Development of semi-automated macro- and small-scale baking test

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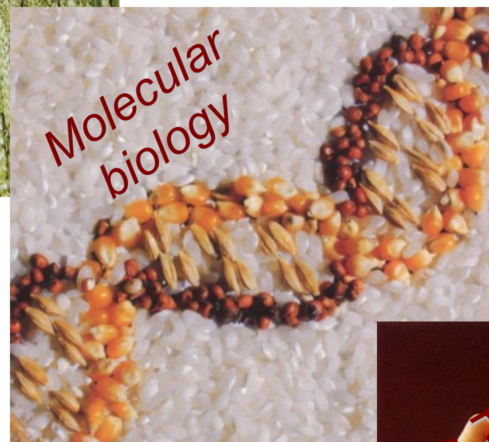
Possibilities in micro-scale wheat quality characterization

Why micro-tests?
Where the amount of sample is limited…

Earlier quality-based selection of wheat lines



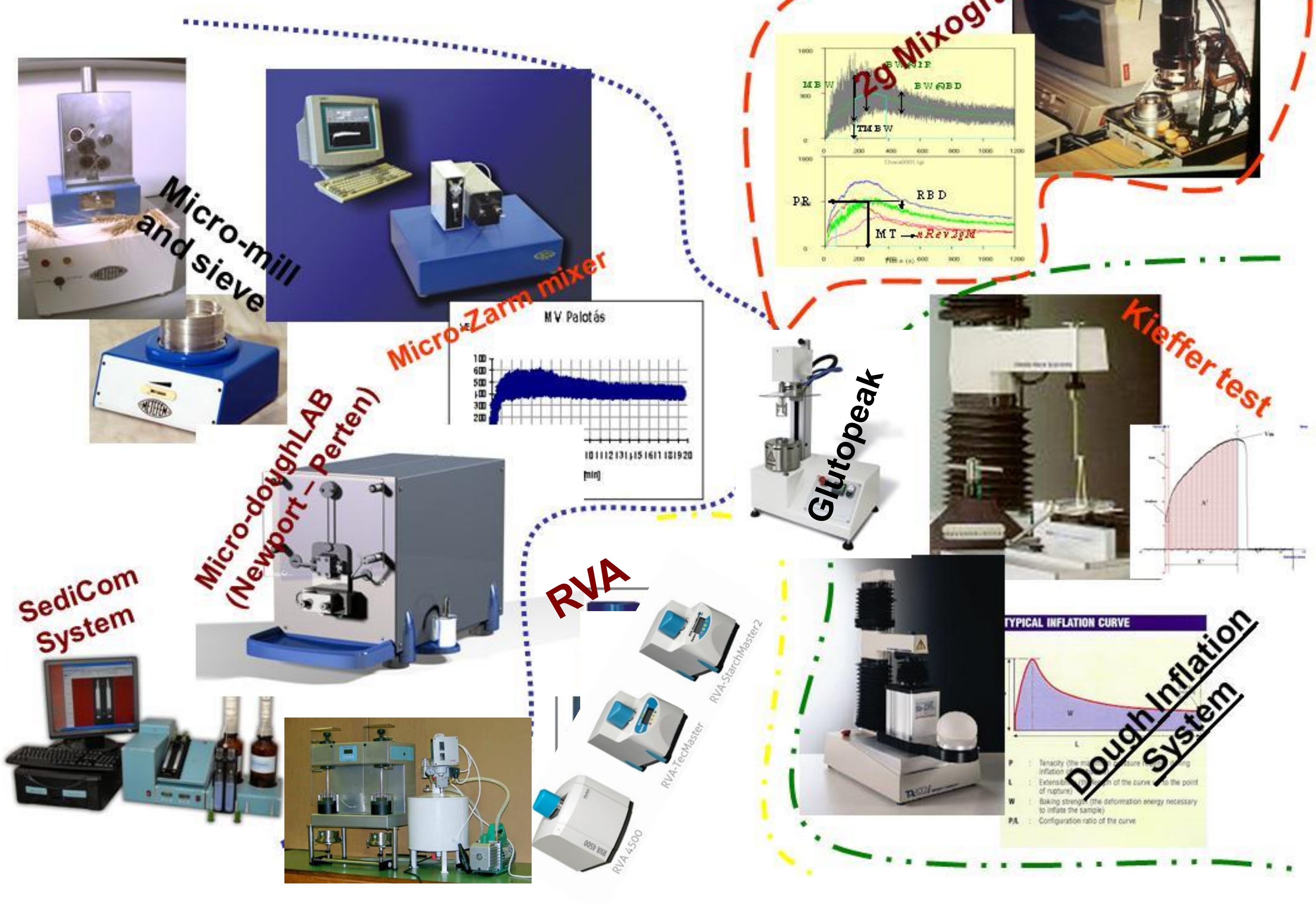
Studying the roles of protein subunits in modified wheat varieties

Investigation of the effects of different types of additives (protein subunits, carbohydrates, lipoproteins, etc.) on the quality parameters.

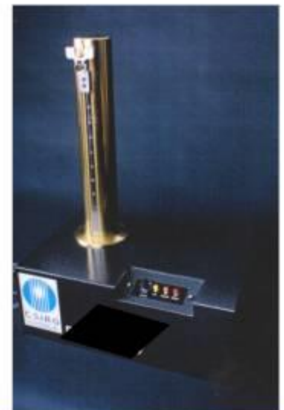
Application in routine analytical work. However, the causes of the differences between standard and small-scale procedures have to be identified.

Possibilities in micro-scale wheat quality characterization

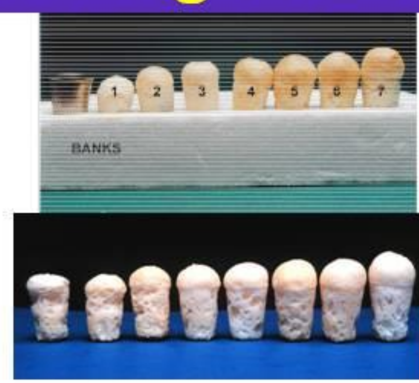
Available or previously developed small (and combined) -scale tools



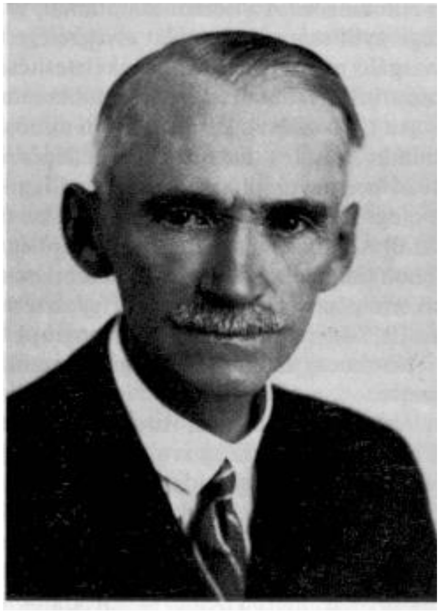
Instrumental and methodological background of micro-scale research in 1990s



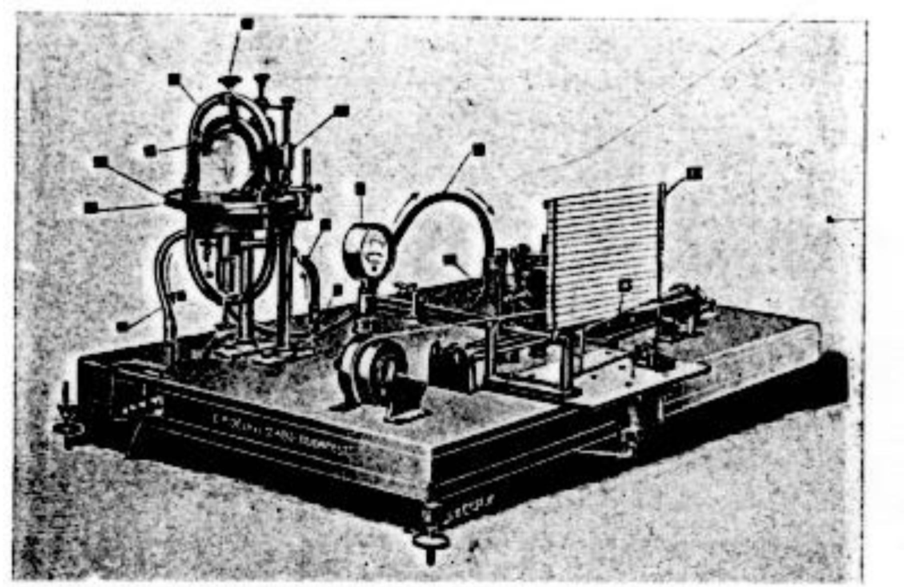
Tools for breeding and basic research



Tradition 2: Development of routine tests for determination of wheat qulaity



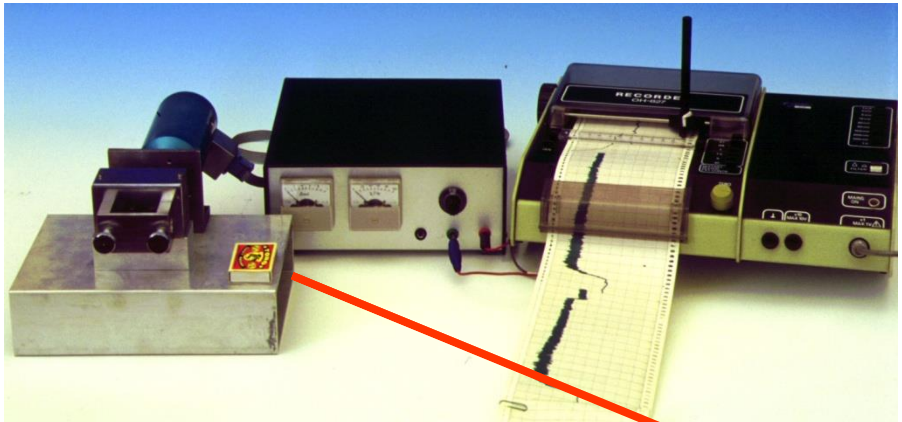
Jenő Hankóczy
(1869 – 1939)
Hungarian inventor of the Farinograph and Extensograph

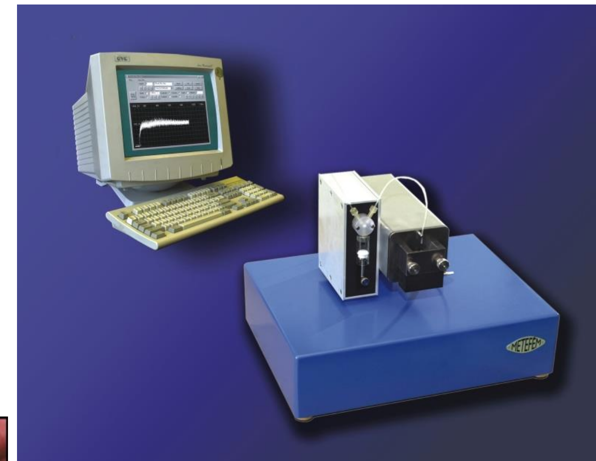


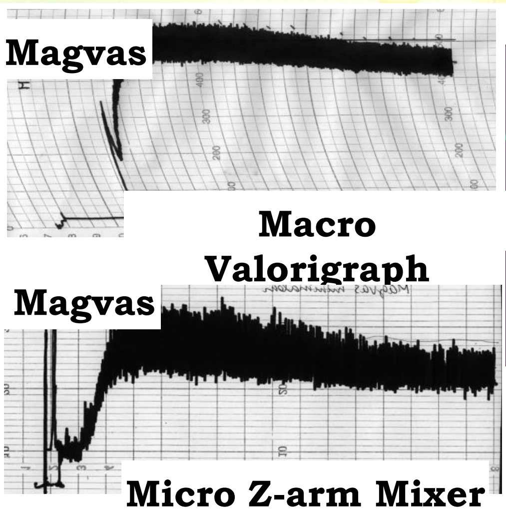
The prototype of the Farinograph (1912- 1928)

Possibilities in micro-scale wheat quality characterization

Development the prototype of micro-scale Z-arm mixer, cooperation with CSIRO, Newport Scientific and later with Perten





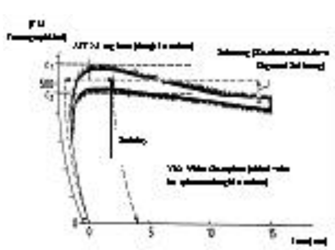
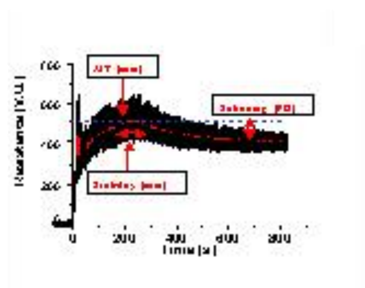
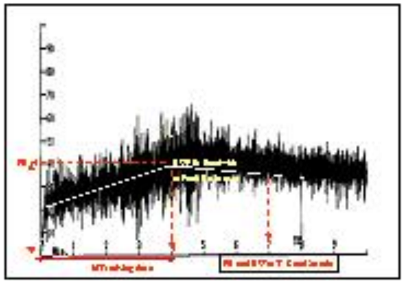
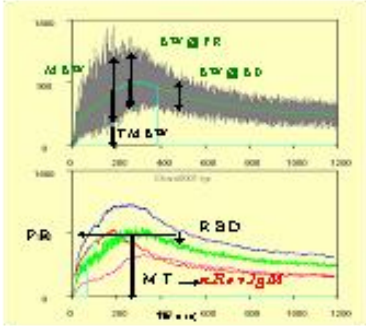


Features and benefits:

- *Small (4 gram) Sample Size*
- *Correlates with Standard Tests*
- *Programmable Mixing Speed*

Possibilities in micro-scale wheat quality characterization

Application of micro-mixer: Comparison of mixing properties

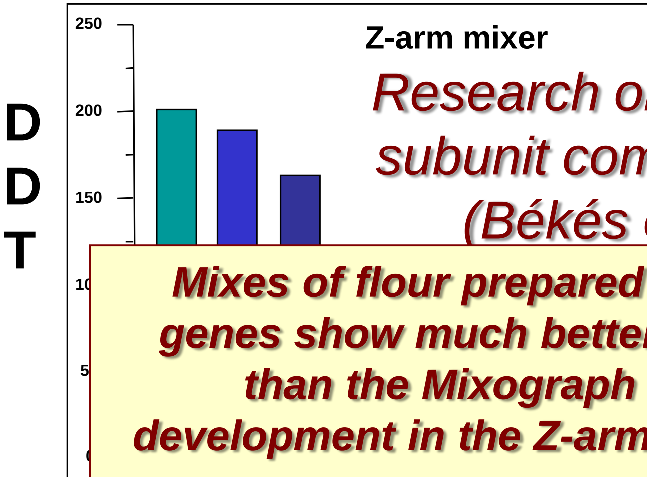
FARINOGRAPH	Micro Z-arm mixer	10g MIXOGRAPH	2g MIXOGRAPH
Method: ISO 5530 - 1	Method: according to ISO 5530 -3	Method: according to AACC 54-40	Method: according to Békés and Gras
Evaluation of registered curves			
			
Statistical evaluation: In every cases three paralel measrement were evaluated. The correlation matrex was calculated wit Statistica 6. software (StatSoft Inc, USA)			

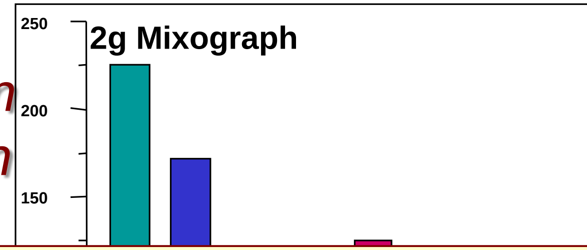
Summary:

- ***Characteristics of curves registered with micro- and macro methods are similar.***
- ***The correlations between macro and micro parameters are highly significant.***
- ***Some alterations can be identified – for example in case of dough development time. We have to learn more about the causes of identified differences.***

Possibilities in micro-scale wheat quality characterization

Applications of micro-mixer in research (examples)





1 , 17+18,5+10

- , 17+18,5+10

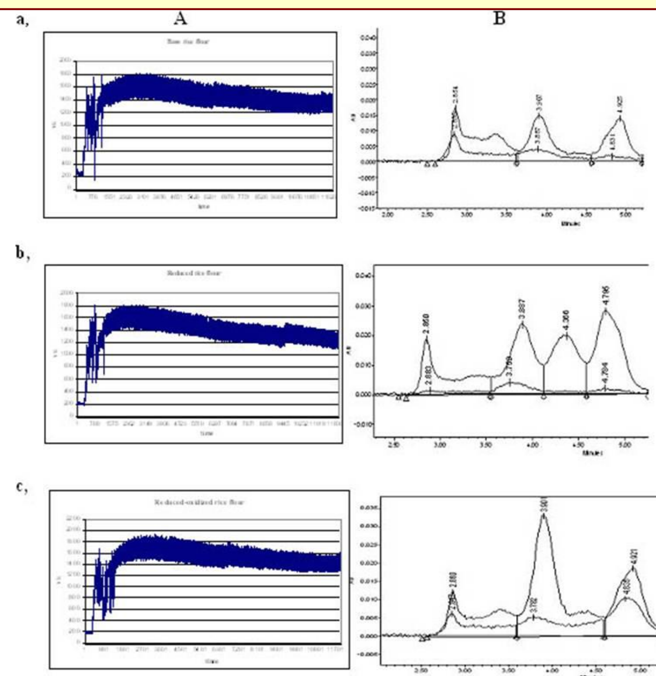
1 , - ,5+10

1 , 17+18, -

Research on protein subunit composition (Békés et al)

Mixes of flour prepared from wheat with deletions of glutenin subunits genes show much better discrimination between poor and good wheats than the Mixograph probably because the mechanism of dough development in the Z-arm mixer is not as dependant on dough strength as in pin mixers.

Research on glutenin subunit incorporation into rice dough (Oszvald et al)



Possibilities in micro-scale wheat quality characterization

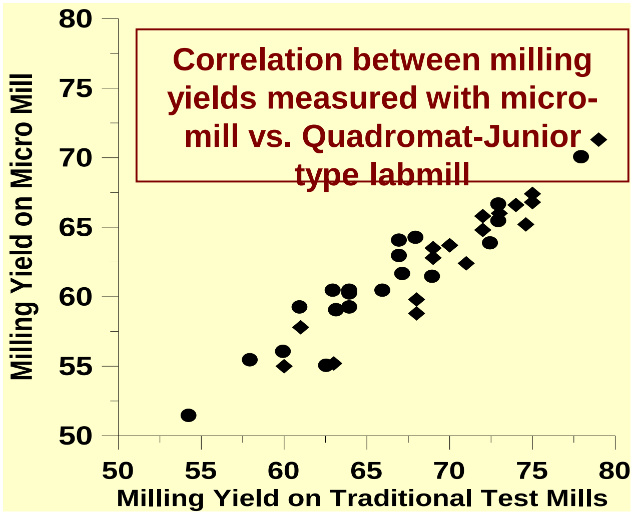
Sample preparation with micro mill and sieve

Technical parameters

Optimal moisture content :	
durum wheat	16 %
aestivum wheat	15 %
Milling yields :	51-70 %
Weight :	17.5 kg
Dimensions :	270×210×350 mm
Sample size :	> 3 g

Possibilities in micro-scale wheat quality characterization

Comparison with standard laboratory milling procedures

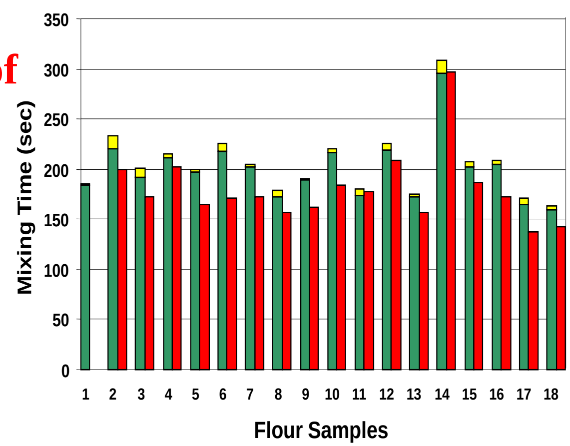


Summary:

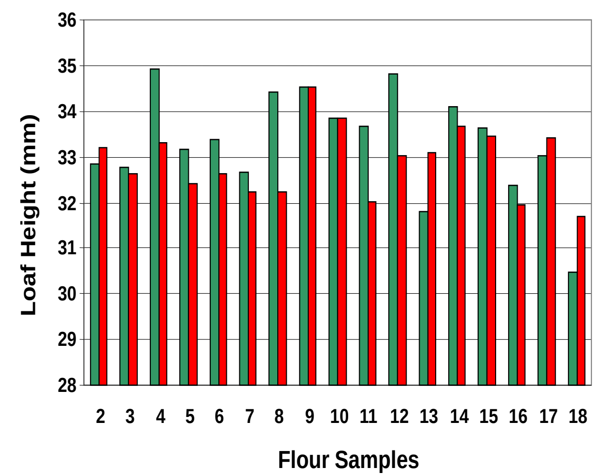
- ***Milling yields are slightly lower in case of micro-mill.***
- ***The mixing curves are similar and the calculated parameters are in good correlation.***

Comparison studies of dough properties with BUHLER and FQC-2000 flours

Effect on Mixing Time

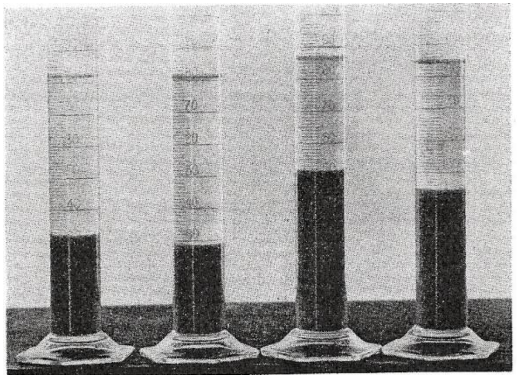
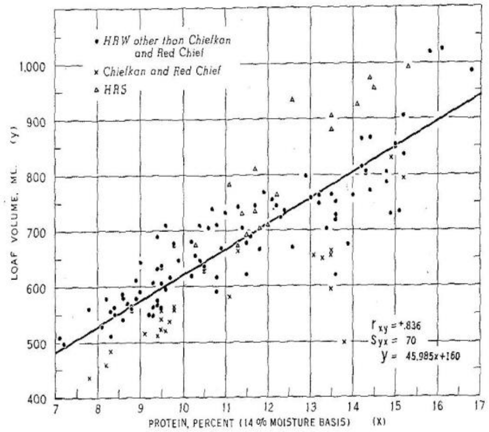
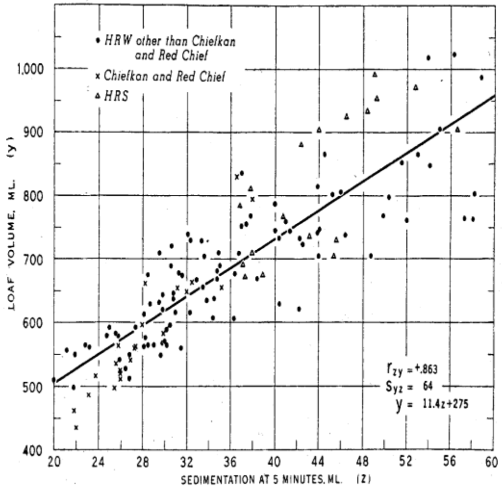


Effect on Loaf Height



Principle and interpretation of sedimentation tests

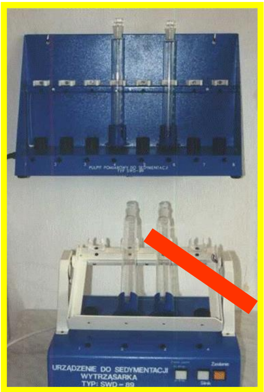
The Zeleny value means the degree of sedimentation of suspended flour in lactic acid in a given time. The method is characterising the swelling properties of wheat proteins and insoluble components.

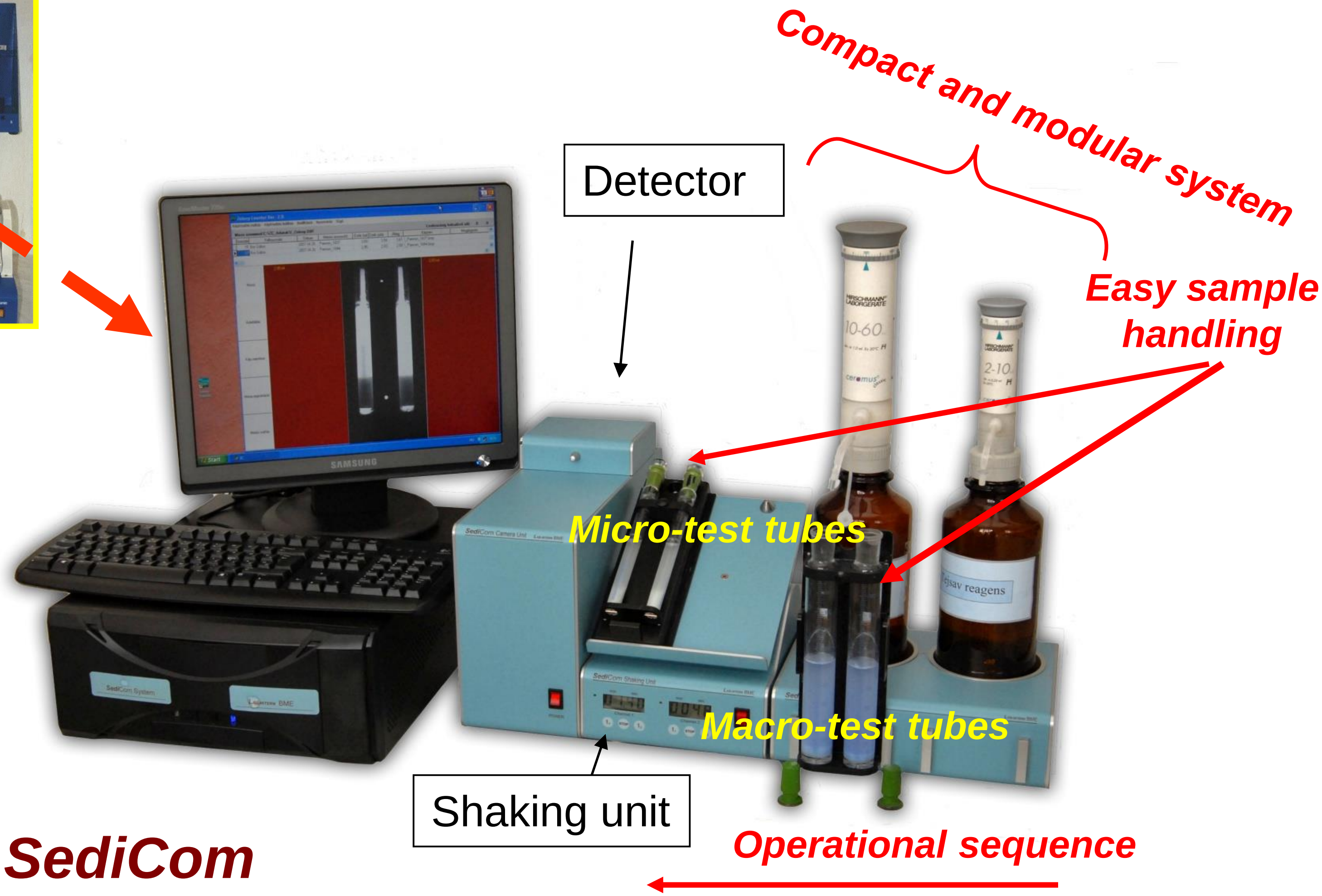
First experiments	Corr. between prot. cont. and sedimentation value	Corr. between loaf valume and sedimentation value
		

Zeleny, L, november, 1947

Possibilities in micro-scale wheat quality characterization

Semi-automatic instrument and methods for determination of Zeleny value on micro- and micro-scale in cooperation with Labintern Ltd, Hungary





SediCom Tester

Possibilities in micro-scale wheat quality characterization

Application of sedimentation test in research: QTL mapping for Zeleny values

Experimental design followed, consisting of blocking for individual days and day order recorded. Population: Chara (Aus) x Glenlea (Can), 180 DH lines. Field and milling effects were also included in the QTL model. Replication at the zeleny testing consisted of double replicates for each genotype (Cavanagh, C. et al)

Functional data and their relationships to allelic composition indicated that while dough strength and partly extensibility are depend on the presence of <u>HMW glutenin alleles</u>, the allelic composition of <u>LMW glutenins are mostly responsible for the variation of Zeleny indeces</u> of the wheats, investigated. Among glutenin loci, significant QTLs were found in the regions of both type of gliadin loci on chromosome 1 and 6.

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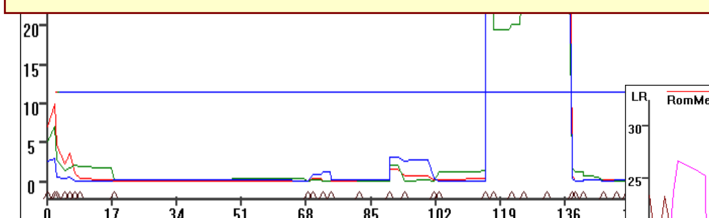
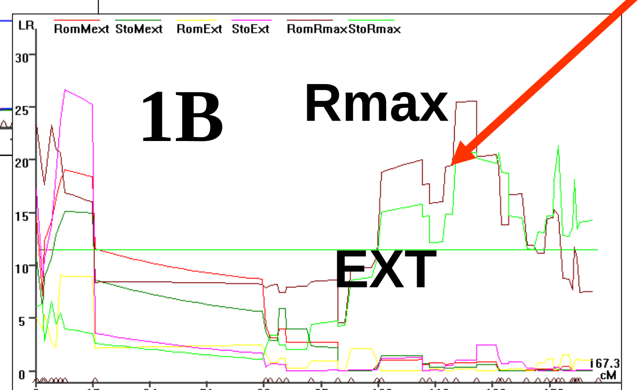
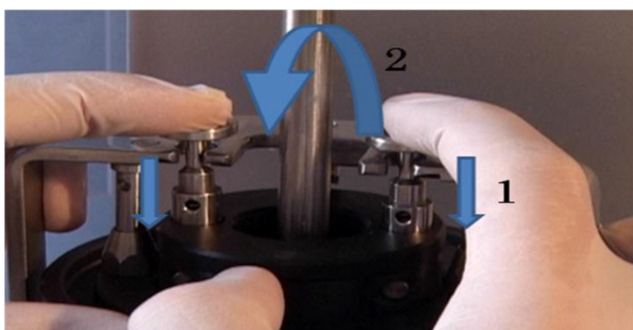




Possibilities in micro-scale wheat quality characterization

Development of GluStar system and methods for determination of gluten content and separation of wheat starch (in collaboration with Labintern Ltd, Hungary and CSIRO Plant Industry, Australia)

The novelty is the capability the determination of wet gluten content and the separation of starch from flour samples, in same time. The modularity of the measuring system ensures the utilization of basic modules, separately.



The combined measuring system is available with ***standard (10 g) and micro-scale (5g)*** bowls.

Filters for separation of starch (soluble carbohydrate polimers)

Vacuum system

Possibilities in micro-scale wheat quality characterization

Application of gluten washer in research: An example for investigation of gluten proteins

Rudi Appels et al: Proteome bioinformatics and genetics for associating proteins with grain phenotype

- A total of **740 flour samples** from lines in a MAGIC population (4-way cross) established in CSIRO Plant Industry were analysed using the GluStar equipment.
- Based on **control samples** (from cv Carnamah) analysed every 10 samples, the %wet gluten ranged from **1.295 - 1.405 g/4.5g** flour and hence the **reproducibility** of the measurement for these 74 control samples was good.
- The genetic variation assayed by GluStar for the set of samples from the structured MAGIC population, **ranged from 0.95 g wet gluten/4.5g flour to 2.8g wet gluten/4.5 g flour** and within this analysis the reproducibility was consistent with that defined by the control Carnamah samples.
- A particularly **useful aspect** of the small scale analyses, in addition to the % wet gluten measurement, was the **fast qualitative assessment of the dough** formed by the flour samples.

Our new (and maybe the last ☺) development: a semi-automated macro- and small-scale baking test

The motivation of this development was very simple:

Mixing

Proofing

Device-supported baking test ????

Product volume

Crumb Quality (Image analysis)

Our new (and maybe the last ☺) development: a semi-automated macro- and small-scale baking test

The role of baking tests in flour characterization

-Contribute direct information about baking performance
- Wide field of application:
    - product development and quality assurance
    - research and development
    - breeding programs

Disadvantages
- time consuming and labour intensive
- require large amount of sample
- reproducibility problems

- Standardization: national and international standard methods
- Size reduction: micro-scale tests
- Automation in laboratory scale

Objectives

*Development of hardware, software and methods for **macro AND micro** baking tests* — ***Part 1***

↓

Optimation and method development

↓

Investigation of repeatability — ***Part 2***

↓

Comparative analyses — ***Part 3***

Development of semi-automated macro- and small-scale baking test

Standard methods and method developments for scale reduction and automation of baking tests

AACCI Method 10-11.01
Baking Quality of Bread Flour -- Sponge-Dough, Pound-Loaf Method

VIEW METHOD

Objective
This method provides a bread-baking test for assessing the quality of wheat flour by a sponge-dough method. It involves a two-step process. In the first step, the *sponge* is made by mixing part of the total flour with water, yeast, and yeast food. The sponge is allowed to ferment 4 hr. In the second step, the sponge is incorporated with the rest of the flour, water, and other ingredients to make *dough*. This method may also be used for wheat-based composite flours and for other ingredients that may affect loaf characteristics.

Microbread: use of a micro-scale screening bread-baking platform for high-throughput screening of new ingredients and...

Conference Paper · April 2013

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...ale reduction in a laboratory bread-making ...parative analysis and method development

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A new lean no time test baking method with improved discriminating power

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Grain Research Laboratory, Canadian Grain Commission, 303 Main Street, Winnipeg, MB, R3C 3G8, Canada

TÜBİTAK
Research Article
Turk J Agric For
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Determination of the bread-making quality of flours using an automatic bread machine

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Development of semi-automated macro- and small-scale baking test

Materials and methods

Samples and sample preparation

- Grains of ten winter wheat cultivars (Agricultural Institute, Centre for Agricultural Research, Hungarian Academy of Sciences, Martonvásár, Hungary) and an average quality flour for the development and for standard

- Milling of grains by CD1 laboratory mill (Chopin, Villeneuve-la-Garenne, France) according to Standard NF EN ISO 27971

Characterization of the flours

-Determination of chemical composition of grains and flours by Near Infrared Spectroscopy using Infratec 1241 Grain Analyser (Foss Tecator, Höganäs, Sweden)

- Characterization of flour mixing properties and water absorption by Farinograph method (ICC standard Nr. 115/1) using 50g Farinograph-E (Brabender, Duisburg, Germany)

Baking tests and evaluation of loaf properties

- Bread baking according to ICC Standard 131 and its modified versions (macro and micro baking) using the bread making machine

- Determination of bread volume by seed displacement method (AACCI Method 10-05.01) and by water displacement method (in case of micro loaves)

- Determination of bread crumb firmness by texture profile analysis (T.P.A.) test (TA-XT2 Texture Analyser, Stable Micro Systems, England) using P36 and P20 cylinder probes

-Investigation of bread crumb porosity by image analysis (ImageJ 1.41o, Wayne Rasband, National Institute of Health, USA)

-Statistical evaluation of the data by Statistica 13 software (Dell Inc., Round Rock, USA) and MS Office Excel (2010)

Results 1 – Optimization of scale reduction and method development

Baking methods*

Macro method

Mixing ingredients by 300 g Farinograph until optimal consistency

Making one dough piece of 250 g flour

Insert dough into the baking pan

Micro method

Mixing ingredients by 50 g Farinograph until optimal consistency

Making three dough pieces of 10 g flour

Insert dough into the baking pan

Program settings for optimized macro and micro baking methods

Process	Macro method				Micro method			
	Temperature (°C)	*Period (min)*	*Working heating wire*		*Temperature (°C)*	*Period (min)*	*Working heating wire*	
			upper	lower			upper	lower
Leavening	30	80		X	30	80		X
	80	5	X	X	80	5	X	X
Baking	120	5	X		120	20	X	
	140	20	X					

*** Using the same recipe as the applied standard method (ICC Nr. 131)**

Results 1 – Optimization of scale reduction and method development

Composition of the flours (Mean ± SD)

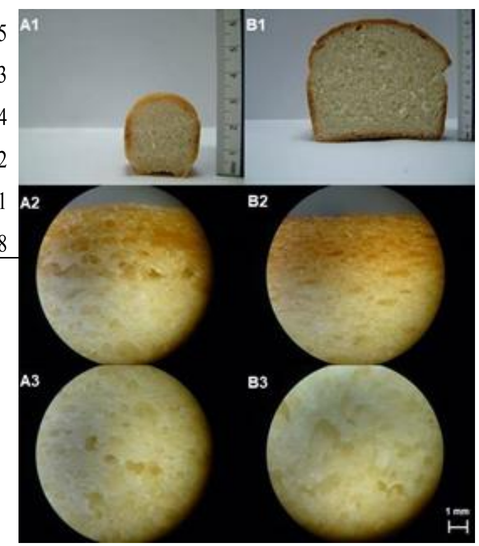
Cultivar	Protein (DM%)	Ash (DM%)	Gluten (DM%)
MV-Toborzó	13.7±0.00	0.64±0.01	36.6±0.87
MV-Marsall	12.5±0.00	0.65±0.00	32.0±0.40
MV-Magdaléna	12.4±0.05	0.65±0.01	32.4±0.55
MV-Suba	13.0±0.06	0.65±0.01	34.2±0.87
Bánkuti-1201	13.3±0.06	0.63±0.00	34.5±0.55
MV-Karéj	14.4±0.00	0.61±0.01	38.2±0.85
MV-Pántlika	11.9±0.06	0.57±0.01	29.1±0.61
MV-Tallér	12.2±0.06	0.57±0.01	31.2±0.46
MV-Lepény	12.2±0.06	0.58±0.01	29.9±2.06
MV-Nemere	12.05±0.06	0.61±0.02	31.1±1.08
Ranges	**12.05-14.4**	**0.57-0.65**	**29.1-38.2**

Results 1 – Optimization of scale reduction and method development

Bread properties measured in standard and micro baking trials (Mean ± SD)

Cultivar	Volume (cm^3)			Specific volume (cm^3/g)			
	standard	micro		standard	micro		standard
		by hand	by moulder		by hand	by moulder	
Range	777-984	22.2-33.5	21.7-34.4	2.25-2.64	1.90-2.89	1.74-2.91	73-86
Bánkúti-1201	984[b] ±15*	32.5[b]±1.87	31.6[b]±1.82	2.64±0.13*	2.61±0.074	2.47±0.074	80±1.3
MV-Karéj	924[a] ±14	29.3[b]±1.98	26.8[a]±2.31	2.54±0.11	2.37±0.105	2.13±0.238	82±3.1
MV-Karizma	817[a] ±15*	24.2[b]±1.91	29.3[a]±1.53	2.30±0.08*	1.99±0.357	2.40±0.122	75±2.8
MV-Kokárda	857[a] ±16	33.5[b]±1.15*	34.4[a]±1.82*	2.53±0.03	2.89±0.158*	2.91±0.163*	81±3.3
MV-Lepény	777[a] ±11*	22.2[b]±2.38	27.9[a]±1.58	2.25±0.03*	1.90±0.230	2.34±0.271	73±0.9
MV-Magdaléna	925[a] ±10	27.2[b]±1.47	29.9[a]±2.34	2.53±0.03	2.19±0.191	2.38±0.098	80±1.5
MV-Nádor	883[a] ±13*	24.0[b]±1.68*	21.7[a]±1.81*	2.46±0.04*	1.95±0.071*	1.74±0.121*	81±2.3
MV-Nemere	924[a] ±15*	27.7[b]±3.11	29.0[a]±2.03	2.57±0.05*	2.27±0.026	2.35±0.242	82±1.4
MV-Pántlika	847[a] ±11*	25.3[b]±1.50	30.6[a]±1.70	2.37±0.03*	2.09±0.113	2.53±0.263	79±1.2
MV-Suba	896[a] ±14*	27.8[b]±2.94	30.3[b]±2.06	2.48±0.05*	2.26±0.146	2.43±0.371	80±1.1
MV-Tallér	944[a] ±13*	29.3[b]±2.27	29.9[b]±2.06	2.61±0.05*	2.39±0.071	2.41±0.256	86±0.8

[a] Mean value of a triplicate determination ± standard deviation
[b] Mean value of a duplicate determination ± standard deviation
(*) Significant at P<0.05 level



Renata Nemeth, Agnes Banfalvi, Andras Csendes, Sandor Kemeny, Sandor Tomoskozi: Investigation of scale reduction in a laboratory bread-making procedure: Comparative analysis and method development, ***Journal of Cereal Science 79 (2018) 267-275***

Results 2 – Hardware and software development

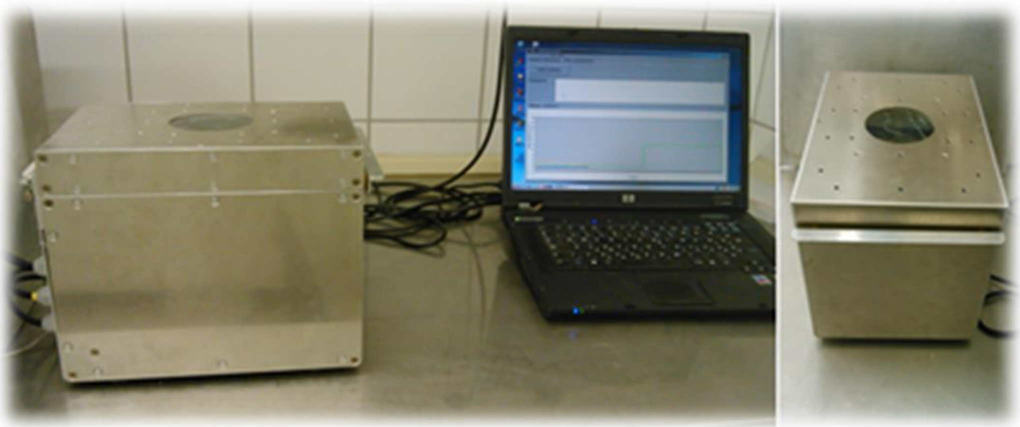
1st prototype of the baking machine

Features:
- Automated dough mixture
- Baking on macro scale
- Baking of three loaves at once
- Separated baking chambers
- Software controlled
- Programmable: time and temperature
- Processes: leavening and baking

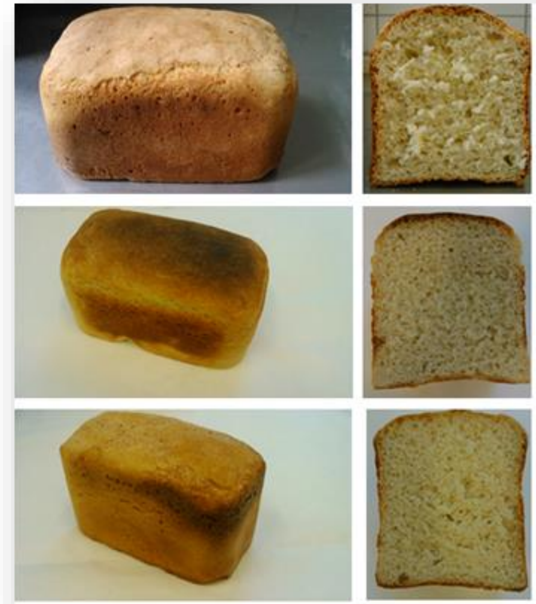
Problems:
- Unbaked top and burnt sides of loaves
- Difficult temperature control
- Limited mobility

Change of concept

Results 2 – Hardware and software development



2nd prototype of the baking machine



Teflon-coated baking pans for micro and macro baking

Changes:

- Baking on macro and micro scale
- Baking of three micro loaves or one macro loaf
- Mobility (small and light aparatus)
- Improved temperature controll
- Improved baking properties

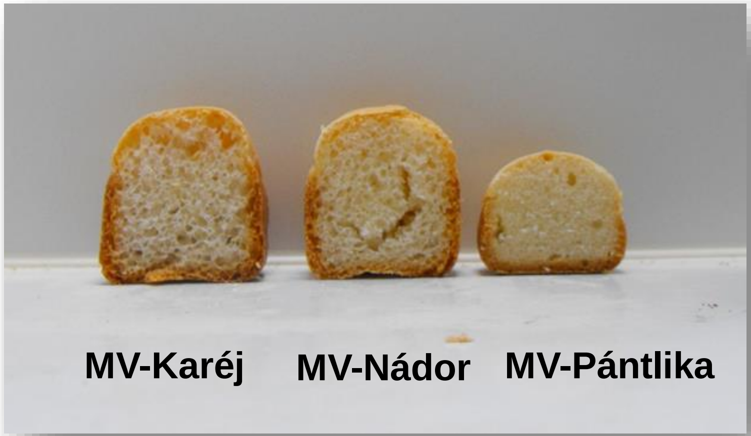
Results 2 – Hardware and software development

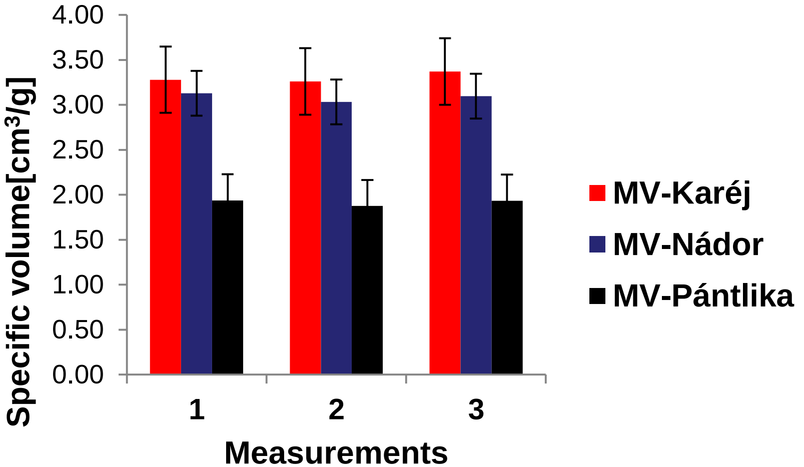
Prototype of semi-automated equipment

Final appearance of the baking machine

Improvements:

- Thermal insulation coating
- More user-friendly software
- Better temperature controll
- Improved heat transfer
- Optimized baking programs
- Improved baking properties



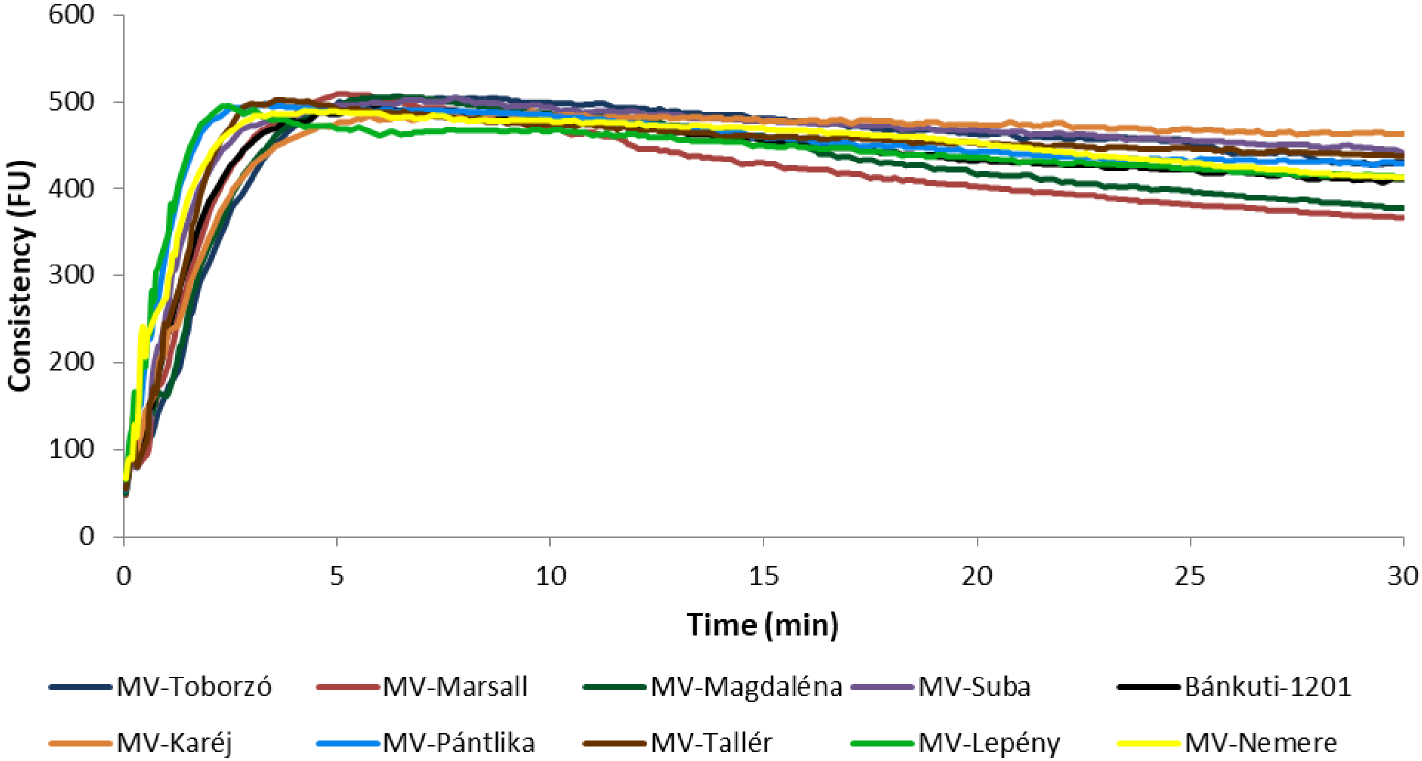


Investigation of repeatability of micro baking

Results 3 – Application of prototype for baking trials

Quality of investigated wheat flours

Mixing properties of wheat flours

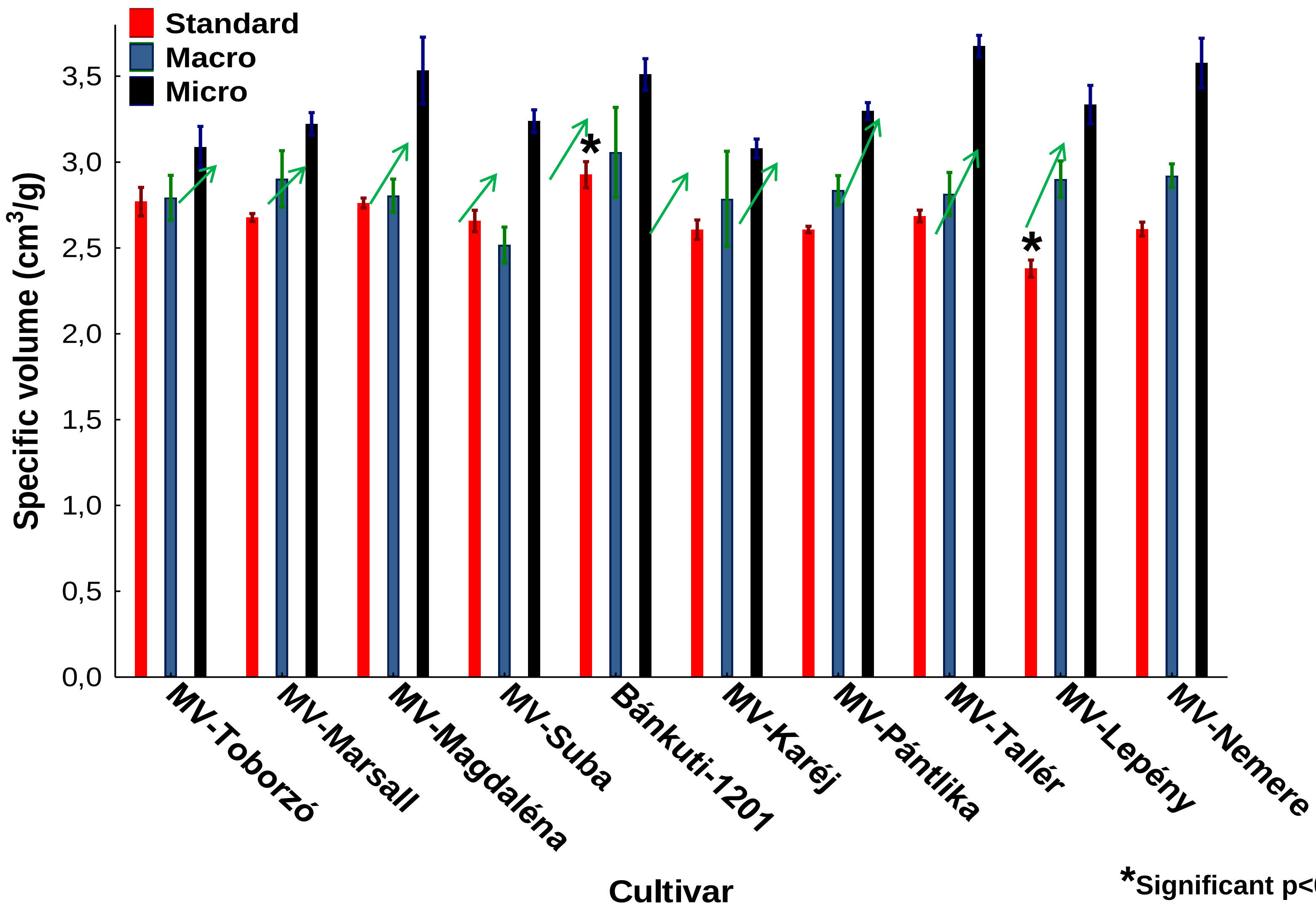


	MV-Toborzó	MV-Marsall	MV-Magdaléna	MV-Suba	Bánkuti-1201	MV-Karéj	MV-Pántlika	MV-Tallér	MV-Lepény	MV-Nemere
WA(%)	**72.6**	67.5	69.4	66.6	65.0	67.0	60.0	66.0	**58.9**	63.8
DT (min)	5.8	3.5	4.3	5.2	4.0	**6.4**	2.2	2.5	**1.7**	2.8
S (min)	8.0	**3.3**	5.2	8.8	6.6	**17.5**	7.7	5.7	6.5	9.3
DS (FU)	63.0	**121.0**	107.0	52.0	69.0	**27.0**	59.0	52.0	62.0	50.0
QN	112.0	60.0	84.0	108.0	91.0	**200.0**	88.0	70.0	**38.0**	125.0

WA: water absorption; DT: development time; S: stability; DS: degree of softening; QN: quality number

Results 3 – Application of prototype for baking trials

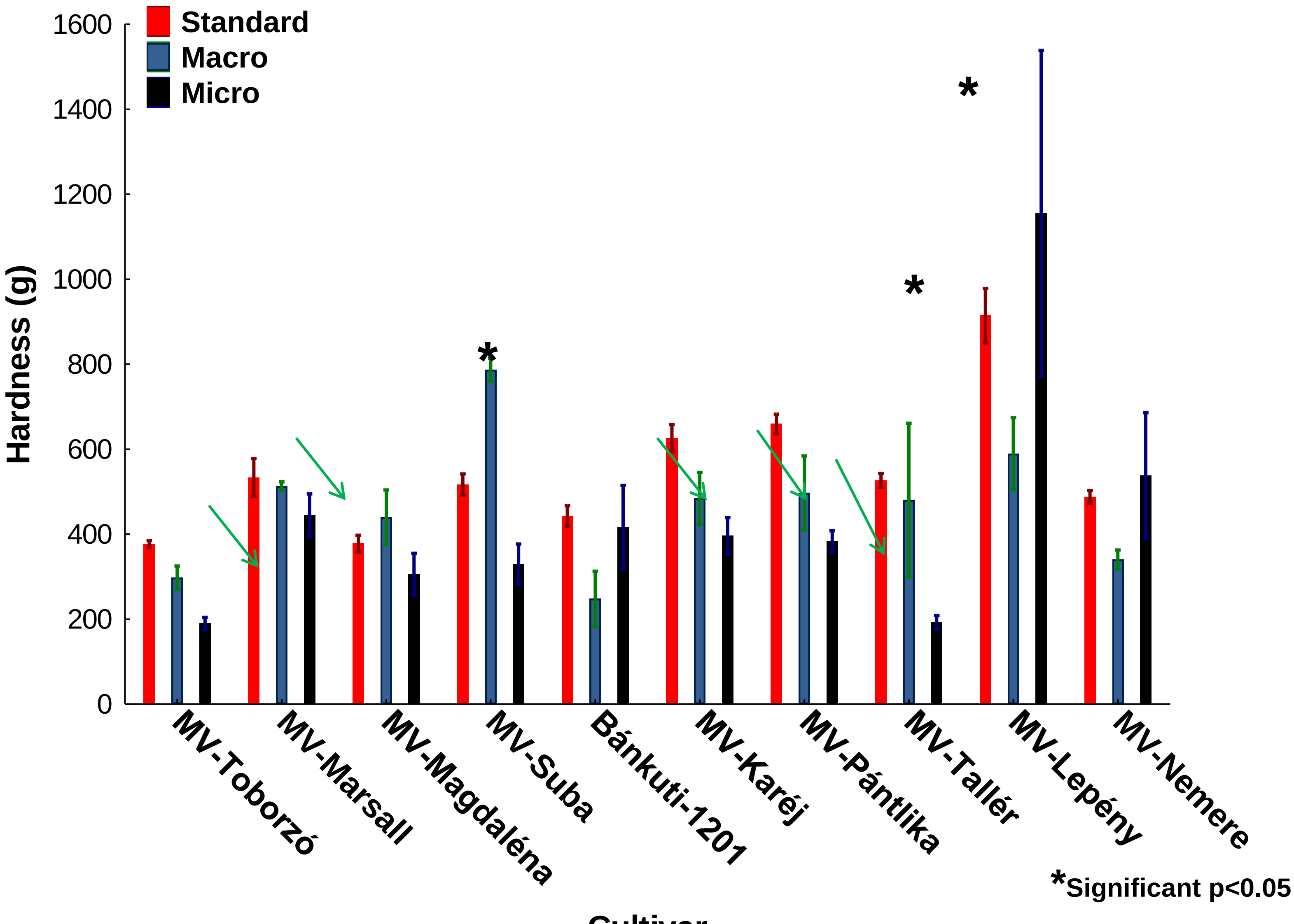
Comparison of specific volumes (Mean ± SD)



*Significant $p<0.05$

Results 3 – Application of prototype for baking trials

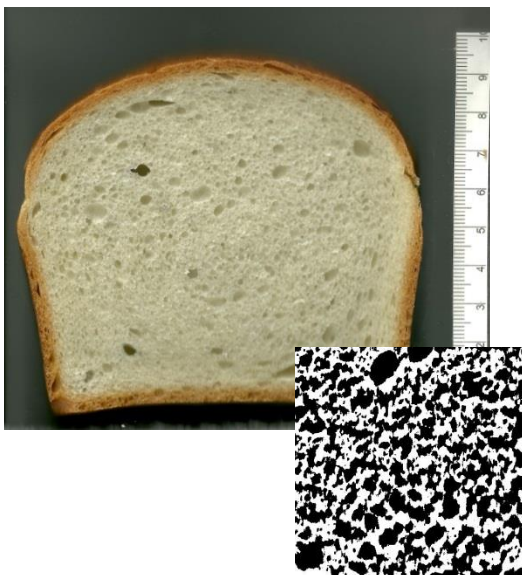
Comparison of crumb hardness (Mean ± SD)



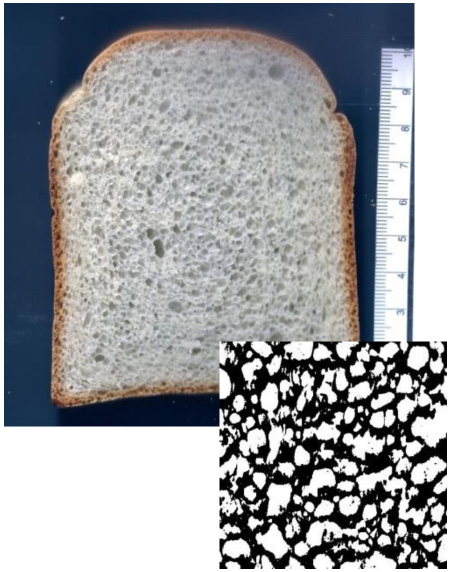
Results 3 – *Application of prototype for baking trials*

Comparison of crumb porosity (Bánkúti 1201)

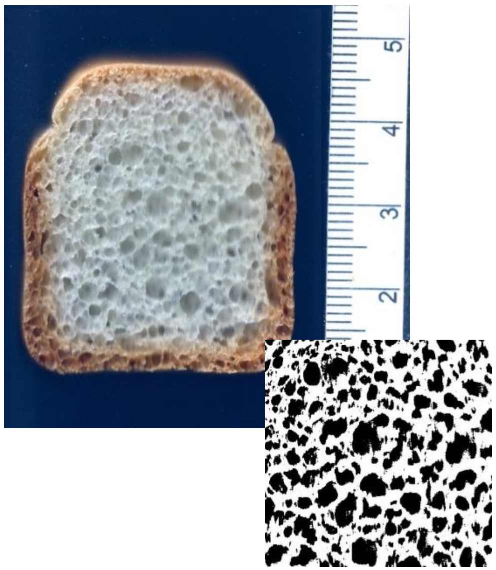
Standard



Macro



Micro



Method	Pore number	Pore size (mm)			Area (%)
		Average ± SD	Minimum	Maximum	
Standard	98	1.907±2.878	0.191	20.703	46.741
Macro	85	2.238±3.246	0.208	23.815	47.562
Micro	101	1.872±2.019	0.183	9.717	47.257

Conclusion

Instrument development

- The second instrument (the prototype) seems to be suitable and user-friendly
- Improvement of the software and optimation of program settings

→ Repeatable measurements, improved baking properties

Testing the prototype in comparative analyses

- Differentiation of the samples similarly to standard method
- Alterations in the results determined by different methods can be originated from the different methodology and thermal conditions
- Significant correlation of crumb hardness between standard loaves and macro/micro loaves
- Even crumb porosity showed similarities

↓

Further slight improvements and optimization of system are needed,
but the concept seems to work

Development of semi-automated macro- and micro-scale baking test

Future plans and intentions

1. Further developments in the standardization of methods and in the evaluation of results
2. Updating the software for the better applicability
3. Application of the method in gluten-free product

Micro bread from buckwheat (P. Szepesvári et al)

Mixing

Proofing

Baking

Product volume

Crumb quality (Image analysis)

Thank you for your kind attention!

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