress, temperaure, pressure)

…where quality is measured.

Brabender®

New methods
How food extruders can contribute to product development




Process	Application / product
Direct Expansion	Snacks, Cereals
Indirect Expansion	e.g. crab-crisps
Cold forming	Pellets, Drops
No Expansion	Pet Food, Feed, Pasta, Chewing Gum
Sweets	Licorice
Reactive Extrusion	Modified starch / flour



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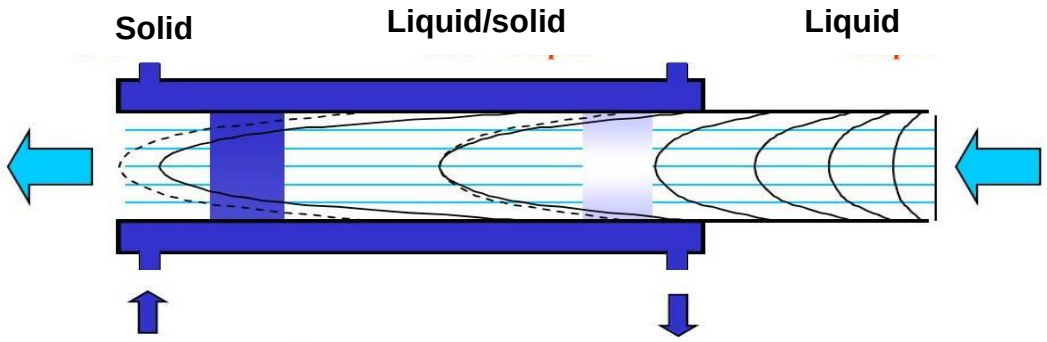
New methods
How food extruders can contribute to product development

Texturized Vegetable Proteins (TVP)



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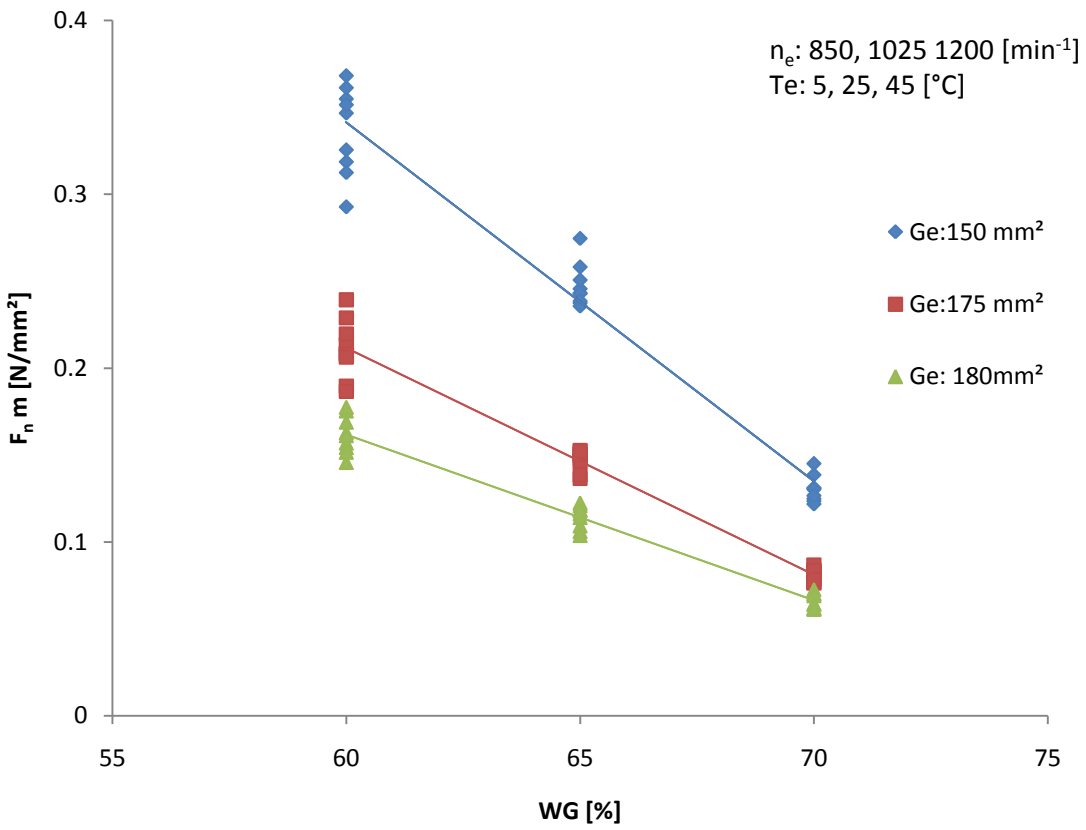
New methods
How food extruders can contribute to product development

Texturized Vegetable Proteins (TVP)

Variation of product and process paramaters such as:

- Moisture content
- Screw speed
- Screw configuration
- Temp. heating zones
- Temp. cooling die
- Diameter cooling die
- …



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New methods
How food extruders can contribute to product development

…where quality is measured.

New methods
How food extruders can contribute to product development

- Project: **Development of a procedure for expanded soy protein**
- Target: processing soy with the KE19 extruder
- Result: expanded product based on soy

3mm round die

ViscoQuick
Brabender’s newest viscometer

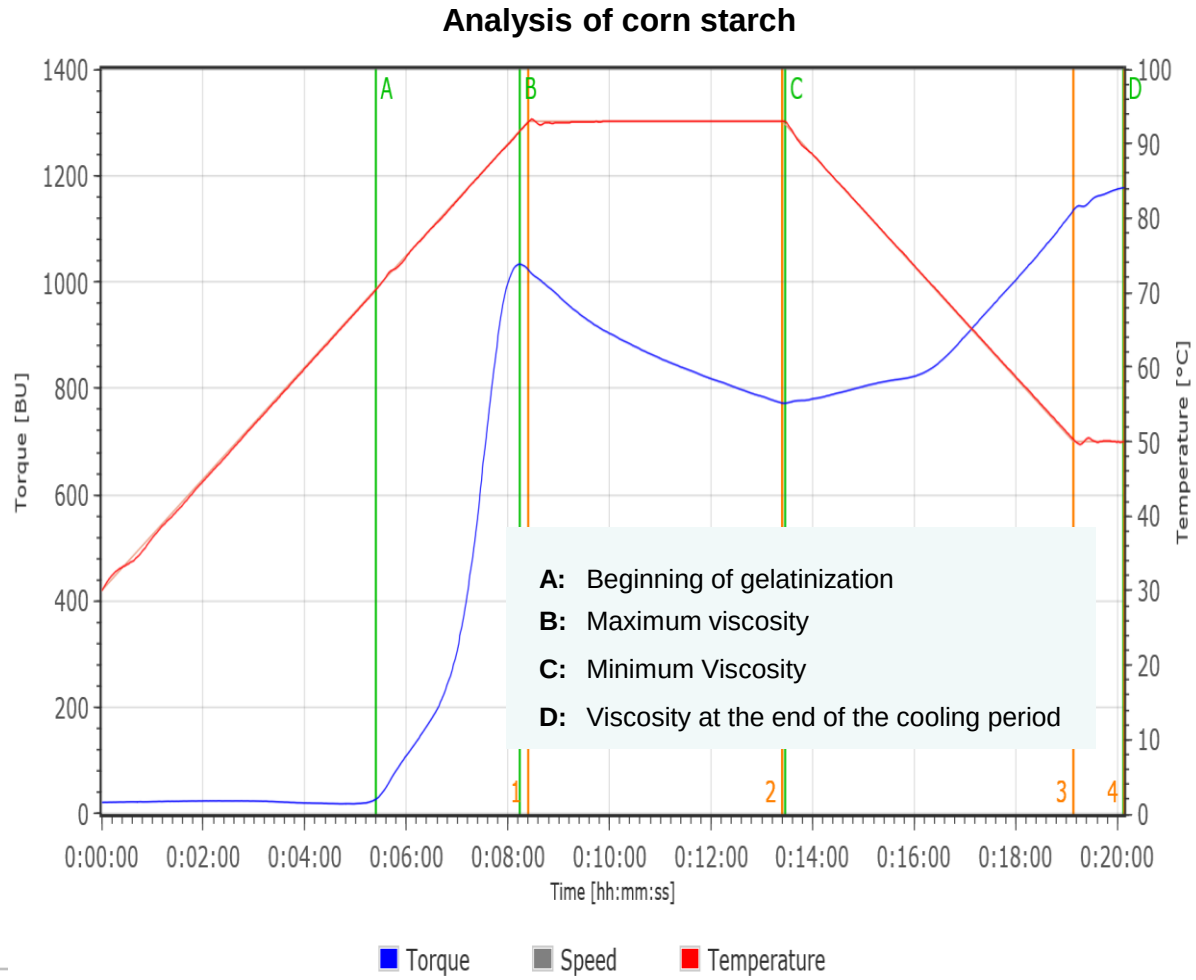
- Successor of the MVAG
- Universal viscosity measurement
- First implementation of new Brabender
- product design for table devices
- Precise, high reproducibility
- Compact, new architecture
- Flexible, different paddle geometries

…where quality is measured.

Brabender®

Applications:

- Starch
- Flour
- Backing goods
- Dough
- Sweets
- Milk
- Paper
- Cosmetics
- …



…where quality is measured.

Current Food Trends & Research Projects
Future

…where quality is measured.

https://3dprint.com/151348/barilla-pasta-3d-printer/

Current Food Trends & Research Projects
Literature

AACC (2018): Ancient Grains and Pssudocerealas. https://aaccipublications.aaccnet.org/doi/pdf/10.1094/CFW-61-5-0198 (Access at 1st September, 2018)

Advanced Biotech (2018): The Ins and Outs of Cake and Cake Batter Flavours. www.adv-bio.com/ins-outs-cake-cake-batter-flavors/ (Access at 1st September, 2018)

Anusci, V. (2018): Food 3D Printing Starts from the Sweet Ending. https://all3dp.com/food-3d-printing-starts-sweet-ending (Access at 1st September, 2018)

Best, S. (2016): Is this the future of fine dining? Restaurant where all the food and even the table is 3D printed - but it will cost you £250 a head. http://www.dailymail.co.uk/sciencetech/article-3685998/Is-future-fine-dining-Restaurant-food-table-3D-printed-cost-250-head.html (Access at 25th August, 2018)

Bernstein, M. (2018): The science of baking bread. https://www.seriouseats.com/2014/10/breadmaking-101-the-science-of-baking-bread-and-how-to-do-it-righ.html (Access at 1st September, 2018)

Bonduelle (2018): Legumino Pasta. https://www.bonduelle.fr/nos-bons-produits/rayon-conserves-de-legumes/legumio-pasta--pois-chiches-et-mais-en-fusilli; https://www.bonduelle.fr/nos-bons-produits/rayon-conserves-de-legumes/legumio-pasta--pois-casses-et-courgettes-en-rigatoni; https://www.bonduelle.fr/nos-bons-produits/rayon-conserves-de-legumes/legumio-pasta--lentilles-corail-et-carottes-en-penne (Access at 25th August, 2018)

Bundeszentrum für Ernährung (2018a): Proteintrend bei Lebensmitteln. https://www.bzfe.de/inhalt/proteintrend-bei-lebensmitteln-32492.html (Access at 25th August, 2018).

Bundeszentrum für Ernährung (2018b): Pasta aus Kichererbsen. ttps://www.bzfe.de/inhalt/pasta-aus-kichererbsen-co-32594.html. (Access at 25th August, 2018).

Bundeszentrum für Ernährung (2018b): Urgetreide. https://www.bzfe.de/inhalt/urgetreide-28442.html (Access at 25th August, 2018).

Culliney, C. (2014): Processing with ancient grains. https://www.bakeryandsnacks.com/Article/2014/01/23/Ancient-grains-fermentation-improvements-needed (Access at 1st September, 2018)

Eatbanza (2018): Collections. https://www.eatbanza.com/collections/store?page=2 (Access at 25th August, 2018)

EU Machinery (2018): Diosna Wendel. http://eu-mach.ru/store/testomesy_promyshlennye/testomesilnye_mashiny_wendel/. (Access at 1st September, 2018)

Halterman, T. (2014): Barilla Announces Their 3D Printed Pasta Contest Winners. https://3dprint.com/32604/3d-printed-pasta-contest (Access at 1st September, 2018)

Low Carb Ernährung (2018): Die Low Carb Ernährung. http://www.low-carb-ernaehrung.de/ (Access at 25th August, 2018)

Menayang, A. (2016): **Tolerant Foods poised to be top contender in legume pasta category.** https://www.foodnavigator-usa.com/Article/2016/11/03/Tolerant-Foods-poised-to-be-top-contender-in-legume-pasta-category (Access at 1st September, 2018)

Nestlé (2016): Forschen für den Fortschritt. https://www.nestle.de/good2016/forschen-fortschritt (Access at 25th August, 2018)

Nieburg, O. (2013): Mixing ha major influence on gluten free bread. https://www.bakeryandsnacks.com/Article/2013/02/06/Gluten-free-bread-quality-with-mixing (Access at 1st September, 2018)

Scott, C. (2016): Barilla Continues to Develop Pasta 3D Printer, Envisions Gourmet Customization. https://3dprint.com/151348/barilla-pasta-3d-printer/ (Access at 1st September, 2018)

Thierry GmbH (2018): Viskosität. https://www.thierry-gmbh.de/pruefgeraete/viscosity/ (Access at 1st September, 2018)

Trenderous (2018): The 3d-printed food revolution is here and this is what it looks like. http://www.trenderous.com/lifestyle/the-3d-printed-food-revolution-is-here-and-this-is-what-it-looks-like/. (Access at 1st September, 2018)

Waffel Meyer (2018): Industrie. http://www.waffel-meyer.com/mobile/index.php?p=pindustrie (Access at 1st September, 2018)

Wholegrainsconcil (2018): Gluten free whole grains. https://wholegrainscouncil.org/whole-grains-101/whats-whole-grain-refined-grain/gluten-free-whole-grains (Access at 1st September, 2018)

World Bakers (2017): Ingredient Report – From Ancient Grains and Pseudocereals to Modern Flour. **https://www.worldbakers.com/white-paper/ingredient-report-ancient-grains-pseudocereals-modern-flour/** (Access at 1st September, 2018)

Yuan, L. (2015): WHEN WILL WE 3D PRINT OUR FOOD? A REPORT FROM THE WORLD'S FIRST 3D FOOD PRINTING CONFERENCE. https://thisismold.com/process/cook/3d-food-printing-conference#.W4r9xUxuKuU (Access at 1st September, 2018)

…where quality is measured.

https://3dprint.com/151348/barilla-pasta-3d-printer/

Thank you for your attention!

Visit us at our booth No. 68

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