WORLD GRAIN NETWORK

Results of the worldwide inter-laboratory study conducted in February/March 2021

Contents

Abstract

A world-wide inter-laboratory study for the determination of protein and moisture in whole kernels of ten wheat and ten barley samples as well as oil and moisture in whole kernels of ten rapeseed samples from the 2020 harvest has been performed. The test for wheat and barley comprises reference analyses methods presently used in the master labs of the grain networks, local NIR prediction models presently in use in the different networks and the FOSS ANN model WB003034 for the simultaneous determination of protein and moisture in whole kernels of wheat and barley. Results are summarized in the table below, indicating that the FOSS ANN model WB003034[*] can be used without loss in accuracy and performance.

WGN 2021 all samples *(2020 harvest)*	**Ref. methods**	**Local models**	**FOSS ANN**
Protein, range	**9.1 % - 15.1 %**		
Mean (%)	**12.08**	**12.11**	**12.04**
deviation from mean		**0.03**	**-0.04**
SD reproducibility	**0.19**	**0.18**	**0.11**
RSD reproducibility	**1.6**	**1.6**	**0.9**
Moisture, range	**11.1 % - 14.6 %**		
Mean (%)	**13.08**	**12.97**	**12.91**
deviation from mean		**-0.10**	**-0.16**
SD reproducibility	**0.15**	**0.24**	**0.08**
RSD reproducibility	**1.2**	**1.8**	**0.6**

[*] The combined Wheat and Barley calibration WB003034 is usually sold as individual calibrations with typical labels WH003034 and BA003034, respectively.

The test for rapeseed was performed in the same way as for wheat and barley but using FOSS ANN model RA002635 for the simultaneous determination of oil and moisture in rapeseed. Results are summarized in the table below, indicating that the FOSS ANN model RA002635 can be used without loss in accuracy and performance.

WGN 2021 **all samples** *(2020 harvest)*	**Ref. methods**	**Local models**	**FOSS ANN**
Oil, range	**40.6 % - 50.3 %**		
Mean (%)	**47.16**	**47.38**	**47.62**
deviation from mean		**0.22**	**0.46**
SD reproducibility	**0.70**	**0.81**	**0.32**
RSD reproducibility	**1.5**	**1.7**	**0.7**
Moisture, range	**6.5 % - 7.4 %**		
Mean (%)	**7.01**	**7.09**	**6.97**
deviation from mean		**0.08**	**-0.04**
SD reproducibility	**0.17**	**0.31**	**0.21**
RSD reproducibility	**2.4**	**4.4**	**2.9**

Forty-six laboratories from twenty-three different countries world-wide (six continents) participated in this test, which is similar as last year. In addition to protein, moisture and oil values some of the participating labs also submitted data for their reference analyses and, in some cases, prediction models on the following parameters:

- *Falling number*
- *Mass per hectolitre*
- *Sedimentation index (Zeleny)*
- *Wet gluten*
- *Starch in wheat and barley*
- *Hardness*
- *Glucosinolates, Erucic acid, Oleic acid, Linolenic acid, Linoleic Acid, Free fatty acid (acidity index), Saturated fatty acids and Iodine Value in rapeseed*

The results of which are also included in this report.

1 Introduction

Annual collaborative studies for World Grain Networks (WGN) have been performed by FOSS since more than twenty years. It started as a European Grain Network (EGN) study and has now grown to a worldwide study. The NIR determinations of wheat and barley fully complies the EN 15948 standard.

The original purpose some twenty years ago was

- harmonization of the different local/ regional grain networks
- see whether there are differences between the master labs
- make adjustments of data to be included in calibrations, if necessary
- serve members with information

Since 2006 a slightly modified format for the study has been applied, following the ISO 5725-2 protocol and including wheat and barley samples.

The reasons for this modification were to give the members improved information and to perform the annual validation of prediction models used in accordance with EN ISO 12099, using samples from the actual harvest in different countries and applying the reference methods valid in the different countries.

The WGN proficiency test is also seen as a tool to achieve or maintain ISO 17025 approvals, i.e. to prove the competencies of participating labs/networks.

The ring test of 2013 were expanded to include rapeseed and became a worldwide study covering four continents. This year ring test follows in these footsteps and now includes participants from six continents with similar number of both participants and countries as last year: forty-six participants as compared to forty-seven last year; and twenty-three as compared to twenty-four countries last year.

This multi sample and multi parameter inter-laboratory study was organized by FOSS Analytical (Denmark) in February/March 2021 with Dr. T. Nilsson as project leader. The preliminary results of the study were presented on the 27th FOSS Grain Network meeting as a Webinar 16 March 2021, due to the Covid-19 pandemic.

2 Participants

Forty-six participants from twenty-three countries submitted results:

Argentina	**Bolsa de Commercio de Rosario (BCR)**
Australia	**GrainCorp**
Austria	**RWA**
Belgium	**CRA-W**
Canada	**Canadian Grain Commission**
Canada	**SGS**
China	**FOSS Suzhou**
Czech Republic	**Agrovykup**
Czech Republic	**Plzensky Prazdroj (Pilsner Urquel)**
Denmark	**FOSS Analytical**
Denmark	**Viking Malt**
Estonia	**Agricultural Research Centre**
Estonia	**Avena Nordic Grain**
Estonia	**Scanola Baltic**
Finland	**Food Safety Authority**
France	**Agroreso (Arvalis)**
France	**Laborargo - InVivo**
France	**Malteurop Technical Center**
France	**Ulice (Limagrain)**
Germany	**Cargill**
Germany	**Max Rubner Institute, Detmold**
Hungary	**Mertcontrol**
Hungary	**SGS**
Italy	**CREA-QCE, Rome**

Latvia	**Eira Lab**
Latvia	**Institute of Agricultural Resources and Economics**
Lithuania	**Plant Products Quality Testing Laboratory**
Malaysia	**Prestasi Flour Mill**
The Netherlands	**Agrifirm Plant**
Poland	**Cargill**
Poland	**Hamilton**
Poland	**Inspectis, Gdansk**
South Africa	**BKB**
South Africa	**GWK**
South Africa	**InBev-BBI**
South Africa	**Overberg Agri**
South Africa	**OVK**
South Africa	**Rhine Ruhr**
South Africa	**SAGL**
South Africa	**Senwes**
South Africa	**SSK**
Sweden	**Eurofins**
Sweden	**Lantmännen**
Ukraine	**Nibulon**
United Kingdom	**Sciantec Analytical Services**
United Kingdom	**Sharnbrook Grain**

Many of the participating laboratories are master labs of NIR networks.

3 Information about the methods used

3.1 Reference analyses

All participating labs were asked to report reference analyses results and the reference analysis methods used by them according to the description and the method codes below.

Wheat & Barley		
Parameter	**Code**	**Method**
Moisture	M01	EN ISO 712 (130° C; 2 h)
	M02	ICC 110/1 (130° C; 2 h)
	M03	other
Protein	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
	P02	EN ISO 16634 (Dumas combustion)
	P03	EN ISO 5983-2 (Keddah, Cu)
	P04	ICC 105/2 (Kjeldahl)
	P05	ICC 167 (Dumas combustion)
	P06	other
Wet	G01	ICC 155
Gluten	G02	ICC 137/1
	G03	ISO 21415-1 (manual)
	G04	ISO 21415-2 (mechanical)
	G05	other
Starch	S01	ICC 122/1 (polarimetric, CaCl2)
	S02	ICC 123/1 (polarimetric, HCl)
	S03	ISO 15914 (enzymatic)
	S04	other
Zeleny	Z01	ICC 116/1
	Z02	ISO 5529
	Z03	other
Test	T01	ISO 7971-3 (mass per hectolitre)
Weight	T02	EEC 71/347 (mass per hectolitre)
	T03	other
Falling	F01	ICC 107/1
Number	F02	ISO 3093
Hardness	H01	SKCS (single kernel characterisation system)
	H02	ICC 129 (vitreousness of durum wheat)
	H03	other
Rapeseed		
Parameter	**Code**	**Method**
Moisture	M01	ISO 665:2000 (103° C; 1 h, whole seed)
	M02	ISO 10565:1998 (NMR)
	M03	other
Oil	O01	ISO 659:2009
	O02	FOSFA 111
	O03	other
	O04	ISO 10565:1998 (NMR)

Table 3.1: Methods and method codes used in this study.

The methods used by each laboratory are reported in the result section for each of the parameters. In addition to the list in Table 3.1, results for Protein, Glucosinolates and Erucic Acid, Oleic Acid, Linolenic Acid, Linoleic Acid and Free fatty acid acidity index were reported for Rapeseed.

3.2 NIR analyses using calibrations currently used in the respective networks

In addition to the reference analyses results each laboratory was asked to report the results for covered parameters predicted by the calibration models installed in their local networks. The calibration models used were FOSS ANN calibrations, locally bias adjusted to the local master lab, or – in some cases – ANN models of older date, or - for other parameters than moisture and protein - also PLS models.

3.3 NIR analyses using the global ANN calibration model WB003034

Participating labs were asked to send scans performed on their Infratec instruments (models 1241 and NOVA) to FOSS for evaluation by the ANN model WB003034. The combined Wheat and Barley calibration WB003034 is usually sold as individual calibrations with typical labels WH003034 and BA003034, respectively. Other labels may exist with variants including other parameters. These options are provided for the convenience of getting results sorted by the different grain types.

The ANN calibration model **WB003034** for the simultaneous prediction of protein and moisture contents in whole grain of wheat and barley is based on 10-30 000 samples (see Table 3.3.1).

Parameter	N	Min	Max
Moisture (%)	**10 572**	**6.2 %**	**30.0 %**
Protein (% d.m.)	**30 092**	**6.7 %**	**23.7 %**

Table 3.3.1: Number of samples (N) included and ranges covered by the ANN model WB003034

The model has been validated in accordance with EN ISO 12099 and EN 15948 using independent test sets of wheat and barley samples, originating from different parts of the world, representing different classes, varieties and growing conditions and analysed by the reference methods given above.
A summary is given in table 3.3.2.

Parameter	N	Accuracy	Min	Max	RSQ
Moisture	**4 600**	**0.24**	**7.8 %**	**29.9 %**	**0.99**
Protein (d.m.)	**11 822**	**0.27**	**6.9 %**	**24.0 %**	**0.99**

Table 3.3.2: ANN model **WB003034** validation summary

N: Number of samples in the independent validation data set.

Accuracy*: Overall accuracy expressed as SEP as constituent % w/w.

Min: Minimum value in the validation set.

Max: Maximum value in the validation set.

RSQ*: Overall linear correlation coefficient between ANN predicted results and chemical reference analysis results.

*NOTE: Depending on the accuracy of the reference values

The predictions made with this model are without any bias correction.

In original development work 50 different test sets covering a wide range of aspects were used to evaluate and choose an ANN model that is as strong as possible on all evaluated parameters – overall accuracy, repeatability, transferability between instruments as well as ability to handle grain temperature variations without showing any significant weaknesses in any of these areas.

In total the independent test sets used included 4600 samples for moisture and 11 822 for protein. When such large data sets are used it is inevitable that there is an influence from the reproducibility between laboratories due to the reference methods used. There is always some uncontrolled variation between the different reference laboratories involved. Individual smaller independent test sets based on data from a single laboratory generally perform much better than the average of the total test set. In the example given in Table 3.3.3 all reference testing was done using one single laboratory.

Parameter	N	Accuracy	Min	Max	RSQ
Moisture	**75**	**0.14**	**1.12%**	**23.70%**	**0.999**
Protein (d.m.)	**67**	**0.16**	**9.70%**	**16.30%**	**0.991**

Table 3.3.3: Example of a validation subset for the ANN model WB003034 (Wheat, harvest 2007, one country, one reference lab)

3.4 NIR analyses using the global ANN calibration model RA002635

Participating labs were asked to send scans performed on their Infratec instruments (models 1241 and NOVA) to FOSS for evaluation by model RA002635.

The calibration model RA002635 for the prediction of oil and moisture contents in whole rapeseeds is based on about 7000 samples (see Table 3.4.1).

Parameter	N	Min	Max
Moisture (%)	6881	3.4 %	34.6 %
Oil (% d.m.)	7458	31.2 %	55.6 %

Table 3.4.1: Number of samples (N) included and ranges covered by the model RA002635

The model has been validated in accordance with EN 12099 using independent test sets, originating from different parts of the world, representing different classes, varieties and growing conditions and analysed by the reference methods given above.
A summary is given in table 3.4.2.

Parameter	N	Accuracy	Min	Max	RSQ
Moisture	2977	0.39	3.4%	25.8 %	0.97
Oil (d.m.)	3175	0.86	34.6 %	54.8 %	0.91

Table 3.4.2: Calibration model RA002635 validation summary

N:	Number of samples in the independent validation data set.
Accuracy*:	Overall accuracy expressed as SEP as constituent % w/w.
Min:	Minimum value in the validation set.
Max:	Maximum value in the validation set.
RSQ*:	Overall linear correlation coefficient between ANN predicted results and chemical reference analysis results.

*NOTE: Depending on the accuracy of the reference values

The predictions made with this model are without any bias correction.

4 Design of the study

Tables 4.1.1 – 4.1.3 gives an overview of the samples used for the study.

Wheat samples		
Marking	**Specification**	**Country**
W1	Wheat	Latvia
W2	Winter Wheat	Poland
W3	“Julius” Wheat	Germany
W4	“Boregar” Wheat	Germany
W5	“Zyatt” Wheat	UK
W6	“Extase” Wheat	Denmark
W7	Wheat	France
W8	Wheat	Latvia
W9	Durum wheat	Italy
W10	Starch wheat	Sweden

Table 4.1.1: 2020 harvest wheat samples selected for the study (W1-W4 from 2019)

Barley samples		
Marking	**Specification**	**Country**
B1	Winter Barley	Poland
B2	Barley	Denmark
B3	” Touareg” Winter Barley	Germany
B4	”California” Winter Barley	Germany
B5	”Flagon” Winter Barley	UK
B6	”Planet” Spring Barley	Denmark
B7	Barley	France
B8	”Laureate” Spring Barley	UK
B9	Barley	Finland
B10	”Planet” Spring Barley	Sweden

Table 4.1.2: 2020 harvest barley samples selected for the study (B1-B4 from 2019)

Rapeseed samples		
Marking	**Specification**	**Country**
R1	Rapeseed	Poland
R2	Rapeseed	Latvia
R3	Rapeseed	Finland
R4	Rapeseed	Denmark
R5	Rapeseed	UK
R6	Rapeseed	Denmark
R7	Rapeseed	France
R8	Rapeseed	Finland
R9	Rapeseed	Poland
R10	Rapeseed	Sweden

Table 4.1.3: 2020 harvest rapeseed samples selected for the study (R1-R4 from 2019)

Samples have been collected by the different networks and were sent to the company Eurofins (SWE) for cleaning and dividing. Each sample was about 1 kg and the sample sets were shipped from Eurofins in Sweden to FOSS in Denmark and then forwarded to each participant.

In total 46 laboratories from 23 countries participated in this study.

All wheat and barley samples had to be analyzed at least for the **moisture** and **protein** contents by the reference methods used and/or for the moisture and protein contents predicted by the local prediction models used in the respective networks. In a similar way, oil and moisture in rapeseed had to be analyzed. In addition, scans from the respective master instruments were supplied to be analyzed by FOSS using the ANN calibration model WB003034 and RA002635.
On a voluntary basis, participants could also submit data for the reference analysis of other parameters, for the mass per hectoliter using the Infratec TWM and for results obtained by NIR prediction models for other parameters.

5 Results for protein and moisture in Wheat & Barley

5.1 Collation of results

5.1.1 Protein content by reference methods

Twenty-seven labs reported reference data on basis of reference methods for Protein.

Labcode	Method code	Standard
1	P04	ICC 105/2 (Kjeldahl)
2	P02	EN ISO 16634 (Dumas combustion)
4	P01	EN ISO 20483 (KJELDAHL, Cu/Ti)
5	P01	EN ISO 20483 (KJELDAHL, Cu/Ti)
8	P04	ICC 105/2 (Kjeldahl)
10	P02	EN ISO 16634 (Dumas combustion)
12	P02	EN ISO 16634 (Dumas combustion)
15	P02	EN ISO 16634 (Dumas combustion)
17	P01	ISO 20483 (Kjeldahl, Cu/Ti)
18	P01	EN ISO 20483 (KJELDAHL, Cu/Ti)
19	P01	ISO 20483 (Kjeldahl, Cu/Ti)
27	P06	AACCI 46-30.01 (Dumas)
30	P06	AACCI 46-30.01 (Dumas)
32	P06	Analytica EBC 3.3.1 Total Nitrogen of barley (Kjeldahl)
33a	P02	EN ISO 16634 (Dumas combustion)
35	P02	EN ISO 16634 (Dumas combustion)
64	P01	ISO 20483 (Kjeldahl, Cu/Ti)
68	P01	ISO 20483 (Kjeldahl, Cu/Ti)
73	P06	AOAC 984.13 (Kjeldahl)
75a	P03	EN ISO 5983-2 (Kjeldahl, Cu)
77a	P06	AOAC 2001.11:2005 (Kjeldahl)
80	P01	ISO 20483 (Kjeldahl, Cu/Ti)
81	P04	ICC 105/2 (Kjeldahl)
84	P01	ISO 20483 (Kjeldahl, Cu/Ti)
88	P03	EN ISO 5983-2 (Kjeldahl, Cu)
94	P02	EN ISO 16634 (Dumas combustion)
98	P03	EN ISO 5983-2 (Kjeldahl, Cu)

Table 5.1.1: Reference methods used for protein determination

A complete compilation of the protein results for all samples by the reference methods is shown in tables 5.1.1.1 (wheat) and 5.1.1.2 (barley) below.

5.1.2 Moisture content by reference methods

Twenty-nine labs reported reference data on basis of reference methods for Moisture.

Labcode	Method code	Standard	Description
1	M01	ISO 712:2009	130° C, 2 h
2	M01	ISO 712:2009	130° C, 2 h
4	M02	ICC 110/1	130° C, 2 h
5	M01	ISO 712:2009	130° C, 2 h
8	M02	ICC 110/1	130° C, 2 h
10	M03	ASAE S352.2 DEC97	130° C, 19 h
12	M02	ICC 110/1	130° C, 2 h
15	M01	ISO 712:2009	130° C, 2 h
17	M01	ISO 712:2009	130° C, 2 h
18	M01	ISO 712:2009	130° C, 2 h
19	M01	ISO 712:2009	130° C, 2 h
25	M01	ISO 712:2009	130° C, 2 h
27	M03	AACC 44-15A	130° C, 1 h
30	M02	ICC 110/1	130° C, 2 h
32	M03	Analytica EBC 3.2	130° C, 2 h
33	M01	ISO 712:2009	130° C, 2 h
35	M03	AACC 44-15.02	130° C, 1 h
64	M01	ISO 712:2009	130° C, 2 h
68	M01	ISO 712:2009	130° C, 2 h
75a	M01	ISO 712:2009	130° C, 2 h
77a	M03	IRAM 15850-1:2009	130° C, 2 h
80	M01	ISO 712:2009	130° C, 2 h
81	M02	ICC 110/1	130° C, 2 h
82	M01	ISO 712:2009	130° C, 2 h
84	M03	Non-compliant	Speed dry machine
88	M01	ISO 712:2009	130° C, 2 h
91	M01	ISO 712:2009	130° C, 2 h
94	M01	ISO 712:2009	130° C, 2 h
98	M01	ISO 712:2009	130° C, 2 h

Table 5.1.2: Reference methods used for moisture determinations

A complete compilation of the moisture results for all samples by the reference methods is shown in tables 5.1.2.1 (wheat) and 5.1.2.2 (barley) below.

5.1.3 Protein content by NIR predictions using calibrations currently used in the respective networks

See tables I.1 (wheat) and I.2 (barley) in Annex I.

5.1.4 Moisture content by NIR predictions using calibrations currently used in the respective networks.

See table I.3 (wheat) and I.4 (barley) in Annex I.

5.1.5 Protein content by using the ANN model WB003034

See table II.1 (wheat) and II.2 (barley) in Annex II.

5.1.6 Moisture content by using the ANN model WB003034

See table II.3 (wheat) and II.4 (barley) in Annex II.

Legend to tables below:

Mean Average value of values for all samples reported by one lab (lab average)

Dev Deviation (difference) of this average value (Mean) from the average values of all labs

SDD Standard deviation of the differences of the reported values for a certain sample by a certain lab from the average values

Average >Average< of the reported value for a certain sample (before elimination of outliers)

Std Standard deviation of the values reported for a certain sample (before elimination of outliers)

Min Minimum of the reported values for a certain sample

Max Maximum of the reported values for a certain sample

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	12.80	14.80	12.30	12.30	12.70	12.60	11.60	13.30	12.20	12.30	12.69	-0.32	0.10
2	13.25	15.46	12.50	12.59	12.99	13.27	12.20	13.91	12.87	12.80	13.18	0.17	0.09
4	13.16	15.08	12.44	12.45	12.80	12.74	11.84	13.72	12.54	12.49	12.93	-0.08	0.11
5	13.10	15.00	12.50	12.40	12.90	13.10	12.10	13.90	12.80	12.60	13.04	0.03	0.12
8	13.03	15.06	12.49	12.43	12.80	13.02	11.97	13.55	12.56	12.49	12.94	-0.07	0.05
10	13.30	15.20	12.70	12.50	12.80	12.80	12.00	13.70	12.50	12.60	13.01	0.00	0.14
12	13.00	15.00	12.00	12.30	12.80	13.00	11.90	13.60	12.60	12.70	12.89	-0.12	0.14
15	13.31	15.26	12.68	12.74	13.07	13.06	12.02	13.68	12.78	12.92	13.15	0.14	0.10
17	13.30	15.20	12.50	12.40	13.00	13.20	12.00	13.50	12.50	12.60	13.02	0.01	0.11
18	13.12	15.23	12.08	12.47	12.95	13.07	12.11	13.72	12.57	12.65	13.00	-0.01	0.14
19	13.13	15.09	12.37	12.49	12.84	12.91	11.98	13.56	12.66	12.52	12.96	-0.06	0.06
27	12.81	14.95	12.29	12.34	12.69	12.87	11.79	13.51	12.66	12.54	12.85	-0.17	0.09
30	13.24	15.28	12.60	12.55	12.91	13.11	12.02	13.73	12.68	12.63	13.08	0.06	0.05
33	13.10	15.23	12.59	12.43	12.98	13.09	12.06	13.96	12.76	12.88	13.11	0.10	0.11
35	13.20	15.40	12.80	12.60	13.20	13.20	12.20	13.80	13.00	12.70	13.21	0.20	0.11
64	13.10	14.90	12.50	12.40	12.90	13.10	11.90	13.70	12.40	12.50	12.94	-0.07	0.10
68	13.29	14.99	12.42	12.51	12.66	13.00	11.83	13.50	12.52	12.60	12.93	-0.08	0.11
73	13.41	15.31	12.49	12.44	13.29	13.65	12.41	13.64	12.96	13.18	13.28	0.27	0.23
75a	13.11	15.14	12.46	12.47	12.86	13.07	11.96	13.64	12.62	12.57	12.99	-0.02	0.02
77a	13.10	15.00	12.40	12.70	12.80	13.30	12.00	13.50	12.70	12.50	13.00	-0.01	0.14
80	13.51	15.64	12.79	12.86	13.28	13.26	12.32	13.92	12.79	12.86	13.32	0.31	0.10
81	12.90	15.10	12.30	12.40	12.70	12.90	11.60	13.40	12.40	12.40	12.81	-0.20	0.10
88	13.00	15.14	12.31	12.34	12.80	13.00	11.94	13.54	12.65	12.51	12.92	-0.09	0.06
94	13.15	15.06	12.55	12.36	12.92	13.00	12.07	13.74	12.57	12.54	13.00	-0.02	0.08
98	13.30	14.90	12.80	12.40	12.70	13.30	12.00	13.70	12.40	12.90	13.04	0.03	0.21
Average	13.1	15.1	12.5	12.5	12.9	13.1	12.0	13.7	12.6	12.6	13.0	0.0	0.1
Std	0.17	0.19	0.20	0.14	0.17	0.21	0.19	0.17	0.18	0.19	0.14	0.14	0.05
Min	12.8	14.8	12.0	12.3	12.7	12.6	11.6	13.3	12.2	12.3	12.7	-0.3	0.0
Max	13.5	15.6	12.8	12.9	13.3	13.7	12.4	14.0	13.0	13.2	13.3	0.3	0.2

Deviation = Mean Value - Average Value
SDD=Standard Deviation of Differences (after adjustment for deviation)

Table 5.1.1.1: Compilation of results for the reference analyses of the protein content (d.m.) in wheat samples

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	9.70	11.50	10.10	11.70	9.30	8.80	11.00	11.70	12.10	10.80	10.67	-0.46	0.16
2	10.65	12.26	10.20	11.77	10.23	9.13	11.48	12.64	12.83	11.43	11.26	0.13	0.26
4	10.28	11.51	10.47	11.88	9.73	9.03	11.11	12.14	12.44	11.16	10.98	-0.15	0.15
5	10.30	11.70	10.50	12.10	10.20	9.20	11.20	12.40	12.80	11.40	11.18	0.05	0.13
8	10.52	11.80	10.46	12.05	10.22	9.14	11.28	12.17	12.64	11.39	11.16	0.03	0.09
12	10.50	12.20	10.40	12.20	9.50	9.10	11.70	12.20	12.40	11.30	11.15	0.02	0.28
15	10.39	12.08	10.44	12.26	10.15	8.85	11.29	12.30	12.89	11.88	11.25	0.12	0.20
17	10.00	11.90	10.40	11.90	9.90	9.10	11.30	12.00	12.30	11.30	11.01	-0.12	0.12
18	10.36	11.83	10.57	12.32	10.35	9.31	11.38	12.30	12.64	11.40	11.25	0.12	0.09
19	10.29	11.90	10.34	12.07	10.10	9.11	11.34	12.13	12.52	11.37	11.12	-0.01	0.04
27	10.19	11.78	10.28	12.11	9.99	8.96	11.19	11.80	12.58	11.54	11.04	-0.09	0.13
30	10.30	11.75	10.45	12.17	10.15	9.24	11.33	12.24	12.62	11.44	11.17	0.04	0.06
32	10.38	11.81	10.69	12.25	10.13	9.25	11.25	12.38	12.44	11.34	11.19	0.06	0.13
33	10.07	11.74	10.31	12.18	10.06	8.99	11.18	12.20	12.59	11.56	11.09	-0.04	0.12
35	10.65	12.17	10.45	12.47	10.51	9.41	11.47	12.30	12.71	11.68	11.38	0.25	0.11
64	10.40	11.90	10.50	12.10	10.00	9.20	11.20	12.20	12.40	11.40	11.13	0.00	0.08
68	10.23	11.86	10.31	12.00	10.11	9.10	11.22	12.28	12.48	11.40	11.10	-0.03	0.06
75a	10.35	11.78	10.46	12.04	10.15	9.20	11.18	12.00	12.54	11.37	11.11	-0.02	0.08
77a	10.20	12.00	10.60	12.20	9.80	9.10	11.10	12.10	12.60	11.90	11.16	0.03	0.22
80	10.71	12.22	10.64	12.44	10.63	9.58	11.59	12.59	12.97	11.73	11.51	0.38	0.08
84	9.90	11.20	10.20	12.00	10.00	9.00	10.70	11.30	11.90	10.70	10.69	-0.44	0.29
88	10.03	11.88	10.28	12.10	10.13	9.16	11.28	12.19	12.47	11.22	11.07	-0.06	0.10
94	10.34	11.98	10.28	12.06	10.11	9.09	11.15	11.92	12.23	11.38	11.05	-0.08	0.13
98	10.39	11.99	10.16	12.31	10.68	9.49	11.76	12.48	12.90	11.79	11.40	0.27	0.23
Average	10.3	11.9	10.4	12.1	10.1	9.1	11.3	12.2	12.5	11.4	11.1	0.0	0.1

Std	0.24	0.24	0.15	0.19	0.31	0.18	0.22	0.29	0.25	0.28	0.19	0.19	0.07
Min	9.7	11.2	10.1	11.7	9.3	8.8	10.7	11.3	11.9	10.7	10.7	-0.5	0.0
Max	10.7	12.3	10.7	12.5	10.7	9.6	11.8	12.6	13.0	11.9	11.5	0.4	0.3

Deviation = Mean Value - Average Value
SDD=Standard Deviation of Differences (after adjustment for deviation)

Table 5.1.1.2: Compilation of results for the reference analyses of the protein content (d.m.) in barley samples

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	12.78	13.80	11.14	11.63	13.20	14.15	13.66	12.95	11.99	12.80	12.8	-0.01	0.05
2	13.10	14.08	11.35	11.75	13.35	14.39	13.95	13.19	12.47	13.14	13.1	0.26	0.08
4	12.90	13.97	11.16	11.73	13.26	14.31	13.88	13.03	12.18	12.93	12.9	0.12	0.03
5	12.70	13.80	11.20	11.70	13.20	13.90	13.30	12.90	12.10	12.80	12.8	-0.06	0.17
8	12.78	13.78	11.06	11.58	13.04	13.99	13.60	12.84	11.99	12.63	12.7	-0.09	0.07
10	12.40	13.30	10.50	11.30	12.80	13.70	13.30	12.30	11.60	12.30	12.4	-0.47	0.10
12	12.90	13.80	10.90	11.50	13.10	14.20	13.70	12.80	12.10	12.90	12.8	-0.03	0.09
15	12.80	13.72	10.99	11.51	13.15	14.20	13.59	12.85	11.99	12.75	12.8	-0.06	0.05
17	12.96	13.96	11.21	11.67	13.27	14.34	13.90	13.10	12.31	12.98	13.0	0.15	0.05
18	12.84	13.86	11.10	11.59	12.86	14.29	13.71	13.08	12.08	12.95	12.8	0.02	0.13
19	12.98	14.04	11.25	11.73	13.32	14.45	13.95	13.11	12.28	13.06	13.0	0.20	0.04
25	12.50	13.60	10.30	11.40	13.00	14.10	13.40	12.60	11.80	12.60	12.5	-0.29	0.19
27	12.85	13.87	11.14	11.60	13.25	14.26	13.73	12.87	12.11	12.87	12.9	0.04	0.04
30	12.33	13.13	10.63	10.91	12.22	13.11	12.80	12.02	11.20	11.87	12.0	-0.80	0.22
33	13.29	14.32	11.69	12.21	13.74	14.80	14.24	13.50	12.73	13.26	13.4	0.56	0.07
35	12.72	13.78	10.88	11.44	13.17	14.12	13.71	12.76	11.87	12.70	12.7	-0.10	0.08
64	12.91	13.99	11.26	11.71	13.35	14.29	13.82	13.06	12.15	13.04	13.0	0.14	0.05
68	12.95	13.87	11.18	11.76	13.27	14.36	13.89	12.97	12.09	12.95	12.9	0.11	0.05
75a	12.79	13.80	11.08	11.61	13.16	14.20	13.72	12.92	12.08	12.83	12.8	0.00	0.00
77a	12.70	13.70	11.20	11.60	13.10	14.20	13.70	12.90	12.20	12.90	12.8	0.00	0.08
80	13.03	14.08	11.27	11.89	13.36	14.51	13.95	13.20	12.36	13.10	13.1	0.26	0.04
81	12.70	13.70	10.90	11.60	13.10	14.20	13.70	12.90	11.90	12.70	12.7	-0.08	0.07
82	12.81	13.95	11.34	11.83	13.20	14.34	13.89	13.07	12.29	13.01	13.0	0.16	0.08
88	12.68	13.84	11.05	11.60	13.14	14.18	13.80	12.97	12.07	12.87	12.8	0.00	0.05
91	12.77	13.74	11.14	11.56	13.13	14.19	13.96	12.92	12.00	12.75	12.8	0.00	0.10
94	12.98	14.04	11.18	11.77	13.36	14.46	13.94	13.12	12.29	13.05	13.0	0.20	0.04

98	12.30	13.20	10.90	11.40	13.20	14.10	13.60	12.90	11.70	12.50	12.6	-0.24	0.21
Average	12.8	13.8	11.1	11.6	13.2	14.2	13.7	12.9	12.1	12.8	12.8	0.0	0.1
Std	0.22	0.26	0.28	0.23	0.26	0.30	0.28	0.28	0.29	0.28	0.25	0.25	0.05
Min	12.3	13.1	10.3	10.9	12.2	13.1	12.8	12.0	11.2	11.9	12.0	-0.8	0.0
Max	13.3	14.3	11.7	12.2	13.7	14.8	14.2	13.5	12.7	13.3	13.4	0.6	0.2

Deviation = Mean Value - Average Value
SDD=Standard Deviation of Differences (after adjustment for deviation)

Table 5.1.2.1: Compilation of results for the reference analyses of the moisture content in wheat samples

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	13.69	12.91	12.02	13.55	14.55	13.16	13.00	12.86	13.07	13.04	13.2	-0.05	0.06
2	13.94	13.13	12.43	13.91	14.78	13.37	13.38	13.11	13.58	13.45	13.5	0.27	0.06
4	13.83	13.05	12.25	13.70	14.71	13.26	13.22	13.01	13.30	13.28	13.4	0.12	0.03
5	13.80	12.80	12.20	13.60	14.50	12.90	12.80	12.80	13.00	12.90	13.1	-0.11	0.15
8	13.68	12.95	12.13	13.54	14.48	13.01	12.96	12.76	13.10	13.03	13.2	-0.08	0.08
12	13.80	13.00	12.20	13.60	14.60	13.20	13.10	12.90	13.40	13.30	13.3	0.07	0.05
15	13.71	13.05	12.09	13.56	14.67	13.35	13.25	13.08	13.38	13.32	13.3	0.11	0.08
17	13.92	13.05	12.32	13.68	14.65	13.31	13.25	13.04	13.41	13.37	13.4	0.16	0.04
18	13.69	12.70	11.98	12.71	14.74	13.20	13.21	12.82	13.32	13.26	13.2	-0.07	0.29
19	13.98	13.18	12.34	13.90	14.80	13.43	13.38	13.13	13.51	13.44	13.5	0.27	0.04
25	13.60	13.10	12.30	13.60	14.20	13.10	13.00	12.80	13.20	13.10	13.2	-0.04	0.16
27	13.73	12.81	12.10	13.54	14.49	13.13	13.03	12.69	13.20	13.00	13.2	-0.06	0.07
30	13.59	12.81	12.13	13.38	14.44	13.10	13.05	12.81	13.21	13.16	13.2	-0.07	0.05
32	13.70	12.90	12.10	13.50	14.60	13.20	13.10	12.90	13.20	13.10	13.2	-0.01	0.03
33	14.07	13.16	12.44	13.92	14.79	13.42	13.49	13.12	13.65	13.43	13.5	0.31	0.07
35	13.82	12.99	11.98	13.53	14.65	13.18	13.17	12.90	13.20	13.20	13.3	0.03	0.07
64	13.85	12.95	12.26	13.82	14.69	13.25	13.32	13.09	13.39	13.44	13.4	0.17	0.08
68	13.75	12.96	12.10	13.65	14.66	13.24	13.14	12.94	13.29	13.04	13.3	0.04	0.07
75a	13.70	12.91	12.18	13.48	14.49	13.19	13.13	12.80	13.21	13.08	13.2	-0.02	0.05
77a	13.60	12.80	12.00	13.50	14.40	13.10	13.10	12.80	13.20	13.00	13.2	-0.09	0.05
80	13.90	13.11	12.26	13.60	14.80	13.40	13.35	13.12	13.41	13.41	13.4	0.20	0.06
82	13.84	13.00	12.27	13.59	14.61	13.27	13.28	13.00	13.37	13.24	13.3	0.11	0.04
84	11.80	11.20	10.60	11.60	12.80	11.60	11.40	11.50	11.50	11.60	11.6	-1.68	0.17
88	13.70	12.83	12.00	13.54	14.42	13.21	13.14	12.86	13.14	13.09	13.2	-0.04	0.06
91	13.79	13.03	11.95	13.51	14.68	13.29	13.08	13.03	13.27	13.31	13.3	0.06	0.10
94	14.03	13.19	12.38	13.92	14.85	13.49	13.43	13.18	13.51	13.44	13.5	0.31	0.04

98	13.90	13.10	12.20	13.70	14.70	13.40	13.00	12.80	13.20	13.10	13.3	0.07	0.13
Average	13.7	12.9	12.1	13.5	14.5	13.2	13.1	12.9	13.2	13.2	13.2	0.0	0.1
Std	0.40	0.37	0.33	0.45	0.38	0.34	0.38	0.31	0.38	0.35	0.36	0.36	0.06
Min	11.8	11.2	10.6	11.6	12.8	11.6	11.4	11.5	11.5	11.6	11.6	-1.7	0.0
Max	14.1	13.2	12.4	13.9	14.9	13.5	13.5	13.2	13.7	13.5	13.5	0.3	0.3

Deviation = Mean Value - Average Value
SDD=Standard Deviation of Differences (after adjustment for deviation)

Table 5.1.2.2: Compilation of results for the reference analyses of the moisture content in barley samples

5.2 Statistical evaluation for protein and moisture in Wheat & Barley

The statistical evaluation was made according to ISO 5725-2 using the Excel spreadsheet CLSTD.XLT version 4.0 from Ken Mathieson, CSL, York, UK. The results are summarized below. For detailed results and graphical presentation see Supplementary material WGN2021.

As no blind duplicates were included in the sample set only an evaluation of the reproducibility has been made, after outlier elimination according to Grubb's.

5.2.1 Protein by reference method

Twenty-seven sets of results on basis of Kjeldahl and Dumas methods (see table 5.1.1 above) have been used for this evaluation. A summary is given in tables 5.2.1.1 and 5.2.1.2 – for detailed results see section 1 in Supplementary material WGN2021.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	13.15	15.14	12.47	12.47	12.89	13.04	11.99	13.66	12.63	12.62
3	0.17	0.19	0.20	0.14	0.17	0.18	0.11	0.17	0.18	0.16
4	1.30	1.26	1.61	1.10	1.35	1.36	0.90	1.21	1.46	1.27

Table 5.2.1.1 Results of statistical analysis for the determination of the protein content in wheat samples by reference methods

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	10.30	11.89	10.40	12.11	10.09	9.15	11.28	12.20	12.57	11.47
3	0.24	0.20	0.15	0.19	0.31	0.18	0.22	0.23	0.22	0.20
4	2.31	1.70	1.47	1.55	3.06	1.97	1.97	1.85	1.74	1.77

Table 5.2.1.2 Results of statistical analysis for the determination of the protein content in barley samples by reference methods

Legend to tables: 1 = sample no, 2 = average value after elimination of outliers, 3 = standard deviation of reproducibility (in % CP), 4 = relative standard deviation of reproducibility (in %).

Z- Values for protein reference analyses:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results, i.e. line 2 in above tables) by the standard deviation of the method.

In the case of protein, a fixed value of s_R = 0.2 % has been chosen in accordance with EN ISO 20483 (Kjeldahl) and EN ISO 16634 (Dumas). Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 (marked yellow in below tables) and unsatisfactory for absolute values above 3 (marked red in below tables).

The wheat results show that the reference analyses for protein are overall under control in most labs. Lab 73 has four samples deviating with three (W5, W7 and W10) only mildly, whereas W6

deviate significantly. This is most likely random errors. There are a few yellow marked samples for some labs (1, 12, 18, 80 and 81), but nothing systematic that need to be corrected.

For barley, Labs 1 and 84 show evidence of a systematic negative bias with each having three red marked and 2-4 yellow marked samples. It is not the same samples being red marked so seems more to be method dependent rather than sample dependent. It is worth checking out the reason behind this bias. Lab 80 has 4 yellow marked and all samples have positive values, so an indication of a systematic shift, hence should be monitored. A few other labs have 1-2 yellow marked samples (labs 2, 12, 15, 27 and 77a), but seem to be more random error. Lab 98 has one red marked (W6) and one yellow marked (W8) but is otherwise aligned so probably random errors here also.

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-1.7	-1.7	-0.9	-0.9	-1.0	-2.2	-2.0	-1.8	-2.1	-1.6
2	0.5	1.6	0.1	0.6	0.5	1.2	1.0	1.2	1.2	0.9
4	0.1	-0.3	-0.2	-0.1	-0.5	-1.5	-0.8	0.3	-0.4	-0.6
5	-0.2	-0.7	0.1	-0.4	0.0	0.3	0.5	1.2	0.9	-0.1
8	-0.6	-0.4	0.1	-0.2	-0.5	-0.1	-0.1	-0.5	-0.3	-0.7
10	0.8	0.3	1.1	0.1	-0.5	-1.2	0.0	0.2	-0.6	-0.1
12	-0.7	-0.7	-2.4	-0.9	-0.5	-0.2	-0.5	-0.3	-0.1	0.4
15	0.8	0.6	1.0	1.3	0.9	0.1	0.1	0.1	0.8	1.5
17	0.8	0.3	0.1	-0.4	0.5	0.8	0.0	-0.8	-0.6	-0.1
18	-0.1	0.5	-2.0	0.0	0.3	0.1	0.6	0.3	-0.3	0.2
19	-0.1	-0.2	-0.5	0.1	-0.3	-0.7	-0.1	-0.5	0.2	-0.5
27	-1.7	-0.9	-0.9	-0.7	-1.0	-0.9	-1.0	-0.7	0.2	-0.4
30	0.5	0.7	0.6	0.4	0.1	0.3	0.1	0.4	0.3	0.1
33	-0.2	0.5	0.6	-0.2	0.4	0.2	0.3	1.5	0.7	1.3
35	0.3	1.3	1.6	0.6	1.5	0.8	1.0	0.7	1.9	0.4
64	-0.2	-1.2	0.1	-0.4	0.0	0.3	-0.5	0.2	-1.1	-0.6
68	0.7	-0.7	-0.3	0.2	-1.2	-0.2	-0.8	-0.8	-0.5	-0.1
73	1.3	0.9	0.1	-0.2	2.0	3.0	2.1	-0.1	1.7	2.8
75a	-0.2	0.0	-0.1	0.0	-0.1	0.2	-0.2	-0.1	-0.1	-0.2
77a	-0.2	-0.7	-0.4	1.1	-0.5	1.3	0.0	-0.8	0.4	-0.6
80	1.8	2.5	1.6	1.9	1.9	1.1	1.6	1.3	0.8	1.2
81	-1.2	-0.2	-0.9	-0.4	-1.0	-0.7	-2.0	-1.3	-1.1	-1.1
88	-0.7	0.0	-0.8	-0.7	-0.5	-0.2	-0.3	-0.6	0.1	-0.5
94	0.0	-0.4	0.4	-0.6	0.1	-0.2	0.4	0.4	-0.3	-0.4
98	0.8	-1.2	1.6	-0.4	-1.0	1.3	0.0	0.2	-1.1	1.4

Table 5.2.1.3: Z-scores for the determination of protein in wheat samples by reference methods

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	-3.0	-2.0	-1.5	-2.1	-3.9	-1.7	-1.4	-2.5	-2.3	-3.4
2	1.8	1.8	-1.0	-1.7	0.7	-0.1	1.0	2.2	1.3	-0.2
4	-0.1	-1.9	0.4	-1.2	-1.8	-0.6	-0.8	-0.3	-0.6	-1.6
5	0.0	-1.0	0.5	-0.1	0.6	0.3	-0.4	1.0	1.2	-0.4
8	1.1	-0.5	0.3	-0.3	0.6	-0.1	0.0	-0.2	0.4	-0.4
12	1.0	1.5	0.0	0.4	-2.9	-0.2	2.1	0.0	-0.8	-0.9
15	0.5	0.9	0.2	0.8	0.3	-1.5	0.0	0.5	1.6	2.0
17	-1.5	0.0	0.0	-1.1	-0.9	-0.2	0.1	-1.0	-1.3	-0.9
18	0.3	-0.3	0.9	1.0	1.3	0.8	0.5	0.5	0.4	-0.4
19	0.0	0.0	-0.3	-0.2	0.1	-0.2	0.3	-0.4	-0.2	-0.5
27	-0.5	-0.6	-0.6	0.0	-0.5	-0.9	-0.4	-2.0	0.1	0.3
30	0.0	-0.7	0.3	0.3	0.3	0.5	0.3	0.2	0.3	-0.2
32	0.4	-0.4	1.5	0.7	0.2	0.5	-0.1	0.9	-0.6	-0.7
33	-1.1	-0.8	-0.4	0.3	-0.1	-0.8	-0.5	0.0	0.1	0.4
35	1.8	1.4	0.3	1.8	2.1	1.3	1.0	0.5	0.7	1.0
64	0.5	0.0	0.5	-0.1	-0.4	0.3	-0.4	0.0	-0.8	-0.4
68	-0.3	-0.2	-0.4	-0.6	0.1	-0.2	-0.3	0.4	-0.4	-0.4
75a	0.3	-0.6	0.3	-0.4	0.3	0.3	-0.5	-1.0	-0.2	-0.5
77a	-0.5	0.5	1.0	0.4	-1.4	-0.2	-0.9	-0.5	0.2	2.1
80	2.1	1.6	1.2	1.6	2.7	2.2	1.6	1.9	2.0	1.3
84	-2.0	-3.5	-1.0	-0.6	-0.4	-0.7	-2.9	-4.5	-3.3	-3.9
88	-1.3	-0.1	-0.6	-0.1	0.2	0.1	0.0	-0.1	-0.5	-1.3
94	0.2	0.4	-0.6	-0.3	0.1	-0.3	-0.6	-1.4	-1.7	-0.5
98	0.5	0.5	-1.2	1.0	3.0	1.7	2.4	1.4	1.7	1.6

Table 5.2.1.4: Z-scores for the determination of protein in barley samples by reference methods

5.2.2 Moisture by reference method

Twenty-nine laboratories submitted reference results for the moisture content of the test samples. The methods used are given in table 5.1.2 above. Details are given in section 2 of Supplementary material WGN2021.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.79	13.86	11.13	11.62	13.17	14.24	13.77	12.96	12.08	12.86
3	0.22	0.13	0.14	0.14	0.14	0.15	0.15	0.14	0.20	0.21
4	1.75	0.96	1.24	1.22	1.09	1.02	1.09	1.10	1.69	1.64

Table 5.2.2.1- Results of statistical analysis for the determination of the moisture content in wheat samples by reference methods

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	13.79	12.98	12.18	13.63	14.61	13.24	13.17	12.94	13.30	13.21
3	0.13	0.13	0.14	0.15	0.15	0.14	0.16	0.14	0.16	0.17
4	0.94	1.03	1.18	1.11	1.05	1.05	1.24	1.09	1.19	1.28

Table 5.2.2.2 - Results of statistical analysis for the determination of the moisture content in barley samples by reference methods

Legend to tables: 1 = sample no, 2 = average value after elimination of outliers, 3 = standard deviation of reproducibility (in % H2O), 4 = relative standard deviation of reproducibility (in %).

Z- Values for moisture reference analyses:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

For moisture a fixed value of s_R = 0,14 % for wheat and of s_R = 0,17 % for barley has been chosen in accordance with EN ISO 712.

Absolute z-scores below 2 correspond to good laboratory performance.
The performance is questionable for absolute scores between 2 – 3 (marked yellow in below tables) and unsatisfactory for absolute values above 3 (marked red in below tables).

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-0.1	-0.4	0.1	0.1	0.2	-0.6	-0.8	-0.1	-0.6	-0.4
2	2.2	1.6	1.6	0.9	1.2	1.1	1.3	1.7	2.8	2.0
4	0.8	0.8	0.2	0.8	0.6	0.5	0.8	0.5	0.7	0.5
5	-0.7	-0.4	0.5	0.6	0.2	-2.4	-3.4	-0.4	0.1	-0.4
8	-0.1	-0.6	-0.5	-0.3	-1.0	-1.8	-1.2	-0.9	-0.6	-1.6
10	-2.8	-4.0	-4.5	-2.3	-2.7	-3.8	-3.4	-4.7	-3.4	-4.0
12	0.8	-0.4	-1.6	-0.8	-0.5	-0.3	-0.5	-1.1	0.1	0.3
15	0.0	-1.0	-1.0	-0.8	-0.2	-0.3	-1.3	-0.8	-0.6	-0.8
17	1.2	0.7	0.6	0.4	0.7	0.7	0.9	1.0	1.6	0.9
18	0.3	0.0	-0.2	-0.2	-2.2	0.4	-0.4	0.9	0.0	0.6
19	1.3	1.3	0.9	0.8	1.0	1.5	1.3	1.1	1.4	1.4
25	-2.1	-1.9	-5.9	-1.6	-1.2	-1.0	-2.7	-2.6	-2.0	-1.9
27	0.4	0.1	0.1	-0.1	0.5	0.2	-0.3	-0.6	0.2	0.1
30	-3.3	-5.2	-3.5	-5.1	-6.8	-8.1	-6.9	-6.7	-6.3	-7.1
33	3.5	3.3	4.0	4.2	4.0	4.0	3.3	3.9	4.6	2.9
35	-0.5	-0.6	-1.8	-1.3	0.0	-0.8	-0.4	-1.4	-1.5	-1.1
64	0.8	0.9	1.0	0.7	1.3	0.4	0.3	0.7	0.5	1.3
68	1.1	0.1	0.4	1.0	0.7	0.9	0.8	0.1	0.1	0.6
75a	0.0	-0.4	-0.3	0.0	-0.1	-0.3	-0.4	-0.3	0.0	-0.2
77a	-0.7	-1.1	0.5	-0.1	-0.5	-0.3	-0.5	-0.4	0.9	0.3
80	1.7	1.6	1.0	1.9	1.3	1.9	1.3	1.7	2.0	1.7
81	-0.7	-1.1	-1.6	-0.1	-0.5	-0.3	-0.5	-0.4	-1.3	-1.1
82	0.1	0.6	1.5	1.5	0.2	0.7	0.8	0.8	1.5	1.1
88	-0.8	-0.1	-0.5	-0.1	-0.2	-0.4	0.2	0.1	-0.1	0.1
91	-0.2	-0.9	0.1	-0.4	-0.3	-0.3	1.3	-0.3	-0.6	-0.8
94	1.3	1.3	0.4	1.1	1.3	1.6	1.2	1.1	1.5	1.4
98	-3.5	-4.7	-1.6	-1.6	0.2	-1.0	-1.2	-0.4	-2.7	-2.6

Table 5.2.2.3: Z-scores for the determination of moisture in wheat samples by reference methods

The results show that the determination of moisture in wheat deviates with a significant negative bias for two labs (10 and 30). Moisture loss during milling is the most likely reason. One lab has a significant positive bias (33), which could mean that their procedure is more optimized to withstand milling issues than for the other labs. Also, labs 25 and 98 samples deviating significantly and all with negative bias, hence an indication of moisture loss during milling as a possible reason. There are a few more labs with yellow marked samples (labs 2, 5, 18 and 80) and one with a red marked (lab 5). For labs 5 and 18, this seems to be of more random character, whereas for labs 2 and 80, there is a tendency of a positive bias.

The moisture determination for barley looks in general very good, but one lab 84 has a systematic negative bias. The reason for this is that they are using a speed drying method, which cannot be considered a standard method and is therefore designated a non-compliant method in the evaluation. A few labs (5, 25 and 33) has one or two yellow marked results of random nature. One lab (18) has a red marked sample that also seem to be random. These labs should be aware, but it is not alarming in any way.

The kind of mill used in connection with moisture determinations is very critical and this is probably the most common issue causing the deviating results for wheat and barley.

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	-0.6	-0.4	-0.9	-0.5	-0.4	-0.5	-1.0	-0.5	-1.3	-1.0
2	0.8	0.9	1.5	1.6	1.0	0.8	1.2	1.0	1.6	1.4
4	0.2	0.4	0.4	0.4	0.6	0.1	0.3	0.4	0.0	0.4
5	0.0	-1.1	0.1	-0.2	-0.7	-2.0	-2.2	-0.8	-1.7	-1.8
8	-0.7	-0.2	-0.3	-0.5	-0.8	-1.4	-1.2	-1.0	-1.2	-1.1
12	0.0	0.1	0.1	-0.2	-0.1	-0.2	-0.4	-0.2	0.6	0.5
15	-0.5	0.4	-0.5	-0.4	0.3	0.7	0.5	0.8	0.5	0.6
17	0.8	0.4	0.8	0.3	0.2	0.4	0.5	0.6	0.7	0.9
18	-0.6	-1.6	-1.2	-5.4	0.7	-0.2	0.3	-0.7	0.1	0.3
19	1.1	1.2	1.0	1.6	1.1	1.1	1.3	1.1	1.3	1.3
25	-1.1	0.7	0.7	-0.2	-2.4	-0.8	-1.0	-0.8	-0.6	-0.7
27	-0.4	-1.0	-0.5	-0.5	-0.7	-0.6	-0.8	-1.5	-0.6	-1.3
30	-1.2	-1.0	-0.3	-1.5	-1.0	-0.8	-0.7	-0.7	-0.5	-0.3
32	-0.5	-0.5	-0.5	-0.8	-0.1	-0.2	-0.4	-0.2	-0.6	-0.7
33	1.6	1.1	1.5	1.7	1.0	1.1	1.9	1.1	2.1	1.3
35	0.2	0.1	-1.2	-0.6	0.2	-0.3	0.0	-0.2	-0.6	-0.1
64	0.3	-0.2	0.5	1.1	0.4	0.1	0.9	0.9	0.5	1.3
68	-0.2	-0.1	-0.5	0.1	0.3	0.0	-0.2	0.0	0.0	-1.0
75a	-0.5	-0.4	0.0	-0.9	-0.7	-0.3	-0.2	-0.8	-0.5	-0.8
77a	-1.1	-1.1	-1.0	-0.8	-1.3	-0.8	-0.4	-0.8	-0.6	-1.3
80	0.6	0.8	0.5	-0.2	1.1	1.0	1.1	1.1	0.7	1.2
82	0.3	0.1	0.5	-0.3	0.0	0.2	0.7	0.4	0.4	0.2
84	-11.7	-10.5	-9.3	-12.0	-10.7	-9.6	-10.4	-8.5	-10.6	-9.5
88	-0.5	-0.9	-1.0	-0.5	-1.1	-0.2	-0.2	-0.5	-0.9	-0.7
91	0.0	0.3	-1.3	-0.7	0.4	0.3	-0.5	0.5	-0.2	0.6
94	1.4	1.2	1.2	1.7	1.4	1.5	1.5	1.4	1.3	1.3
98	0.6	0.7	0.1	0.4	0.5	1.0	-1.0	-0.8	-0.6	-0.7

Table 5.2.2.4: Z-scores for the determination of moisture in barley samples by reference methods

5.2.3 Protein determination using NIR prediction models currently used

Predictions of the protein content of each sample were made by the different laboratories using different instruments and their respective prediction models. A summary of the results of the statistical evaluation are given in table 5.2.3.1 and 5.2.3.2 – for detailed results see section 3 in Supplementary material WGN2021.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	13.17	15.09	12.52	12.42	12.94	13.16	12.15	13.67	12.53	12.70
3	0.02	-0.05	0.04	-0.06	0.05	0.12	0.15	0.01	-0.10	0.09
4	0.16	0.17	0.17	0.16	0.15	0.18	0.18	0.20	0.20	0.14
5	1.21	1.15	1.32	1.27	1.19	1.34	1.46	1.44	1.60	1.13

Table 5.2.3.1 - Results of statistical analysis for the determination of the protein content in <u>wheat</u> by local NIR predictions

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	10.46	11.94	10.55	12.15	10.04	9.33	11.38	12.13	12.36	11.50
3	0.17	0.05	0.15	0.04	-0.04	0.18	0.10	-0.07	-0.21	0.03
4	0.25	0.22	0.18	0.18	0.23	0.24	0.20	0.13	0.15	0.19
5	2.39	1.83	1.67	1.50	2.31	2.59	1.80	1.07	1.20	1.69

Table 5.2.3.2 - Results of statistical analysis for the determination of the protein content in <u>barley</u> by NIR predictions using calibrations currently used in the respective networks

Legend to tables: 1 = sample no, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % CP), 5 = relative standard deviation of reproducibility (in %).

Z- Values for protein by local NIR prediction models:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.2 % has been used as for the protein reference analyses.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 (marked yellow in above tables) and unsatisfactory for absolute values above 3.

The results do not only reflect variations due to sample inhomogeneity but also variations of the used prediction models. These may be due to optimization to local samples and local reference results. However, the deviations between different local protein prediction models seem to be rather small. For most wheat results, it looks good with only few yellow marked results. However, there are three instruments (labs 27b, 30f and 97) that deviate significantly. For labs 27b and 97, having all results red marked, it is most likely an incorrect bias adjustment or a moisture

compensation enabled. This can be verified with the re-prediction of the unadjusted ANN model, which is shown in a later section.

For barley, there are only four red marked results for lab 35 (35a-35c) and one for lab 97. It might be an instrument adjustment that pushes them over the limit, but it could also be outlier warning causing an incorrect average over subsamples. There are some yellow marked samples for several labs that most likely is related to inhomogeneity and thereby outlier results. It is recommended to check if any of the results are due to outliers or if there is a tendency to a systematic shift.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-1.4	-2.4	-1.1	-2.1	-1.2	-1.8	-0.7	-1.3	-2.2	-1.5
2	0.5	0.1	0.3	0.3	0.2	0.6	0.9	0.2	0.2	0.4
4a	0.1	0.6	-0.7	0.4	-0.2	-0.2	0.8	-0.2	-1.4	-0.9
4b	-0.1	-0.5	0.7	-0.4	-0.2	0.3	0.8	-0.7	0.1	-0.2
5	0.6	0.6	-0.1	0.4	0.8	0.2	0.3	-0.3	0.3	0.5
8a	0.1	1.1	0.2	-0.6	0.3	0.7	0.3	-0.1	-0.4	-0.3
8b	0.4	-0.2	-0.1	-0.1	0.3	0.0	-0.7	-0.3	0.1	0.0
10	-0.9	-1.9	0.4	0.4	0.3	-1.3	-0.7	-1.8	-0.7	-1.0
11	0.0	0.0	-0.3	-0.2	-0.3	0.2	-0.2	-0.1	0.1	-0.4
12	-0.4	-0.9	-1.1	-0.6	-0.7	-0.8	-1.2	-0.3	0.3	0.0
15	-0.4	-1.0	0.3	0.3	-0.2	-0.8	-1.5	-0.2	-0.7	-0.7
17a	-0.1	-0.4	0.4	0.2	0.5	-0.3	-0.2	-0.1	-0.7	-0.3
17b	-0.4	-0.4	0.4	0.4	-0.5	-0.5	-0.2	-0.1	0.1	-0.5
18	-0.9	0.1	0.4	-1.1	0.3	0.7	-0.2	0.2	0.3	0.0
19	-0.6	-1.0	0.0	0.0	-0.5	0.0	-0.4	-0.2	0.1	-0.7
25	-0.9	0.1	-1.1	-0.6	-0.2	-0.3	-0.7	-0.8	-0.7	-0.5
27a	1.0	1.3	1.4	0.9	1.1	2.1	-0.1	1.6	1.4	0.6
27b	-6.0	-7.5	-6.0	-5.9	-6.3	-6.7	-6.1	-6.0	-6.0	-6.0
30a	1.2	0.7	1.1	1.5	0.6	0.7	0.1	0.4	1.0	0.7
30b	1.2	1.3	-0.1	1.5	1.2	0.1	1.2	1.0	1.0	1.8
30c	-0.1	0.4	-0.7	-0.1	0.3	0.2	0.2	-0.1	-1.0	0.2
30d	0.1	0.4	-0.3	0.8	0.3	0.3	0.7	0.7	0.1	0.3
30e	0.7	0.7	0.9	-0.1	0.8	0.3	0.6	1.0	1.3	0.5
30f	0.7	-0.7	-2.1	0.2	7.0	11.8	14.0	2.0	2.5	6.9
30h	1.7	1.7	0.9	0.0	1.1	1.8	1.4	2.1	1.6	1.1
30i	1.0	1.1	0.9	0.3	0.7	0.4	1.4	0.5	-0.5	0.4
33	0.1	0.1	-0.1	0.4	0.8	-0.3	0.3	-0.3	-1.2	0.5
35a	1.1	1.1	0.9	1.4	2.3	1.2	1.8	1.7	0.8	1.0
35b	1.1	1.1	1.4	1.4	1.3	1.2	1.3	1.7	1.8	1.0
35c	1.1	1.1	1.9	1.4	2.3	1.7	1.8	1.7	1.3	2.0
35d	0.1	0.1	0.4	0.4	0.8	0.7	-0.2	0.7	-0.2	0.0
64	-0.9	-0.4	-0.6	-0.6	-0.2	-0.8	-0.7	-0.3	-0.7	-0.5
66	-0.4	0.6	0.4	-0.6	0.3	0.2	0.3	0.7	-0.2	0.0
68	-1.4	-2.4	-1.1	-1.1	-1.3	-1.3	-1.7	-0.8	-2.7	-1.0
73	-0.3	0.3	0.0	0.0	-0.1	0.1	-0.1	-0.3	0.3	0.5
75	-0.2	-0.2	-0.2	-0.1	0.0	-0.2	0.1	-0.2	-0.1	-0.3

77a	-0.1	-2.1	0.1	0.0	0.1	0.4	1.1	-1.2	-0.2	0.3
80	-0.4	0.5	0.3	0.0	0.4	-0.1	-0.4	0.7	-0.4	-0.3
81	-0.4	0.1	-0.1	-0.6	0.3	0.2	0.3	0.2	-0.2	-0.5
82	0.1	-0.4	0.4	0.4	-0.7	0.2	0.3	0.2	0.3	0.0
85	-1.9	-1.4	-1.1	-1.6	-1.7	-1.8	-1.2	-2.3	-0.7	-1.5
88	-0.4	-0.9	-1.6	-1.1	-0.7	-1.3	-1.2	-1.3	0.3	-1.5
91	-0.9	-0.9	-0.1	-0.1	-1.7	-0.8	-0.7	-0.8	-0.7	-0.5
94a	0.6	-0.4	-0.6	-0.6	-1.2	-0.3	0.3	-0.3	0.3	-0.5
94b	0.1	0.1	-0.1	-0.1	0.3	-1.3	-0.7	-0.3	0.8	-0.5
97	7.6	7.9	5.9	5.9	6.5	6.6	6.3	6.2	5.8	7.0
98	-1.4	-0.9	-1.1	-0.6	-1.2	-0.8	-1.2	-1.3	-1.7	-0.5

Table 5.2.3.3: Z-scores for the determination of protein in wheat samples by local NIR models

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	0.7	2.8	0.3	-0.3	-0.2	0.9	1.6	0.3	0.2	0.0
2	0.1	0.1	0.1	0.4	-0.9	-0.7	-0.3	-0.4	0.4	-0.2
4a	0.4	-0.3	-0.6	-0.9	-0.6	-0.6	-1.3	-0.3	-0.6	-0.1
4b	-1.2	-1.5	0.0	-0.4	-0.7	-1.5	0.4	-0.3	0.3	-0.6
5	0.7	-0.7	0.3	-0.8	0.3	0.4	-0.4	0.8	0.2	0.5
6	-0.5	0.0	-0.7	-2.5	-0.8	-1.1	-1.0	0.3	-0.8	-0.5
8a	0.2	-1.0	-0.5	-0.3	-0.2	-1.1	-0.7	-0.2	0.7	-1.0
8b	-0.3	-2.0	-1.0	-1.3	-0.7	-0.9	-0.4	0.1	0.9	0.2
11	2.4	-0.8	0.6	0.4	0.5	-1.4	-0.1	0.7	0.1	-0.3
12	-2.3	-0.2	-0.7	-0.8	-1.7	-0.6	-1.4	0.3	1.2	-0.5
15	0.5	1.2	0.1	-0.4	0.4	0.6	-0.7	0.6	0.1	0.9
17a	-0.6	-1.2	-0.5	-1.0	-1.2	-0.9	-0.9	-0.4	-0.8	-1.5
18	0.2	0.3	-1.2	-0.3	-0.7	-1.1	-0.9	0.3	0.2	-0.5
19	-0.4	0.1	-0.5	-0.5	-0.2	-0.9	-0.1	-0.7	0.5	-1.5
25	-0.3	-0.7	-0.2	-0.8	-0.2	-0.6	-1.4	-0.2	-0.8	-0.5
27a	0.3	2.7	0.9	-0.3	2.1	2.3	1.5	1.8	1.3	0.6
27b	2.2	0.9	1.3	1.2	1.7	2.2	1.3	1.4	0.2	1.2
30a	0.8	-0.3	0.4	1.7	-0.2	0.2	-0.7	1.8	0.7	1.9
30b	0.8	-1.3	-0.2	0.2	-0.8	-0.7	-0.7	0.3	-0.3	-2.5
30c	0.5	-0.3	0.1	0.5	1.3	-0.4	1.8	0.9	0.1	1.2
30d	1.4	1.5	-0.2	-0.1	0.4	0.2	1.2	0.0	-0.3	1.2
30e	-2.0	1.5	-0.5	0.5	2.3	2.1	0.6	0.0	2.9	2.5
30f	0.5	0.6	0.4	2.1	2.0	0.2	1.2	-1.0	-0.3	1.2
30h	-0.4	1.2	-0.5	0.8	-0.2	-0.4	0.0	0.3	-1.2	-0.3
30i	2.9	1.4	1.4	1.9	1.9	2.5	1.2	-1.1	-0.3	1.7
30j	0.5	-1.6	1.0	0.5	0.1	0.2	0.9	0.3	1.0	0.6
32	-0.2	-0.6	-0.9	0.1	-0.4	-0.6	0.1	0.7	-0.3	-0.7
33	0.7	-0.2	1.3	-0.3	-0.7	0.4	0.1	1.8	0.7	-1.0
35a	0.7	1.3	1.3	-0.3	1.3	1.4	0.1	1.8	4.2	1.0
35b	0.7	4.3	1.8	1.7	3.3	1.4	2.1	0.8	2.2	2.5

35c	1.7	3.3	1.3	1.2	2.3	2.4	1.6	1.8	0.7	2.0
35d	0.2	1.3	0.3	0.7	0.8	0.9	1.1	-0.2	1.2	1.0
64	-0.3	-0.2	-0.7	-0.3	-0.7	-1.1	-1.4	0.8	0.2	-0.5
68	0.7	-1.7	0.3	-2.3	-0.2	-1.1	0.6	-0.7	0.2	0.0
75	0.1	-0.1	0.1	-0.4	0.2	0.1	-0.2	-0.4	0.3	-0.1
77a	1.1	-1.1	2.0	-0.7	1.5	2.9	0.2	-2.3	-1.3	0.1
80	-2.2	-0.8	-1.1	-1.4	-1.5	-1.8	-0.5	-0.5	-1.9	-0.7
82	-0.8	-0.2	-0.7	-1.3	-0.2	-1.1	-0.9	-0.7	-0.3	0.0
84	-1.3	-1.2	-0.7	-2.3	-1.7	-0.6	0.1	-1.7	-0.8	-1.0
85	-1.8	-0.2	-0.7	-1.8	-0.2	-0.6	-1.4	0.3	1.2	-1.5
88	-1.8	-0.2	-1.7	0.2	0.3	-0.1	-0.4	-0.2	-0.3	-1.0
91	-0.8	0.8	-0.7	-0.8	-1.7	-1.6	-1.4	-0.7	-0.3	-2.5
94a	-1.8	0.3	-1.2	-2.3	-1.2	0.4	-1.9	-1.2	-1.3	-0.5
94b	-1.3	-0.2	-0.7	0.2	-2.2	0.4	-0.4	0.3	-0.3	-2.0
97	-2.3	0.3	1.3	0.7	1.3	0.4	1.1	0.3	4.7	0.5
98	1.7	0.3	0.3	-0.3	-0.2	-0.6	0.6	0.3	-0.3	0.5

Table 5.2.2.4: Z-scores for the determination of protein in barley samples by local NIR models

5.2.4 Moisture determination using local NIR prediction models

Predictions of the moisture content of each sample were made by the different laboratories using different instruments and their respective prediction models. A summary of the results of the statistical evaluation are given in table 5.2.4.1 and 5.2.4.2 – for detailed results see section 4 in Supplementary material WGN2021.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.71	13.64	11.08	11.40	13.09	14.06	13.54	12.80	11.94	12.77
3	-0.09	-0.22	-0.05	-0.22	-0.08	-0.18	-0.23	-0.16	-0.14	-0.09
4	0.22	0.25	0.19	0.23	0.24	0.25	0.22	0.22	0.23	0.22
5	1.76	1.81	1.73	1.98	1.80	1.80	1.65	1.71	1.96	1.75

Table 5.2.4.1 - Results of statistical analysis for the determination of the moisture content in <u>wheat</u> by local NIR predictions

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	13.67	12.97	12.14	13.48	14.53	13.05	13.13	12.87	13.42	13.21
3	-0.12	-0.01	-0.04	-0.15	-0.08	-0.19	-0.04	-0.07	0.12	0.00
4	0.27	0.28	0.21	0.24	0.23	0.28	0.23	0.22	0.29	0.26
5	2.01	2.13	1.75	1.77	1.57	2.18	1.72	1.73	2.14	1.96

Table 5.2.4.2 - Results of statistical analysis for the determination of the moisture content in <u>barley</u> by local NIR predictions

Legend to tables: 1 = sample, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % H2O), 5 = relative standard deviation of reproducibility (in %).

Z- Values for moisture content by local NIR prediction models:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.14 % for wheat and of s_R = 0.17 % for barley as for reference analyses has been applied.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 (marked in yellow in tables below) and unsatisfactory for absolute values above 3.

The wheat results show a systematic shift for labs 10, 30a, 30b, 30e-30i and 98, which originate from adjustment to a deviating reference method that have negative bias. There are also a few labs with a positive systematic shift (33, 94a and 97). For lab 33, it is due to being adjusted to a reference method with a positive bias. It may explain the other two labs as well, but for lab 94a that positive bias is not significant for the reference method. A few labs have an indication of systematic shift, where only a very few of the results become yellow or red marked hence should be aware of the situation. Labs in this category are 4a, 11f, 68, 80, 82 and 91.

For barley, there is a systematic deviation for lab 68 with a negative bias. Three labs (2, 33 and 91) show a positive bias possibly due to adjustment to a reference method with a slightly positive systematic shift, but not for lab 91. Labs 30c-30f and 30i cannot be explained by adjustment to a reference method that deviate hence it might be moisture loss of the samples. Beside this, only sample inhomogeneity seems to be causing some yellow marked results.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.7	1.2	0.1	0.7	0.8	0.7	0.8	0.8	0.4	0.6
2	1.2	1.1	1.2	1.3	1.0	1.4	1.0	1.2	1.7	1.2
4a	1.4	2.7	0.2	1.0	2.4	3.0	2.7	1.6	1.2	1.8
4b	0.8	1.4	0.4	0.9	1.0	1.6	1.1	1.1	1.0	0.9
5	-0.1	0.5	0.2	0.7	0.8	1.0	0.4	0.7	0.4	0.2
8a	-0.1	0.5	0.2	0.7	0.8	-0.1	0.4	0.0	0.4	0.2
8b	-0.1	0.5	0.2	0.7	0.4	0.7	0.4	0.7	0.4	0.2
10	-6.5	-6.7	-7.0	-6.4	-7.1	-6.8	-6.7	-6.4	-6.7	-6.2
11a	-0.4	-0.1	-1.0	-0.6	-0.2	-0.3	-0.3	-0.5	-0.4	-0.5
11f	-1.3	-2.7	-1.8	-2.0	-2.2	-2.0	-1.5	-2.1	0.0	-2.1
12	-0.1	0.5	-0.6	0.0	0.8	0.3	0.4	0.0	0.4	0.2
15	0.7	0.5	0.9	0.7	0.8	1.0	0.4	0.7	1.2	0.9
17a	1.7	1.9	1.6	1.4	1.5	1.7	1.5	1.8	1.5	1.6
17b	-0.1	-0.3	-0.6	-0.7	0.0	-0.4	-0.3	-0.4	-0.3	-0.5
18	-0.8	-1.0	-1.3	-0.7	-7.1	-0.4	-1.0	-0.7	-1.0	-1.2
19	1.6	1.8	1.3	1.4	1.9	1.8	2.0	1.6	1.0	1.6
25	-0.8	-1.0	-1.3	-0.7	-0.7	-1.1	-1.0	-0.7	-1.0	-1.2
27a	-0.7	-0.5	-0.8	-0.8	-0.6	-1.0	-0.9	-0.8	-1.0	-0.9
27b	-0.8	-0.8	-0.5	-0.6	-1.2	-1.1	-1.4	-1.0	-0.6	-1.0
30a	-2.2	-2.4	-3.4	-2.1	-2.1	-2.6	-2.5	-2.2	-2.4	-2.7
30b	-2.9	-2.4	-3.4	-2.8	-2.1	-1.8	-1.7	-2.2	-2.4	-1.9
30c	-1.6	-0.8	-1.0	-0.7	-0.9	-1.0	-0.7	-0.7	-0.7	-0.7
30d	-1.8	-1.8	-1.1	-0.9	-1.2	-1.5	-1.5	-1.0	-1.2	-1.2
30e	-4.4	-3.8	-3.4	-3.1	-3.5	-3.4	-2.9	-3.4	-3.6	-3.2
30f	-4.0	-3.5	-3.1	-3.1	-3.3	-2.9	-2.8	-3.0	-3.3	-2.7
30h	-3.2	-2.7	-2.6	-2.6	-2.7	-2.6	-2.6	-2.5	-2.5	-2.4
30i	-4.4	-4.2	-3.3	-3.3	-3.7	-3.6	-3.7	-3.2	-3.1	-3.4
33	2.8	2.6	2.3	3.6	2.2	2.4	2.5	2.8	2.6	2.3
35a	0.7	0.5	0.2	0.0	0.0	0.3	0.4	0.7	0.4	0.9
35b	1.4	1.2	0.9	0.7	0.8	0.3	0.4	0.7	0.4	0.9
35c	0.7	0.5	0.2	0.7	0.0	0.3	0.4	0.7	0.4	0.9
35d	0.7	0.5	0.9	0.7	0.0	0.3	1.1	0.7	0.4	0.9
64	1.2	1.5	0.9	1.1	1.5	1.3	1.3	1.2	1.4	1.5
66	-0.1	-0.3	-0.6	0.7	0.0	0.3	-0.3	0.0	0.4	0.2
68	-2.2	-1.7	-2.0	-1.4	-2.1	-4.0	-1.7	-2.2	-3.8	-1.9
73	1.0	1.2	0.9	0.7	0.8	1.0	1.1	1.4	1.2	1.3
75	-0.3	-0.2	-0.4	-0.2	8.5	-0.1	-0.2	-0.3	-0.5	0.1
77a	0.6	0.9	0.4	0.6	0.7	1.0	0.5	0.8	0.9	0.8
80	1.7	1.7	1.7	2.2	2.0	2.2	1.8	1.9	2.1	1.9
81	1.4	1.9	1.6	1.4	1.5	1.7	1.1	1.4	1.9	1.6

82	2.1	1.9	1.6	2.2	2.2	1.7	1.8	1.4	1.2	1.6
85	-1.5	-1.0	-1.3	-0.7	-1.4	-1.1	-1.0	-0.7	-1.0	-0.5
88	-0.1	0.5	0.2	0.7	0.0	0.3	1.1	0.7	1.2	0.2
91	2.1	1.9	1.6	1.4	2.2	1.7	1.8	1.4	1.9	1.6
94a	2.1	2.6	2.3	2.2	2.2	2.4	2.5	2.1	2.6	2.3
94b	-0.8	-0.3	-1.3	-0.7	0.0	0.3	-0.3	-0.7	-0.3	-0.5
97	2.1	1.9	2.3	2.2	2.2	3.2	1.8	2.1	2.6	2.3
98	-2.9	-2.4	-2.7	-2.8	-2.8	-3.3	-2.5	-2.2	-2.4	-2.7

Table 5.2.4.3: Z-scores for the determination of moisture in wheat samples by local NIR models

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	0.0	2.5	0.4	1.0	2.2	0.5	0.6	0.5	0.6	0.4
2	2.4	3.8	1.7	1.8	1.7	2.4	2.2	1.6	3.7	2.2
4a	0.8	0.6	1.3	1.4	1.5	1.2	1.2	0.8	1.7	0.6
4b	0.6	1.2	0.4	0.5	0.8	0.9	0.5	0.1	0.6	1.1
5	0.2	0.2	0.4	0.1	0.4	0.3	0.4	0.2	-0.1	0.5
6	0.5	0.4	1.1	0.8	1.3	1.4	0.7	0.9	1.2	1.0
8a	-0.1	0.5	-0.2	0.1	0.4	0.9	0.4	0.2	-0.7	0.2
8b	0.7	0.7	0.1	0.1	0.1	0.3	0.7	0.2	-1.3	-0.1
11a	-0.2	-0.1	0.1	0.3	0.6	0.6	0.2	-0.1	-0.7	0.0
11f	-0.4	0.3	0.2	0.5	-1.1	-0.6	-0.7	-1.2	-2.0	-1.0
12	0.2	-0.4	0.4	0.1	0.4	0.3	0.4	0.2	0.5	-0.1
15	0.2	0.2	-0.2	-0.5	-0.2	-0.3	-0.2	-0.4	-0.1	-0.1
17a	1.0	0.5	1.2	0.1	0.1	0.9	0.7	0.8	1.7	0.8
18	-0.4	0.2	-0.2	0.1	-0.2	0.3	-0.2	-0.4	-0.7	1.1
19	0.5	2.0	1.0	1.4	1.0	1.8	0.9	0.8	1.9	0.7
25	-0.4	-0.4	-0.2	-0.5	-0.8	-0.3	-0.2	-1.0	-0.7	-0.6
27a	-1.1	-0.7	-0.6	-0.5	-0.1	-0.2	-0.2	-0.4	-0.7	-0.6
27b	0.2	-0.6	-0.4	-0.7	-0.6	0.0	0.0	-0.2	1.2	-0.5
30a	0.2	0.2	0.4	0.7	-0.2	0.3	-0.2	0.2	-0.1	-0.1
30b	-2.2	-1.0	-0.2	0.1	-0.2	-0.9	-0.2	0.2	-0.1	0.5
30c	-3.8	-2.7	-2.3	-2.5	-2.6	-3.1	-2.5	-2.5	-3.1	-1.8
30d	-3.3	-2.1	-2.6	-3.1	-2.6	-3.5	-2.7	-1.4	-3.1	-3.0
30e	-5.3	-3.2	-2.5	-3.0	-2.7	-3.3	-2.7	-1.9	-1.5	-1.4
30f	-4.2	-2.9	-1.9	-1.9	-2.9	-3.1	-0.9	-1.8	-3.4	-2.5
30h	-1.3	0.1	-0.2	-0.8	-0.3	-0.8	-0.1	-0.6	-1.0	-0.6
30i	-2.6	-2.5	-2.4	-3.0	-1.8	-3.4	-2.6	-1.2	-0.1	-2.5
30j	-2.0	0.2	-0.6	-1.1	-0.6	-1.6	-0.5	0.0	0.7	0.6
32	-0.4	-0.4	-0.8	-0.5	-0.8	-0.9	-0.7	-1.0	-1.3	-0.6
33	3.7	3.1	2.7	3.6	2.7	3.2	2.8	2.5	4.0	4.1
35a	0.2	-0.4	-0.8	-0.5	-0.8	-0.9	-0.7	0.2	0.5	-0.6
35b	1.9	2.5	1.5	0.1	1.0	1.5	1.6	1.4	1.7	1.1
35c	0.7	0.7	1.5	0.7	0.4	0.9	0.4	2.5	-0.1	2.3
35d	1.3	1.3	2.1	1.3	1.0	1.5	1.6	2.0	1.7	1.1

64	0.3	0.2	0.2	0.2	0.3	0.2	0.5	0.1	-0.6	0.6
68	-5.7	-3.4	-3.8	-4.6	-4.9	-3.2	-3.1	-3.3	-3.0	-3.6
75	-1.9	-1.6	-1.3	-1.9	-2.0	-1.5	-1.5	-1.8	-1.7	-1.9
77a	-1.1	-0.4	-0.3	0.2	-0.2	-0.2	-0.3	-0.3	0.2	-0.4
80	1.9	1.3	1.4	1.1	1.5	1.8	1.4	1.5	2.1	1.5
82	1.3	0.7	1.0	1.3	1.6	1.5	1.0	0.8	1.1	1.1
84	0.2	-0.4	-0.2	-1.1	-0.8	-0.3	-0.7	-0.4	-0.1	-0.6
85	-0.4	-1.0	-0.8	0.1	-0.2	-0.9	-0.7	-1.0	-0.7	-0.6
88	-0.4	-1.6	-0.8	-0.5	-0.8	0.9	-0.2	0.8	-1.9	-1.2
91	1.3	1.3	1.5	3.0	2.2	3.2	2.2	2.0	1.7	2.9
94a	1.3	1.3	1.0	1.3	1.0	1.5	1.0	2.0	0.5	1.1
94b	1.3	0.7	-0.8	0.7	0.4	0.3	0.4	-0.4	2.3	-0.6
97	2.5	1.9	1.0	0.7	1.6	1.5	1.6	1.4	1.7	1.7
98	1.3	-2.8	-2.0	-1.7	-1.4	-1.5	-1.9	-2.2	-2.4	-2.4

Table 5.2.4.4: Z-scores for the determination of moisture in barley samples by local NIR models

5.2.5 Protein content by the ANN model WB003034

There are 52 different set of scans submitted by 42 different laboratories using different instruments. They were evaluated by the FOSS using the ANN model WB003034. A summary of the results of the statistical evaluation are given in table 5.2.5.1 and 5.2.5.2 – see section 5 in Supplementary material WGN2021.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	13.13	15.02	12.47	12.34	12.93	13.08	12.07	13.63	12.41	12.64
3	-0.02	-0.12	0.00	-0.13	0.04	0.04	0.07	-0.03	-0.21	0.02
4	0.07	0.09	0.09	0.09	0.08	0.08	0.08	0.06	0.11	0.06
5	0.56	0.10	0.69	0.73	0.59	0.59	0.70	0.44	0.88	0.47

Table 5.2.5.1 - Results of statistical analysis for the determination of the protein content in <u>wheat</u> by the ANN model WB003034

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	10.50	11.88	10.46	11.99	9.95	9.21	11.26	12.13	12.28	11.43
3	0.20	-0.01	0.07	-0.12	-0.13	0.06	-0.02	-0.08	-0.29	-0.04
4	0.18	0.16	0.09	0.15	0.13	0.14	0.13	0.11	0.16	0.11
5	1.67	1.36	0.87	1.22	1.35	1.56	1.14	0.91	1.28	0.98

Table 5.2.5.2 - Results of statistical analysis for the determination of the protein content in <u>barley</u> by the ANN model WB003034

Legend to tables: 1 = sample, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % CP), 5 = relative standard deviation of reproducibility (in %).

Z- Values for protein by ANN WB003034 prediction model:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.2 % has been used as for the protein reference analyses.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 and unsatisfactory for absolute values above 3.

Results for wheat shows extremely good agreement among all Infratec instruments. There are no red marked results at all and only one yellow marked sample W1 for lab 35d.
This means very good homogeneity and that there is nothing wrong with the spectra that can explain the deviations for the local models suggested. This verifies the possibility of a systematic shift for lab 27b and 97 due to either incorrect adjustment or moisture compensation being enabled.
Barley may sometimes result in yellow or red marked warnings due to sample inhomogeneity and this year it does not seem to be a big problem. There are five red marked and eight yellow marked. This means that the larger number of yellow marked results for the local models originates from other versions or being adjusted differently.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.3	-0.6	0.5	-0.1	0.3	0.1	1.0	0.1	0.0	0.3
2	0.3	-0.2	0.2	0.3	0.1	0.3	0.6	0.0	0.3	0.1
4a	-0.3	-0.9	-0.7	0.9	-0.2	-0.1	0.8	-0.3	-1.1	-0.8
4b	-0.1	-0.6	0.3	-0.3	-0.2	0.3	0.5	-0.5	0.1	-0.3
5	0.3	0.5	-0.4	0.1	0.3	-0.1	0.0	-0.3	0.1	0.3
8a	0.3	1.0	0.5	0.0	0.5	1.5	1.2	0.3	0.0	0.1
8b	0.1	-0.2	-0.1	-0.1	-0.2	-0.2	-0.7	-0.5	0.1	-0.2
10	0.6	-0.2	0.8	1.0	0.3	-0.2	-0.4	0.1	0.5	-0.2
11a	0.2	0.3	-0.1	0.2	-0.2	0.6	0.2	0.2	0.7	-0.1
11b	0.1	0.1	-0.1	-0.2	-0.3	0.5	0.4	-0.3	-0.1	0.1
11d	0.0	-0.1	0.1	-0.3	0.0	0.3	-0.2	-0.3	0.3	-0.1
11e	-0.2	0.3	0.0	-0.6	-0.3	-0.4	-0.2	-0.2	-0.3	-0.1
12	0.0	-0.5	-0.8	0.0	0.0	0.1	-0.5	0.5	0.6	0.3
15	0.6	-0.3	1.1	0.9	0.1	0.0	-0.5	0.2	-0.1	0.1
17	-0.1	-0.3	0.2	0.1	0.3	-0.2	-0.4	0.1	-0.5	-0.2
18	-0.9	0.0	0.5	-1.0	0.0	0.6	-0.5	0.2	0.7	0.0
19	-0.2	-0.1	0.5	0.5	0.3	0.5	0.4	0.4	0.7	0.1
25	-0.6	0.2	-0.9	-0.3	-0.4	0.4	-0.2	-0.6	-0.2	0.0
27a	0.5	0.9	0.8	0.5	0.1	1.8	-0.6	1.0	1.1	0.1
27b	0.8	0.4	0.3	0.6	0.0	0.1	0.0	1.1	0.6	0.6
30a	0.7	0.5	-0.1	0.3	-0.1	0.6	-0.1	0.1	0.0	0.4
30b	0.2	0.4	-0.2	-0.1	0.2	-1.0	0.0	-0.3	-0.1	0.4
30c	-0.4	0.1	-0.7	-0.1	0.0	-0.2	-0.2	-0.4	-0.6	0.0
30d	-0.4	-0.2	-0.7	0.4	-0.3	-0.6	-0.1	0.1	-0.3	-0.2
30e	0.2	0.1	0.4	-0.3	0.2	-0.1	0.1	0.2	0.7	0.0
30f	0.2	-0.8	-0.2	0.4	-0.1	0.4	-0.3	0.2	0.0	0.0
30h	0.5	0.3	-0.2	-0.9	-0.2	0.2	0.0	0.6	0.7	-0.2
30i	0.3	0.4	0.3	-0.1	0.2	-0.3	0.7	-0.3	-0.6	0.0
33	-0.1	-0.1	0.0	0.4	0.2	0.0	0.1	-0.4	-0.9	0.2
35a	-0.5	-0.3	-0.8	-0.6	0.4	-0.5	0.1	0.0	-0.2	-0.1
35b	-0.2	0.0	-0.1	-0.1	-0.3	-0.1	-0.1	-0.1	0.7	0.1
35c	-0.2	0.1	0.5	-0.3	0.8	0.6	0.4	0.3	0.3	0.0
35d	2.3	0.3	0.2	0.0	0.7	0.6	0.2	0.1	-0.1	0.0
64	-0.4	0.1	0.1	0.0	0.0	0.0	-0.1	0.1	0.1	0.1
66	0.0	0.2	0.0	-0.5	0.2	0.1	0.1	0.2	-0.3	-0.1
68	-0.3	-1.4	-0.2	0.0	-0.5	-0.6	-0.4	0.4	-1.3	0.1
75	-0.1	-0.2	0.0	0.1	-0.1	-0.3	0.0	0.1	0.1	-0.4
77a	-0.1	-0.5	0.0	-0.3	0.4	-0.3	0.1	0.3	-0.8	0.4
80	-0.5	0.5	-0.2	-0.4	0.2	-0.5	-0.6	0.3	-1.0	-0.6
81	-0.2	-0.2	-0.3	-0.3	-0.1	0.0	-0.1	-0.1	-0.1	-0.7
82	-0.2	-0.2	0.0	0.3	-0.4	0.3	-0.2	-0.2	-0.2	0.0
88	-0.4	0.6	-0.3	0.1	-0.1	0.1	-0.1	0.3	0.3	0.7
91	-0.3	-0.3	-0.1	0.3	-0.8	-0.4	-0.2	-0.4	-0.4	-0.1
94a	0.5	0.1	-0.3	-0.9	-1.2	-0.4	0.3	0.0	0.3	-0.2
94b	0.2	0.3	0.2	0.2	0.7	-0.1	-0.4	0.2	0.9	-0.2

98	-0.4	0.4	0.1	0.1	-0.5	0.0	-0.3	-0.1	-0.5	0.4

Table 5.2.5.3: Z-scores for the determination of protein in wheat samples by ANN WB003034

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	-0.1	2.8	0.1	0.2	-0.7	0.7	0.7	0.0	0.4	0.1
2	1.0	0.7	0.8	0.7	-0.2	0.4	0.3	-0.2	0.7	0.5
4a	0.7	-0.1	0.1	-0.2	-0.5	-0.1	-1.0	-0.3	-0.3	0.2
4b	-0.1	-1.0	0.3	0.2	-0.3	-0.6	1.0	0.0	1.0	-0.3
5	0.5	-1.2	-0.2	-0.4	-0.2	-0.1	-0.3	0.0	-0.1	0.0
6	-0.2	0.6	0.2	-1.3	-0.2	-0.4	0.1	0.9	-0.1	0.3
8a	0.2	-0.1	0.4	0.5	-0.2	-0.8	-0.2	0.3	-0.9	-0.5
8b	0.1	-0.9	-0.3	-0.4	-1.1	0.1	0.0	-0.2	-1.1	0.7
11a	2.2	-0.5	1.1	1.2	0.9	-0.9	0.5	0.8	0.5	0.1
11b	0.0	-0.3	0.2	-0.2	-0.2	0.4	0.3	-0.1	0.6	-0.2
11d	0.1	0.2	0.2	0.3	-0.2	0.7	0.5	-0.2	0.6	0.4
11e	-1.2	-0.2	0.0	-0.1	0.3	0.1	-0.2	-0.1	1.0	-0.3
12	-1.6	-0.2	-0.2	-0.7	-0.6	-0.4	0.2	-0.2	0.0	-0.6
15	0.5	1.3	0.5	-0.3	0.1	0.7	-0.4	-0.2	-0.9	0.4
17	-1.0	-0.5	0.0	-0.2	-0.6	-0.1	-0.6	0.2	0.0	-0.7
18	0.9	0.2	-0.7	0.1	0.0	-0.6	-0.4	0.4	0.0	0.1
19	0.3	0.8	0.3	0.8	0.5	0.0	0.8	0.1	1.2	-0.3
25	-0.5	-0.5	0.1	-0.3	0.0	-0.1	-0.8	-0.2	-0.4	-0.1
27a	-0.7	1.9	0.5	0.0	1.7	1.9	1.2	1.1	0.5	0.3
27b	1.3	0.5	0.8	1.2	1.2	1.9	1.0	0.7	0.1	0.7
30a	-0.6	-4.8	2.4	0.3	0.4	-0.5	0.1	0.2	0.1	0.5
30b	0.4	-0.7	-0.6	1.1	-0.6	-0.8	-0.4	0.3	0.1	-2.4
30c	0.0	-0.8	-0.1	0.1	0.8	-0.4	0.9	-0.1	-1.0	0.5
30d	0.2	0.8	-0.7	-0.4	0.2	-0.2	0.6	-0.1	-0.5	1.0
30e	-2.0	-1.0	-1.1	0.1	1.8	1.3	0.1	-0.9	1.9	2.0
30f	-0.5	-0.8	-0.7	0.5	0.5	-0.7	-0.1	-2.2	-1.3	0.4
30h	0.1	1.7	-0.1	1.0	0.2	0.3	0.4	0.2	-1.4	-0.1
30i	1.4	-0.3	0.9	0.9	0.0	1.1	0.3	-1.3	-0.5	0.4
30j	-0.3	0.4	-0.4	1.1	0.4	0.2	-0.8	-1.0	0.4	-0.1
32	0.4	0.5	-0.3	1.0	0.0	0.2	0.9	0.7	0.1	-0.4
33	2.1	-0.8	0.6	-0.1	-0.5	0.4	-0.4	0.6	-0.1	-0.9
35a	-1.8	-1.2	-0.2	-1.4	-0.1	-0.5	-1.6	0.5	-1.0	0.2
35b	-0.3	1.2	0.0	0.3	1.3	-1.0	0.4	-0.8	0.2	1.2
35c	0.3	0.7	-0.4	-0.5	0.7	0.3	-0.5	-0.1	-1.3	0.3
35d	-0.1	-0.1	-0.2	0.2	0.1	0.5	0.3	-0.4	0.4	0.6
64	0.2	0.1	-0.4	-0.2	0.0	-0.5	-0.6	1.2	0.6	0.5
68	0.8	-1.6	0.2	-1.9	-0.4	-1.5	-0.1	-0.8	0.4	-0.5
75	0.0	-0.3	0.2	-0.2	0.2	0.2	-0.2	-0.5	0.0	0.0
77a	-3.0	0.4	-0.7	-0.4	0.3	-0.1	-0.6	-0.2	-1.9	-0.6
80	-0.7	-0.1	-0.1	-0.6	-0.4	-0.5	0.5	0.2	-0.9	0.2
82	-0.7	-0.4	-0.3	-0.8	0.1	-0.7	-0.5	-0.3	0.3	-0.1

84	-0.4	-0.8	-0.1	-1.2	-1.4	0.1	0.6	-1.2	-0.1	-0.2
85	-1.1	-0.2	0.0	-1.1	0.3	0.1	-1.1	0.3	1.6	-0.7
88	-1.0	0.4	-0.3	0.6	-0.6	-0.4	-0.7	0.1	0.3	-1.2
91	0.1	0.9	0.1	0.1	-0.8	-0.8	-0.6	-0.3	0.2	-1.4
94a	0.0	1.2	0.5	-0.5	-0.3	1.2	-0.7	0.0	-0.1	0.5
94b	0.2	-4.4	-0.1	1.4	-1.0	0.6	0.7	0.3	0.5	-1.0
98	0.8	-0.2	0.1	-0.1	-0.8	-0.7	0.5	0.6	-3.9	3.4

Table 5.2.5.4: Z-scores for the determination of protein in barley samples by ANN WB003034

5.2.6 Moisture content by the ANN model WB003034

There are 52 sets of scans from 42 different laboratories using different instruments were evaluated by the FOSS ANN model WB003034. A summary of the results of the statistical evaluation are given in table 5.2.6.1 and 5.2.6.2 – see section 6 in Supplementary material WGN2021.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.62	13.57	10.96	11.33	13.03	13.98	13.48	12.73	11.87	12.70
3	-0.17	-0.29	-0.17	-0.29	-0.14	-0.25	-0.30	-0.23	-0.21	-0.16
4	0.08	0.07	0.06	0.06	0.07	0.07	0.07	0.05	0.06	0.06
5	0.6	0.5	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.4

Table 5.2.6.1 - Results of statistical analysis for the determination of the moisture content in wheat by ANN model WB003034

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	13.56	12.92	12.11	13.47	14.53	13.03	13.11	12.82	13.29	13.15
3	-0.23	-0.06	-0.06	-0.16	-0.09	-0.21	-0.06	-0.12	0.00	-0.06
4	0.12	0.09	0.05	0.10	0.08	0.12	0.08	0.06	0.11	0.08
5	0.9	0.7	0.4	0.7	0.5	0.9	0.6	0.5	0.8	0.6

Table 5.2.6.2 - Results of statistical analysis for the determination of the moisture content in barley by ANN model WB003034

Legend to tables: 1 = sample, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % H2O), 5 = relative standard deviation of reproducibility (in %).

Z- Values for moisture content by ANN WB003034 prediction model

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.14 % for wheat and of s_R = 0.17 % for barley as for reference analyses has been applied.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 and unsatisfactory for absolute values above 3.

The results for wheat show the same good alignment as for protein, but with one sample red marked (W6 for lab 68). The same lab also has one yellow marked sample W9. There are no other deviations for wheat.

For barley, lab 68 again has one red marked sample (B1) and two yellow marked samples (B4 and B5). Besides this, there are only 5 yellow marked samples showing good homogeneity for barley. All other labs have very good results showing the good quality of spectra received also for barley.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-0.2	0.1	-0.5	-0.2	-0.2	-0.3	-0.1	-0.3	-0.4	-0.3
2	0.8	0.5	0.7	0.6	0.5	0.6	0.4	0.6	0.9	0.6
4a	-0.1	0.4	-0.2	-0.1	0.5	0.3	0.4	-0.1	-0.1	0.1
4b	0.0	0.2	0.0	0.3	0.0	0.1	0.1	0.1	0.1	-0.1
5	-0.3	0.0	-0.2	-0.3	-0.2	-0.1	-0.4	-0.3	-0.1	-0.4
8a	0.1	0.3	-0.1	0.0	0.1	-0.1	0.1	-0.1	0.0	0.0
8b	0.3	0.4	0.3	0.6	0.2	0.5	0.2	0.4	0.4	0.4
10	0.9	0.7	0.6	0.8	1.0	0.8	0.9	0.8	1.0	0.9
11a	0.2	0.3	-0.2	-0.1	0.3	0.2	0.2	0.0	0.1	0.0
11b	-0.1	0.2	-0.4	-0.3	0.1	0.0	0.1	-0.2	-0.1	-0.2
11d	-0.6	-0.7	-0.3	-0.4	-0.4	-0.6	-0.6	-0.5	-0.6	-0.8
11e	-0.6	-0.8	-0.4	-0.6	-0.6	-0.8	-0.9	-0.6	-0.9	-0.9
12	0.8	1.0	0.5	0.5	0.6	0.7	1.1	0.2	0.6	0.4
15	0.6	0.3	0.7	0.6	0.6	0.4	0.3	0.5	0.7	0.5
17	0.7	0.6	0.5	0.4	0.6	0.7	0.5	0.5	0.5	0.5
18	-0.3	-0.2	-0.1	-0.1	-2.6	-0.1	-0.2	-0.1	0.0	-0.3
19	0.1	0.1	-0.2	-0.2	0.2	0.1	0.3	-0.1	-0.8	-0.1
25	-0.2	0.0	-0.3	-0.2	0.1	-0.1	0.0	-0.2	0.0	-0.4
27a	0.1	0.2	0.1	-0.3	-0.3	-0.4	-0.4	-0.2	-0.3	-0.4
27b	0.1	-0.2	0.4	0.0	-0.6	-0.5	-0.9	-0.4	0.2	-0.5
30a	0.4	0.3	0.1	0.2	0.3	0.4	0.5	0.4	0.0	0.3
30b	-0.1	0.5	0.4	0.2	0.5	0.6	0.7	0.5	0.3	0.6
30c	-0.7	-0.3	0.0	0.0	-0.1	-0.3	0.0	0.1	0.0	0.0
30d	-0.2	-0.3	0.6	0.3	0.0	-0.2	-0.1	0.4	0.2	0.3
30e	-1.0	-0.8	-0.2	-0.4	-0.3	-0.5	0.1	-0.4	-0.6	-0.3
30f	-0.9	-0.6	-0.2	-0.4	-0.4	-0.4	-0.1	-0.1	-0.5	-0.1
30h	-1.0	-0.7	-0.4	-0.6	-0.7	-0.6	-0.5	-0.4	-0.5	-0.4
30i	-0.7	-0.7	0.3	0.1	-0.1	-0.3	-0.1	0.2	0.3	0.0
33	0.6	0.5	0.3	0.9	0.1	0.4	0.5	0.3	0.3	0.3
35a	-0.3	-0.6	-0.5	-0.9	-0.7	-0.9	-0.6	-0.6	-0.7	-0.3
35b	-0.2	-0.2	-0.2	-0.3	-0.4	-0.6	-0.3	-0.3	-0.3	-0.2
35c	-0.6	-0.9	-0.5	-0.7	-1.0	-0.9	-0.9	-0.7	-0.8	-0.5
35d	1.3	-0.6	-0.4	-0.5	-0.6	-0.5	-0.4	-0.4	-0.4	-0.5
64	0.3	0.5	0.1	0.0	0.4	0.1	0.1	0.1	0.2	0.3
66	0.5	0.5	0.6	0.8	0.6	0.6	0.3	0.6	0.6	0.6
68	-1.3	-1.2	-1.1	-1.1	-1.5	-3.0	-1.0	-1.5	-2.6	-1.5
75	0.1	-0.5	0.2	0.1	0.1	0.2	-0.2	-0.3	-0.7	0.4
77a	0.1	0.2	0.0	-0.1	-0.1	0.2	-0.1	0.2	0.3	0.1
80	0.2	0.0	0.2	0.4	0.3	0.4	0.1	0.1	0.3	0.1
81	0.0	0.1	0.0	0.2	0.1	0.1	-0.1	0.0	0.0	0.0
82	0.7	0.5	0.4	0.7	0.4	0.5	0.6	0.3	0.2	0.2
88	-0.6	-0.7	-0.7	-0.4	-0.5	-0.7	-0.7	-0.6	-0.6	-0.6
91	0.5	0.4	0.2	0.1	0.5	0.3	0.0	0.2	0.2	0.4
94a	0.1	0.3	0.1	0.1	0.3	0.5	0.3	0.3	0.4	0.2
94b	0.5	0.8	0.0	0.1	0.1	0.8	0.5	0.2	0.3	0.3
98	-0.1	0.0	0.1	0.1	0.0	-0.5	0.2	0.1	0.1	0.0

Table 5.2.6.3: Z-scores for the determination of moisture in wheat samples by ANN WB003034.

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	0.1	0.7	-0.2	0.5	0.4	0.0	0.1	-0.1	-0.3	0.2
2	1.2	1.0	0.3	0.6	0.3	1.0	0.6	0.4	1.7	0.6
4a	0.2	-0.4	0.1	0.4	0.3	0.4	0.1	-0.3	0.5	-0.2
4b	0.5	0.0	0.1	0.3	0.2	0.5	0.1	-0.1	0.3	0.4
5	0.1	-0.3	0.0	0.1	0.0	0.1	0.0	0.1	-0.4	-0.1
6	0.0	-0.3	0.2	0.0	0.2	0.6	0.2	0.1	0.5	0.4
8a	0.3	0.2	0.0	0.3	0.3	0.6	0.5	0.1	-0.2	0.3
8b	1.1	0.8	0.5	0.3	0.5	0.6	1.0	0.4	0.6	0.5
11a	0.4	0.2	0.2	0.4	0.6	0.7	0.2	0.2	0.0	0.3
11b	0.3	0.1	-0.2	0.1	0.3	0.5	0.2	0.0	-0.1	0.2
11d	-0.1	-0.3	-0.4	-0.4	-0.6	-0.4	-0.5	-0.2	-0.9	-0.7
11e	-0.3	-0.3	-0.4	-0.7	-0.6	-0.7	-0.5	-0.8	-1.0	-0.9
12	0.4	0.0	0.4	0.3	0.6	0.6	0.6	0.7	0.8	0.1
15	1.0	0.8	0.6	0.3	0.3	0.7	0.5	0.5	0.9	0.5
17	0.4	-0.1	0.4	0.1	0.1	0.7	0.5	0.1	0.3	0.6
18	0.6	0.5	0.1	0.2	0.0	0.3	0.2	0.0	-0.2	0.1
19	0.0	0.4	0.0	0.4	0.1	0.3	0.1	0.0	0.6	-0.2
25	0.3	-0.2	-0.2	0.2	0.1	0.3	-0.1	-0.2	0.0	-0.1
27a	-0.7	-0.4	-0.3	-0.6	0.1	0.2	0.0	-0.1	0.1	-0.3
27b	0.2	-0.6	-0.1	-0.7	-0.5	0.3	-0.1	0.0	0.7	-0.2
30a	0.4	-2.8	1.8	0.6	-0.1	0.4	0.0	0.2	0.1	0.0
30b	-1.0	0.1	0.3	0.5	0.6	-0.5	0.2	0.0	0.2	0.9
30c	-1.1	0.2	0.3	0.1	0.2	-1.0	0.1	0.0	0.1	0.5
30d	-0.7	0.3	0.1	-0.4	-0.1	-0.9	-0.1	0.9	-0.3	-0.1
30e	-2.6	-0.9	-0.3	-0.7	-0.3	-1.3	-0.6	-0.1	-1.0	0.4
30f	-2.1	-0.9	-0.2	-0.1	-0.8	-0.9	-0.5	-0.4	-0.9	-0.5
30h	-1.2	0.3	-0.1	-0.4	0.0	-0.7	0.1	-0.2	-0.3	-0.2
30i	-0.2	0.2	0.2	-0.4	0.1	-1.0	-0.2	0.4	1.0	-0.2
30j	-1.5	0.6	0.0	-0.5	-0.1	-1.1	0.1	0.5	-0.1	-0.6
32	0.2	0.3	-0.1	0.0	-0.2	0.0	-0.1	-0.1	0.0	0.1
33	-0.8	0.4	0.3	1.0	0.3	0.6	0.4	0.0	0.5	0.2
35a	-0.3	-1.2	-1.2	-0.9	-1.0	-1.3	-0.8	-0.5	-0.9	-0.7
35b	-0.3	-0.5	-0.7	-1.2	-0.5	-0.9	-0.4	-0.3	-0.6	-0.8
35c	-0.8	-1.1	-0.8	-1.6	-0.9	-1.1	-1.0	-0.6	-0.6	-0.9
35d	-0.3	-0.3	-0.4	-0.8	-0.4	-0.3	-0.4	-0.2	-0.4	-0.4
64	0.6	0.6	0.1	0.5	0.5	0.5	0.5	0.4	0.0	0.2
68	-3.4	-1.8	-1.7	-2.7	-2.8	-1.5	-1.4	-1.4	-1.4	-1.5
75	-0.2	-0.1	0.2	-0.2	-0.2	0.0	0.1	-0.3	-0.1	-0.3
77a	-0.2	0.4	0.2	0.8	0.4	0.3	0.3	0.3	0.8	0.4
80	0.7	0.3	0.1	0.0	0.3	0.7	0.2	0.3	0.7	0.3
82	-0.1	-0.2	0.0	0.1	0.3	0.4	0.0	-0.2	0.1	0.0

84	-0.1	-0.3	0.1	-0.6	-0.7	0.1	-0.2	0.1	0.2	-0.1
85	-0.6	-0.8	-0.7	-0.4	-0.6	-0.3	-0.8	-0.8	-0.2	-0.5
88	-0.6	-0.8	-0.3	-0.5	-1.1	-0.3	-0.4	-0.7	-1.4	-0.6
91	0.6	0.3	0.2	1.0	0.5	0.7	0.4	0.3	0.4	0.8
94a	0.7	0.7	0.1	0.7	0.3	0.7	0.2	0.4	-0.2	0.4
94b	1.6	1.0	0.4	1.2	0.8	0.8	0.7	0.3	1.0	0.1
98	1.0	-0.1	0.0	0.3	0.1	0.5	-0.2	2.8	-0.8	-2.0

Table 5.2.6.4: Z-scores for the determination of moisture in barley samples by ANN WB003034

5.3 Summary and comments for protein and moisture in Wheat & Barley

WGN 2021 all samples *(2020 harvest)*	**Ref. methods**	**Local models**	**FOSS ANN**
Protein, range	**9.1 % - 15.1 %**		
Mean (%)	**12.08**	**12.11**	**12.04**
deviation from mean		**0.03**	**-0.04**
SD reproducibility	**0.19**	**0.18**	**0.11**
RSD reproducibility	**1.6**	**1.6**	**0.9**
Moisture, range	**11.1 % - 14.6 %**		
Mean (%)	**13.08**	**12.97**	**12.91**
deviation from mean		**-0.10**	**-0.16**
SD reproducibility	**0.15**	**0.24**	**0.08**
RSD reproducibility	**1.2**	**1.8**	**0.6**

Table 5.3.1: Summary of results for protein and moisture (all samples)

WGN 2021 Wheat *(2020 samples)*	**Ref. methods**	**Local models**	**FOSS ANN**
Protein, range	**12.0% - 15.1 %**		
Mean (%)	**13.01**	**13.03**	**12.97**
deviation from mean		**0.03**	**-0.03**
SD reproducibility	**0.17**	**0.17**	**0.08**
RSD reproducibility	**1.3**	**1.3**	**0.6**
Moisture, range	**11.1 % - 14.2 %**		
Mean (%)	**12.85**	**12.70**	**12.63**
deviation from mean		**-0.15**	**-0.22**
SD reproducibility	**0.16**	**0.23**	**0.06**
RSD reproducibility	**1.3**	**1.8**	**0.5**

Table 5.3.1a: Summary of results for protein and moisture (wheat samples only)

WGN 2021 Barley *(2020 samples)*	**Ref. methods**	**Local models**	**FOSS ANN**
Protein, range	**9.1 % - 12.6 %**		
Mean (%)	**11.15**	**11.19**	**11.11**
deviation from mean		**0.04**	**-0.04**
SD reproducibility	**0.21**	**0.20**	**0.14**
RSD reproducibility	**1.9**	**1.8**	**1.2**
Moisture, range	**12.2 % - 14.6 %**		
Mean (%)	**13.30**	**13.25**	**13.20**
deviation from mean		**-0.06**	**-0.11**
SD reproducibility	**0.15**	**0.25**	**0.09**
RSD reproducibility	**1.1**	**1.9**	**0.7**

Table 5.3.1b: Summary of results for protein and moisture (barley samples only)

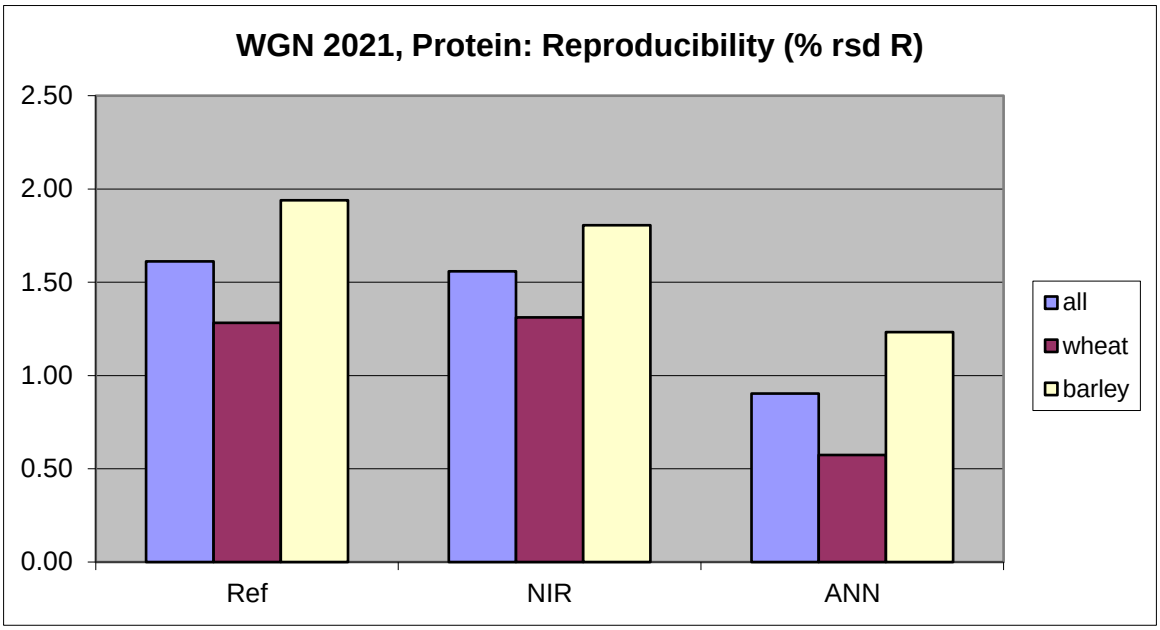


Fig. 5.3.1a: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model WB003034 (ANN) for the determination of **protein**.

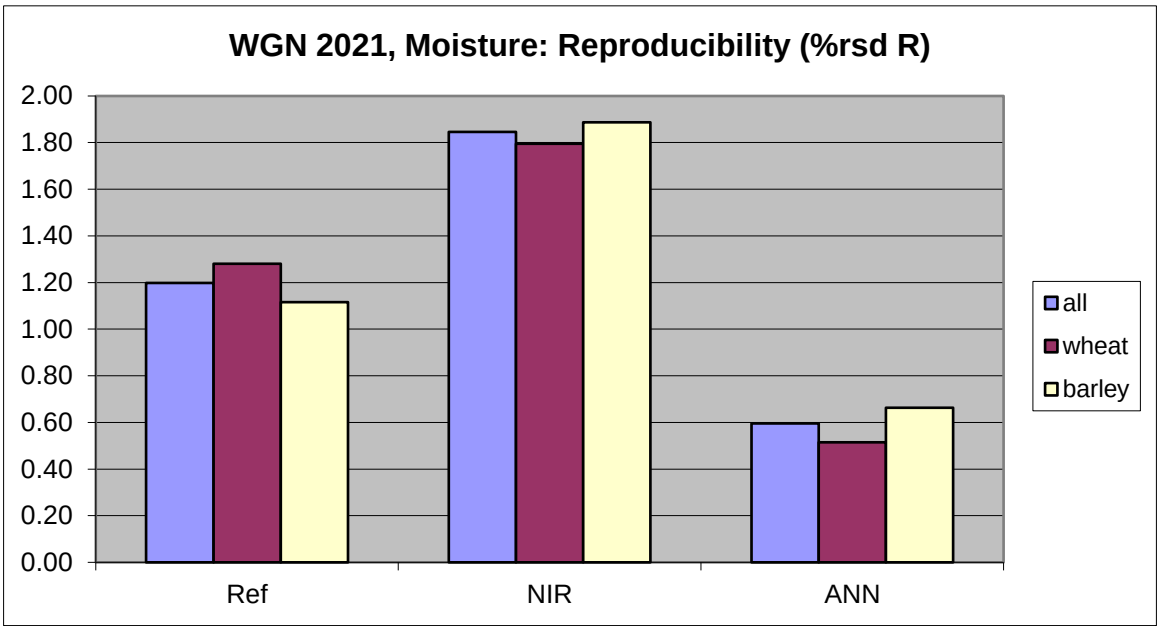


Fig. 5.3.1b: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model WB003034 (ANN) for the determination of **moisture**.

Different instruments and models as well as slightly different NIR prediction models (different versions of ANN models, locally adopted and adjusted) have been used to predict the local NIR results. On an average, the predicted local NIR results were insignificantly higher for protein (0.03%) and somewhat lower for moisture (-0.15%) than the best estimates of the reference

values. The performance in terms of reproducibility for the local protein models are very similar to the reference methods on average. For protein it was equally good than the reference methods for both wheat and barley. For moisture, the reproducibility is better for the reference method compared to local prediction models for both wheat and barley. This indicate a larger spread of adjustments for the local prediction models than seems to be justified. For moisture in wheat, we have noticed that a few labs deviated in their reference methods, which has a negative influence on the reproducibility of the local models due to adjustments.

The predictions made using the FOSS ANN model WB003034 for the simultaneous determination of protein and moisture in whole kernels of wheat and barley showed insignificant differences to the average value of the reference results for protein (-0.04%) and almost an insignificant bias for moisture overall (-0.16%). The unadjusted ANN model has slightly larger deviation for moisture in wheat (-0.22%) than the local models (-0.15%). WB003034 showed an improved reproducibility versus both the reference methods and the locally used/adopted prediction models (see table and figures above). The prediction model ANN WB003034 was not bias corrected and the study shows that the model can be used without losses in accuracy compared to the presently used models and the reference methods for protein and moisture.

The effect of predicted moisture values being on average lower than reference values for wheat is very small. This is confirmed by observing the trend in the stability graph below.

The stability for protein prediction models (local as well as unadjusted ANN) is as always excellent and just fluctuates around zero deviation from the reference method.

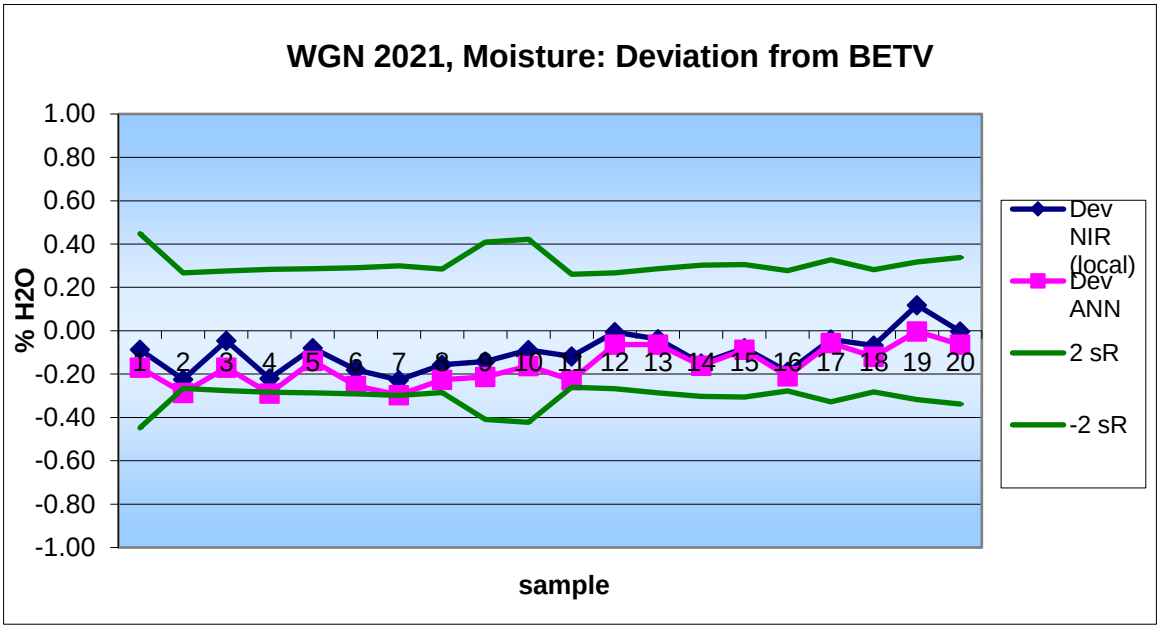


Fig. 5.3.2a: Deviations between predicted **moisture** values and the best estimate of the true value

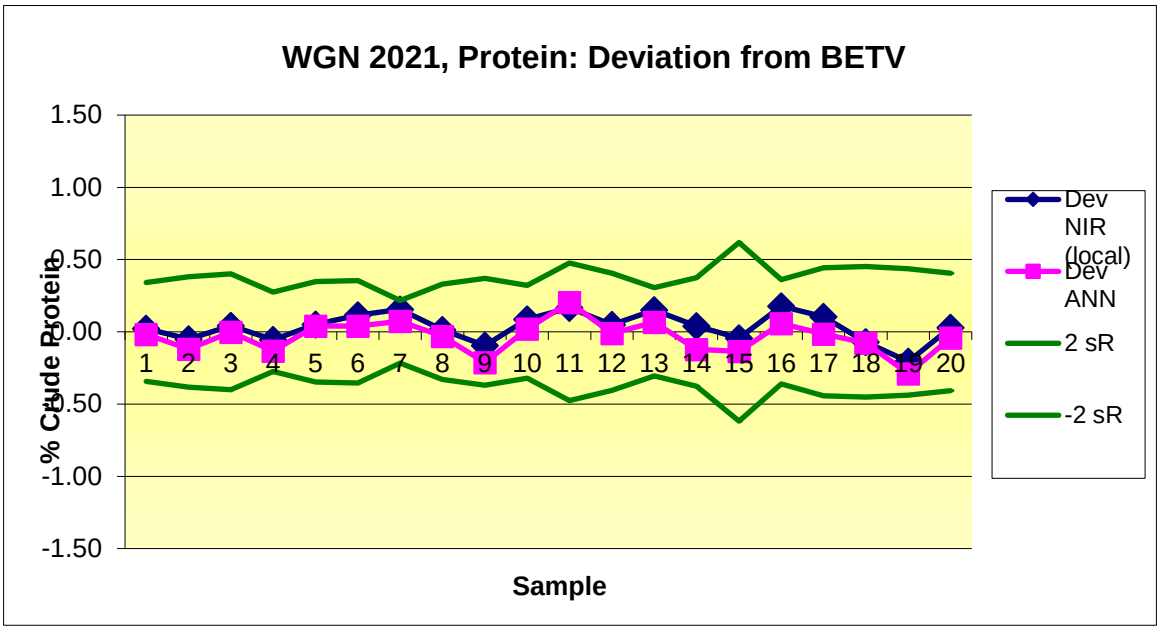


Fig. 5.3.2b: Deviations between predicted **protein** values and the best estimate of the true value Figures 5.3.2a and 5.3.2.b show the differences between predicted values and the best estimate of the true value as determined by reference analyses.

The average results this year are in line with observations from earlier WGN studies, as the stability graphs show:

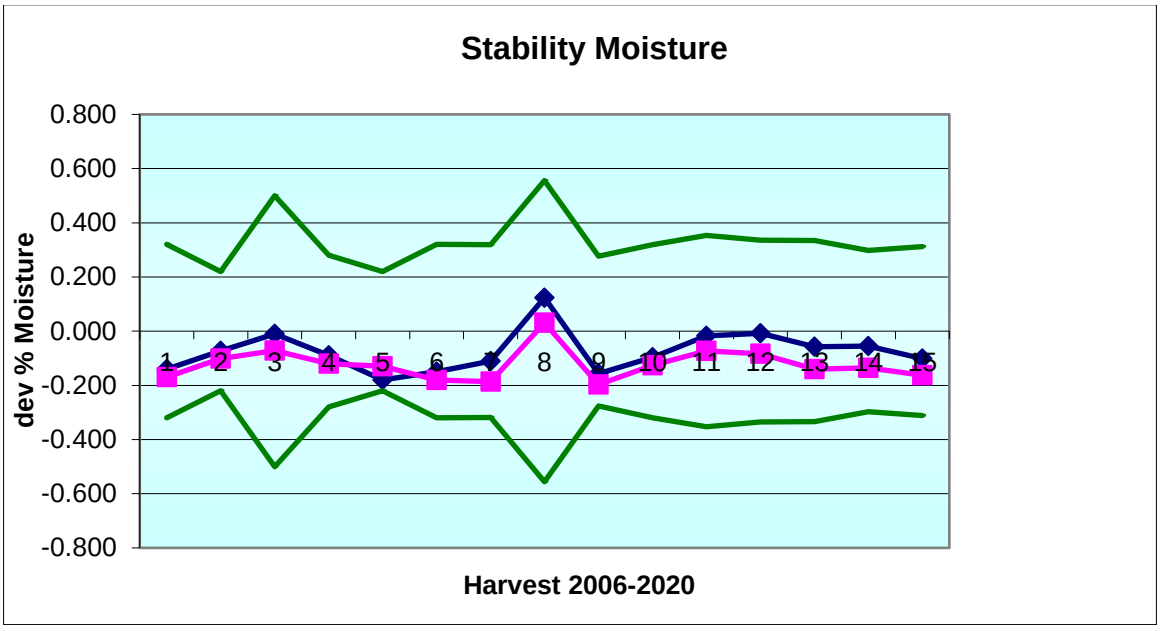


Figure 5.3.3 a: Average deviations of predicted moisture results from the best estimate of the true value during the past thirteen years. Blue = Local and Pink = ANN.

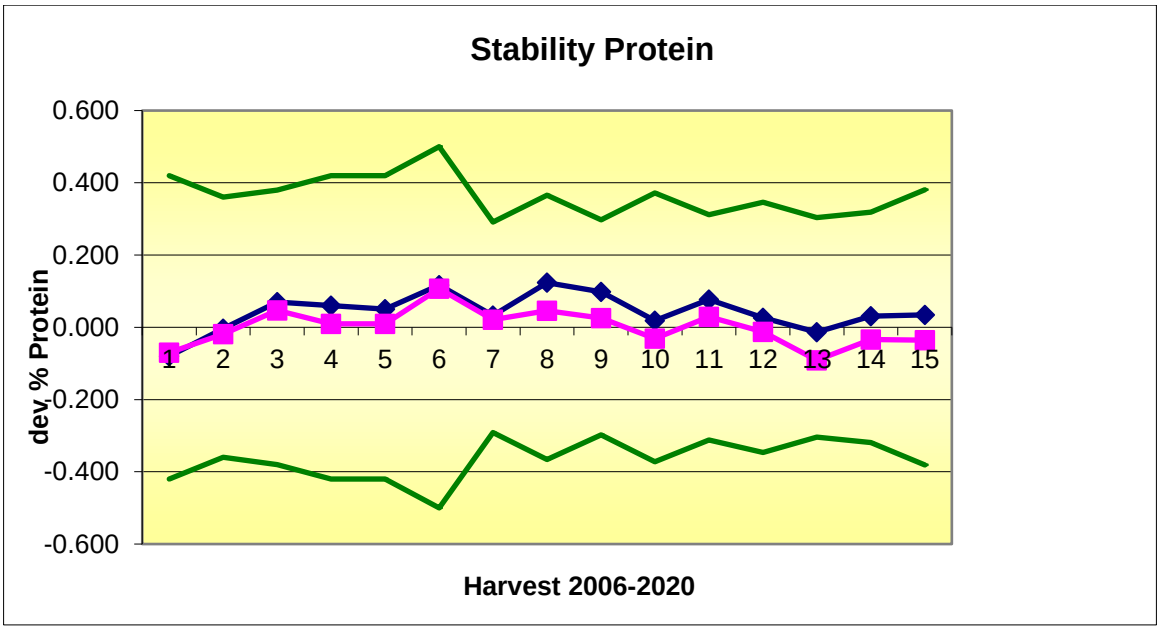


Figure 5.3.3 b: Average deviations of predicted protein results from the best estimate of the true value during the past thirteen years. Blue = Local and Pink = ANN.

6 Results for oil and moisture in Rapeseed

6.1 Collation of results

6.1.1 Oil content by reference methods

Twenty-four sets of reference data from 19 labs were reported:

Labcode	Method code	Standard
2	O1	ISO 659:2009
4	O3	Foss Analytical ASN 3134
8	O1	ISO 659:2009
12a	O3	Troëng (rapid extraction method)
12b	O4	ISO 10565:1998 (NMR)
15a	O4	ISO 10565:1998 (NMR)
15b	O1	ISO 659:2009
17	O1	ISO 659:2009
18	O1	ISO 659:2009
19	O1	ISO 659:2009
26	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
30a	O3	AACCI method 30-25.01. In-House validated Method 024, Petroleum ether extraction, Soxhlet
33a	O1	ISO 659:2009
33b	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
35a	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
64	O1	ISO 659:2009
68a	O1	ISO 659:2009
68b	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
80	O1	ISO 659:2009
88	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
91	O3	Foss Analytical ASN 3134
94	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
98a	O1	ISO 659:2009
98b	O4	ISO 10565:1998 (NMR), Bruker minispec mq10

Table 6.1.1: Reference methods used for oil determination

A complete compilation of the protein results for all samples by the reference methods is shown in table 6.1.1.1 below.

6.1.2 Moisture content by reference methods

Twenty-eight sets of reference values from 24 labs were reported.

Labcode	Method code	Standard	Description
1	M1	ISO 665:2000	103° C, 1 h, whole seed
2	M1	ISO 665:2000	103° C, 1 h, whole seed
4	M1	ISO 665:2000	103° C, 1 h, whole seed
5	M1	ISO 665:2000	103° C, 1 h, whole seed
8	M1	ISO 665:2000	103° C, 1 h, whole seed
12	M1	ISO 665:2000	103° C, 1 h, whole seed
15a	M2	ISO 10565:1998 (NMR)	NMR
15b	M1	ISO 665:2000	103° C, 1 h, whole seed
17	M1	ISO 665:2000	103° C, 1 h, whole seed
18	M1	ISO 665:2000	103° C, 1 h, whole seed
19	M1	ISO 665:2000	103° C, 1 h, whole seed
25	M1	ISO 665:2000	103° C, 1 h, whole seed
26	M1	ISO 665:2000	103° C, 1 h, whole seed
27	M3	ISO 665:2000	103° C, 1 h, whole seed
30	M1	ISO 665:2000	103° C, 1 h, whole seed
33a	M1	ISO 665:2000	103° C, 1 h, whole seed
33b	M2	ISO 10565:1998 (NMR)	Bruker minispec mq10
35a	M1	ISO 665:2000	103° C, 1 h, whole seed
64	M1	ISO 665:2000	103° C, 1 h, whole seed
68a	M1	ISO 665:2000	103° C, 1 h, whole seed
68b	M2	ISO 10565:1998 (NMR)	Bruker the Minispec TD-NMR
80	M1	ISO 665:2000	103° C, 1 h, whole seed
82	M1	ISO 665:2000	103° C, 1 h, whole seed
88	M1	ISO 665:2000	103° C, 1 h, whole seed
91	M1	ISO 665:2000	103° C, 1 h, whole seed
94	M1	ISO 665:2000	103° C, 1 h, whole seed
98a	M1	ISO 665:2000	103° C, 1 h, whole seed
98b	M2	ISO 10565:1998 (NMR)	Bruker minispec mq10

Table 6.1.2: Reference methods used for moisture determinations

*The description of the time for oven method (ISO 665) is just indicative. The correct specification is that drying time is given when constant weight has been reached. This will typically be after 2-3 steps where the first step can be 3 hours and successive confirmation steps of 1 hour. The total time may then be 4-5 hours.

A complete compilation of the moisture results for all samples by the reference methods is shown in table 6.1.2.1 below.

Oil content by NIR predictions using calibrations currently used in the respective networks

See table III.1 in Annex III.

6.1.3 Moisture content by NIR predictions using calibrations currently used in the respective networks.

See table III.2 in Annex III.

6.1.4 Oil content by using the ANN model RA002635 (RAOI0035)

See table IV.1 in Annex IV.

6.1.5 Moisture content by using the ANN model RA002635 (RAMO0026)

See table IV.2 in Annex IV.

Legend to tables below:

Mean Average value of values for all samples reported by one lab (lab average)

Dev Deviation (difference) of this average value (Mean) from the average values of all labs

SDD Standard deviation of the differences of the reported values for a certain sample by a certain lab from the average values

Average >Average< of the reported value for a certain sample (before elimination of outliers)

Std Standard deviation of the values reported for a certain sample (before elimination of outliers)

Min Minimum of the reported values for a certain sample

Max Maximum of the reported values for a certain sample

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
2	44.24	48.14	46.01	47.20	47.71	47.31	48.92	39.85	44.01	45.13	45.9	-1.16	0.28
4	45.35	50.22	48.62	49.07	49.42	49.82	51.26	40.36	46.15	47.18	47.7	0.73	0.50
8	45.23	49.49	47.53	48.56	48.83	48.95	50.54	41.52	45.91	46.39	47.3	0.28	0.31
12a	45.20	49.60	47.40	48.30	49.00	49.20	50.30	40.80	45.80	47.00	47.3	0.25	0.24
12b	45.80	49.70	47.70	48.90	49.40	49.40	50.90	40.70	46.30	46.90	47.6	0.56	0.15
15a	45.44	49.78	47.40	48.55	49.45	48.92	50.46	41.43	45.60	46.53	47.4	0.34	0.29
15b	46.90	49.80	49.00	48.90	48.50	49.00	50.30	42.40	46.70	48.30	48.0	0.97	0.86
17	46.20	49.60	47.20	48.50	48.60	48.90	50.20	42.00	46.50	46.60	47.4	0.42	0.52
18	46.70	50.20	46.50	49.00	49.60	48.50	49.80	40.50	45.90	45.50	47.2	0.21	0.72
19	45.09	49.71	47.86	48.33	48.98	49.90	50.60	42.82	45.99	46.09	47.5	0.52	0.77
26	45.88	50.21	47.53	48.88	49.64	50.14	51.71	41.20	46.98	47.70	48.0	0.97	0.40
30a	41.60	47.05	42.79	46.51	46.73	45.17	46.99	37.64	42.72	42.20	43.9	-3.07	0.84
33a	45.72	50.06	47.64	49.29	49.78	49.92	50.10	40.27	46.51	47.62	47.7	0.68	0.51
33b	46.17	49.79	47.42	48.61	49.14	48.87	50.38	41.20	46.34	47.15	47.5	0.49	0.27
35a	45.44	49.31	47.23	48.50	49.10	48.77	50.62	40.43	45.78	46.28	47.1	0.13	0.14
64	45.18	48.77	46.82	48.13	48.79	48.50	50.16	40.56	46.01	46.50	46.9	-0.07	0.23
68a	45.04	48.42	46.55	47.85	48.32	47.71	50.09	39.40	45.83	45.28	46.4	-0.56	0.41
68b	44.94	48.96	46.70	47.83	48.47	48.48	50.00	39.80	45.28	46.16	46.7	-0.35	0.16
80	43.36	47.90	45.21	46.79	47.61	46.89	49.33	39.22	44.60	45.06	45.6	-1.42	0.35
88	45.61	49.74	47.61	48.76	49.46	49.38	50.81	39.12	46.14	46.71	47.3	0.32	0.60
91	45.80	49.60	48.00	48.30	49.40	49.10	51.10	40.50	46.00	46.10	47.4	0.38	0.37
94	45.30	49.20	47.20	48.50	49.10	48.70	50.50	40.00	45.70	46.70	47.1	0.08	0.25
98a	45.20	49.01	47.06	48.20	48.52	48.49	49.48	40.13	45.58	45.70	46.7	-0.28	0.23
98b	44.90	48.83	46.51	47.98	48.63	48.46	49.95	39.49	45.17	45.99	46.6	-0.42	0.24
Average	45.3	49.3	47.1	48.3	48.8	48.7	50.2	40.5	45.7	46.3	47.0	0.0	0.4
Std	1.07	0.79	1.21	0.69	0.72	1.08	0.91	1.13	0.91	1.19	0.88	0.88	0.22
Min	41.6	47.1	42.8	46.5	46.7	45.2	47.0	37.6	42.7	42.2	43.9	-3.1	0.1
Max	46.9	50.2	49.0	49.3	49.8	50.1	51.7	42.8	47.0	48.3	48.0	1.0	0.9

Deviation = Mean Value - Average Value

SDD=Standard Deviation of Differences (after adjustment for deviation)

Table 6.1.1.1: Compilation of results for the reference analyses of the oil content (d.m.) in rapeseed samples

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	7.13	6.37	6.86	6.72	6.75	7.11	6.45	7.24	6.96	7.08	6.9	-0.12	0.08
2	7.27	6.40	6.89	6.93	6.87	6.87	6.52	7.48	7.20	7.28	7.0	-0.02	0.12
4	7.40	6.43	7.07	6.86	6.86	7.19	6.50	7.18	7.12	7.24	7.0	-0.01	0.07
5	6.90	6.10	6.50	6.50	6.40	6.50	6.00	6.80	6.30	6.70	6.5	-0.52	0.12
8	7.76	6.77	7.38	7.24	7.32	7.44	6.86	7.78	7.56	7.63	7.4	0.38	0.07
12	7.40	6.50	7.10	6.90	7.00	7.10	6.60	7.30	7.10	7.40	7.0	0.05	0.04
15a	7.14	6.14	6.75	6.62	6.83	6.85	6.30	7.15	6.85	7.07	6.8	-0.22	0.07
15b	7.49	6.50	7.13	7.01	7.04	7.13	6.64	7.40	7.22	7.46	7.1	0.11	0.05
17	7.50	6.50	7.10	7.00	7.00	7.20	6.50	7.40	7.30	7.50	7.1	0.11	0.08
18	7.40	6.40	7.00	6.90	6.80	7.10	6.60	7.40	7.10	7.40	7.0	0.02	0.08
19	7.52	6.56	7.13	7.09	7.05	7.28	6.67	7.45	7.25	7.52	7.2	0.16	0.04
25	7.30	6.30	6.60	6.80	6.90	7.00	6.50	7.10	6.90	7.10	6.9	-0.14	0.10
26	7.29	6.36	6.88	6.81	6.85	7.03	6.50	7.30	7.07	7.34	6.9	-0.05	0.05
27	7.61	6.71	7.24	7.23	7.21	7.39	6.79	7.65	7.36	7.64	7.3	0.29	0.05
30	7.43	6.51	7.04	6.93	6.98	6.73	6.21	7.40	6.89	6.96	6.9	-0.08	0.20
33a	7.55	6.56	7.12	6.98	7.07	7.17	6.61	7.68	7.32	7.37	7.1	0.15	0.11
33b	7.30	6.60	6.80	6.80	7.00	7.10	6.70	6.30	7.00	7.10	6.9	-0.12	0.32
35a	7.45	6.57	7.17	7.02	7.07	7.28	6.70	7.51	7.25	7.55	7.2	0.17	0.06
64	7.50	6.50	6.90	7.00	6.90	7.10	6.50	7.40	7.10	7.40	7.0	0.04	0.08
68a	7.14	6.24	6.79	6.72	6.71	6.90	6.35	7.07	6.84	7.11	6.8	-0.20	0.02
68b	7.14	6.41	6.66	6.76	6.90	7.01	6.62	6.40	6.87	7.01	6.8	-0.21	0.26
80	7.50	6.52	7.03	6.93	7.03	7.18	6.58	7.31	7.13	7.35	7.1	0.07	0.03
82	7.27	6.33	6.89	6.83	6.80	7.09	6.46	7.26	7.01	7.23	6.9	-0.07	0.04
88	7.37	6.41	6.95	6.91	6.92	7.07	6.53	7.41	7.18	7.32	7.0	0.02	0.06
91	7.30	6.50	7.00	6.90	7.00	7.30	6.60	7.50	7.20	7.40	7.1	0.08	0.09
94	7.44	6.57	7.15	7.02	7.00	7.17	6.63	7.47	7.24	7.47	7.1	0.13	0.05
98a	7.30	6.35	6.92	6.84	6.84	7.17	6.42	7.29	6.97	7.22	6.9	-0.06	0.06
98b	7.43	6.60	6.94	7.05	7.18	7.29	6.91	6.66	7.15	7.38	7.1	0.07	0.26
Average	7.4	6.5	7.0	6.9	6.9	7.1	6.5	7.3	7.1	7.3	7.0	0.0	0.1
Std	0.18	0.15	0.20	0.16	0.17	0.20	0.19	0.35	0.23	0.22	0.18	0.18	0.07
Min	6.9	6.1	6.5	6.5	6.4	6.5	6.0	6.3	6.3	6.7	6.5	-0.5	0.0
Max	7.8	6.8	7.4	7.2	7.3	7.4	6.9	7.8	7.6	7.6	7.4	0.4	0.3

Deviation = Mean Value - Average Value

SDD=Standard Deviation of Differences (after adjustment for deviation)

Table 6.1.2.1: Compilation of results for the reference analyses of the moisture content in rapeseed samples

6.2 Statistical evaluation of the results for oil and moisture in Rapeseed

The statistical evaluation for rapeseed was made in the same way as for wheat and barley and the results are summarized below. For detailed results and graphical presentation see Supplementary material WGN2021.

As no blind duplicates were included in the sample set only an evaluation of the reproducibility has been made, after outlier elimination according to Grubb's.

6.2.1 Oil by reference method

Twenty-four sets of results on basis of Extraction and NMR methods (see table 5.1.1 above) have been used for this evaluation. A summary is given in tables 5.2.1.1 and 5.2.1.2 – for detailed results see section 8 in Supplementary material WGN2021.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	45.42	49.39	47.25	48.46	48.93	48.84	50.33	40.60	45.94	46.46
3	0.75	0.65	0.81	0.48	0.58	0.79	0.62	0.98	0.53	0.83
4	1.64	1.31	1.71	0.99	1.19	1.63	1.24	2.42	1.15	1.79

Table 6.2.1.1 Results of statistical analysis for the determination of the oil content in rapeseed samples by reference methods

Legend to tables: 1 = sample no, 2 = average value after elimination of outliers, 3 = standard deviation of reproducibility (in % Oil), 4 = relative standard deviation of reproducibility (in %).

Z- Values for oil reference analyses:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results, i.e. line 2 in above tables) by the standard deviation of the method.

In the case of oil, a fixed value of s_R = 0.55 % has been chosen in accordance with ISO 659:1998. Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 (marked yellow in above tables) and unsatisfactory for absolute values above 3 (marked reddish/pink in above tables).

The results show that the reference analyses for oil deviate with a significant negative bias for labs 2, 30a and 80. It could be due to oil loss during sample mill preparation. Lab 15b has three red marked result that may be more random in origin. A few other deviating results for labs 4, 17, 18, 19, 26, 33a, 68a, 88, 98b of which only one sample is red marked (R8 for lab 19). It seems as if those labs with most deviations are conventional extraction methods, whereas methods based on NMR works best. That said, there are also extraction methods that work well in this study.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	-2.2	-2.3	-2.3	-2.3	-2.2	-2.8	-2.6	-1.4	-3.5	-2.4
4	-0.1	1.5	2.5	1.1	0.9	1.8	1.7	-0.4	0.4	1.3
8	-0.4	0.2	0.5	0.2	-0.2	0.2	0.4	1.7	-0.1	-0.1
12a	-0.4	0.4	0.3	-0.3	0.1	0.7	0.0	0.4	-0.3	1.0
12b	0.7	0.6	0.8	0.8	0.9	1.0	1.0	0.2	0.6	0.8
15a	0.0	0.7	0.3	0.2	0.9	0.1	0.2	1.5	-0.6	0.1
15b	2.7	0.7	3.2	0.8	-0.8	0.3	0.0	3.3	1.4	3.3
17	1.4	0.4	-0.1	0.1	-0.6	0.1	-0.2	2.6	1.0	0.3
18	2.3	1.5	-1.4	1.0	1.2	-0.6	-1.0	-0.2	-0.1	-1.7
19	-0.6	0.6	1.1	-0.2	0.1	1.9	0.5	4.0	0.1	-0.7
26	0.8	1.5	0.5	0.8	1.3	2.4	2.5	1.1	1.9	2.3
30a	-6.9	-4.3	-8.1	-3.5	-4.0	-6.7	-6.1	-5.4	-5.9	-7.7
33a	0.5	1.2	0.7	1.5	1.5	2.0	-0.4	-0.6	1.0	2.1
33b	1.4	0.7	0.3	0.3	0.4	0.1	0.1	1.1	0.7	1.3
35a	0.0	-0.1	0.0	0.1	0.3	-0.1	0.5	-0.3	-0.3	-0.3
64	-0.4	-1.1	-0.8	-0.6	-0.3	-0.6	-0.3	-0.1	0.1	0.1
68a	-0.7	-1.8	-1.3	-1.1	-1.1	-2.1	-0.4	-2.2	-0.2	-2.1
68b	-0.9	-0.8	-1.0	-1.1	-0.8	-0.7	-0.6	-1.4	-1.2	-0.5
80	-3.7	-2.7	-3.7	-3.0	-2.4	-3.5	-1.8	-2.5	-2.4	-2.5
88	0.3	0.6	0.7	0.5	1.0	1.0	0.9	-2.7	0.4	0.5
91	0.7	0.4	1.4	-0.3	0.9	0.5	1.4	-0.2	0.1	-0.7
94	-0.2	-0.4	-0.1	0.1	0.3	-0.3	0.3	-1.1	-0.4	0.4
98a	-0.4	-0.7	-0.3	-0.5	-0.7	-0.6	-1.5	-0.8	-0.7	-1.4
98b	-0.9	-1.0	-1.3	-0.9	-0.5	-0.7	-0.7	-2.0	-1.4	-0.9

Table 6.2.1.2: Z-scores for the determination of oil in rapeseed samples by reference methods

6.2.2 Moisture by reference method

Twenty-eight sets of results from twenty-five laboratories submitted reference results for the moisture content of the test samples. The methods used are given in table 6.1.2 above. Details are given in section 9 of Supplementary material WGN2021.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	7.38	6.45	6.96	6.90	6.96	7.12	6.56	7.36	7.12	7.32
3	0.15	0.15	0.20	0.16	0.14	0.16	0.16	0.21	0.17	0.19
4	2.07	2.35	2.82	2.36	2.04	2.28	2.38	2.81	2.45	2.56

Table 6.2.2.1- Results of statistical analysis for the determination of the moisture content in rapeseed samples by reference methods

Legend to tables: 1 = sample no, 2 = average value after elimination of outliers, 3 = standard deviation of reproducibility (in % H2O), 4 = relative standard deviation of reproducibility (in %).

Z- Values for moisture reference analyses:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

For moisture a fixed value of s_R = 0.16 % has been chosen in accordance with ISO 665:2000.

Absolute z-scores below 2 correspond to good laboratory performance.
The performance is questionable for absolute scores between 2 – 3 (marked yellow in above tables) and unsatisfactory for absolute values above 3 (marked red in above tables).

The results show that the determination of moisture in rapeseed is under control for most laboratories. Lab 5 has seven red marked and the other three yellow marked all with a negative sign. This should be investigated and corrected. Lab 8 has nine yellow marked and all results with a positive sign, so should be ware. There are three other labs (33b, 68b, 98b) with red marked results, but all for sample R8 so could perhaps be the sample. A few other yellow marked results can be observed, but nothing that alerts action.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-1.6	-0.5	-0.6	-1.1	-1.3	-0.1	-0.7	-0.7	-1.0	-1.5
2	-0.7	-0.3	-0.5	0.2	-0.6	-1.6	-0.3	0.8	0.5	-0.2
4	0.1	-0.1	0.7	-0.3	-0.6	0.4	-0.4	-1.1	0.0	-0.5
5	-3.0	-2.2	-2.9	-2.5	-3.5	-3.9	-3.5	-3.5	-5.1	-3.8
8	2.4	2.0	2.6	2.1	2.3	2.0	1.8	2.6	2.7	2.0
12	0.1	0.3	0.9	0.0	0.3	-0.1	0.2	-0.4	-0.1	0.5
15a	-1.5	-2.0	-1.3	-1.8	-0.8	-1.7	-1.7	-1.3	-1.7	-1.5
15b	0.7	0.3	1.0	0.7	0.5	0.1	0.5	0.3	0.7	0.9
17	0.7	0.3	0.9	0.6	0.3	0.5	-0.4	0.3	1.2	1.2
18	0.1	-0.3	0.2	0.0	-1.0	-0.1	0.2	0.3	-0.1	0.5
19	0.9	0.7	1.0	1.2	0.6	1.0	0.7	0.6	0.8	1.3
25	-0.5	-1.0	-2.3	-0.6	-0.4	-0.8	-0.4	-1.6	-1.3	-1.3
26	-0.6	-0.6	-0.5	-0.6	-0.7	-0.6	-0.4	-0.4	-0.3	0.2
27	1.4	1.6	1.7	2.0	1.6	1.7	1.4	1.8	1.5	2.0
30	0.3	0.4	0.5	0.2	0.1	-2.4	-2.2	0.3	-1.4	-2.2
33a	1.0	0.7	1.0	0.5	0.7	0.3	0.3	2.0	1.3	0.3
33b	-0.5	0.9	-1.0	-0.6	0.3	-0.1	0.8	-6.6	-0.7	-1.3
35a	0.4	0.7	1.3	0.7	0.7	1.0	0.8	1.0	0.8	1.5
64	0.7	0.3	-0.4	0.6	-0.4	-0.1	-0.4	0.3	-0.1	0.5
68a	-1.5	-1.3	-1.1	-1.1	-1.6	-1.4	-1.3	-1.8	-1.7	-1.3
68b	-1.5	-0.3	-1.9	-0.9	-0.4	-0.7	0.3	-6.0	-1.5	-1.9
80	0.7	0.4	0.4	0.2	0.4	0.4	0.1	-0.3	0.1	0.2
82	-0.7	-0.8	-0.5	-0.5	-1.0	-0.2	-0.7	-0.6	-0.7	-0.5
88	-0.1	-0.3	-0.1	0.0	-0.2	-0.3	-0.2	0.3	0.4	0.0
91	-0.5	0.3	0.2	0.0	0.3	1.1	0.2	0.9	0.5	0.5
94	0.4	0.7	1.2	0.7	0.3	0.3	0.4	0.7	0.8	1.0
98a	-0.5	-0.6	-0.3	-0.4	-0.7	0.3	-0.9	-0.4	-0.9	-0.6
98b	0.3	0.9	-0.1	0.9	1.4	1.1	2.2	-4.4	0.2	0.4

Table 6.2.2.2: Z-scores for the determination of moisture in rapeseed samples by reference methods

6.2.3 Oil determination using NIR prediction models currently used

Predictions of the oil content of each sample were made by the different laboratories using different instruments and their respective prediction models. A summary of the results of the statistical evaluation are given in table 6.2.3.1 – for detailed results see section 10 in Supplementary material WGN2021.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	45.81	49.26	48.08	48.65	48.52	48.92	49.78	41.71	46.25	46.85
3	0.38	-0.13	0.83	0.19	-0.42	0.08	-0.54	1.11	0.30	0.39
4	0.99	0.75	1.14	0.50	0.69	0.55	0.77	1.23	0.91	0.61
5	2.16	1.53	2.37	1.04	1.42	1.13	1.54	2.95	1.98	1.29

Table 6.2.3.1 - Results of statistical analysis for the determination of the oil content in <u>rapeseed</u> by local NIR predictions

Legend to tables: 1 = sample no, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % Oil), 5 = relative standard deviation of reproducibility (in %).

Z- Values for oil by local NIR prediction models:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.55 % has been used as for the oil reference analyses.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 (marked yellow in above tables) and unsatisfactory for absolute values above 3.

The results show that labs 5, 27b, 30a, 30e, 30f and 85 deviates significantly with a clear systematic shift (lab 5 with a positive and the rest with negative bias). It is only lab 30 that has submitted reference results, which have a negative bias and consequently the local models for 30a, 30e and 30f have been adjusted accordingly. For lab 5, 27b and 85, the re-prediction with unadjusted global ANN model will give some idea what these deviations originates from. Lab 80 have 5 red marked and two yellow marked results, but of different signs, so is more random and could be due to outlier warnings. There are some other results with red or yellow marking, which probably is due to outlier warnings.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	1.4	-0.8	2.9	-0.6	-1.1	0.0	-1.4	1.3	1.9	0.6
2	-0.3	-0.2	-1.9	-1.2	-0.7	-0.3	0.2	0.3	-0.2	-0.5
4a	2.3	0.0	1.3	0.8	0.6	0.2	0.0	6.9	2.7	1.2
4b	2.9	0.4	-0.5	0.3	0.5	0.5	0.8	6.5	2.3	0.8
5	3.3	3.0	3.5	2.4	2.9	2.3	2.0	2.4	2.8	2.1
6	-1.6	0.9	0.2	0.2	0.2	0.0	-0.2	-0.6	-0.8	-0.5
8a	0.0	0.1	-0.7	-0.1	0.2	0.7	0.8	0.7	0.1	0.0
8b	1.4	-0.5	0.9	-0.5	0.3	0.0	-0.4	2.1	0.8	0.2
11	1.3	0.1	0.0	0.1	0.7	-0.6	0.5	1.1	0.9	0.1
12	1.1	1.3	-0.9	0.8	1.6	0.9	1.3	0.9	0.6	0.4
15a	1.9	2.1	2.2	1.3	1.0	0.5	1.0	1.2	1.6	1.2
15b	2.0	1.5	2.2	1.1	0.9	0.9	1.5	0.9	1.6	1.6
17a	0.3	1.1	-2.2	-0.5	0.0	-1.0	0.7	0.9	0.7	-1.2
17b	0.8	0.3	0.9	-0.4	0.1	0.0	0.6	2.4	0.1	-0.3
18	-0.6	-1.2	-1.8	-1.2	-0.9	-0.8	-1.6	0.0	-1.0	-1.9
19	1.1	0.6	-0.5	0.0	0.3	0.9	0.6	1.8	1.8	0.8
25	1.1	-0.3	2.2	-0.3	-0.8	-1.7	-0.3	0.2	1.7	-0.3
27a	-0.9	0.3	-0.6	0.9	0.4	0.2	0.2	-0.4	0.2	0.8
27b	-7.2	-7.1	-7.0	-7.1	-6.9	-7.6	-7.9	-6.4	-7.6	-8.5
30a	-3.6	-3.0	-7.1	-4.3	-4.0	-4.2	-3.4	-3.8	-3.4	-4.5
30e	-3.8	-4.7	-4.5	-5.4	-4.0	-6.6	-3.8	-4.7	-4.3	-6.1
30f	-3.9	-3.4	-5.0	-5.4	-3.1	-4.4	-5.4	-4.6	-4.0	-4.6
31	-1.8	1.5	1.7	0.1	0.5	1.4	2.0	-3.5	-0.8	1.4
33	-2.7	0.6	2.4	0.1	1.6	1.1	0.6	-4.4	-1.4	1.2
35a	0.2	-1.7	2.2	-1.4	-2.6	-1.3	-0.9	1.4	-0.3	0.3
35b	1.4	-1.9	2.6	-0.6	-1.7	0.2	-1.2	1.8	0.8	0.3
35c	0.4	-1.2	2.4	-0.5	-1.5	-0.4	-1.6	1.6	0.5	-0.1
35d	0.0	-1.0	2.0	-1.2	-2.0	-1.1	-19.1	1.8	-0.1	-0.5
35e	-1.1	-0.1	-1.9	-0.1	0.9	0.7	1.6	0.1	-1.1	-0.4
35f	-2.4	-1.7	-2.4	-2.5	-0.1	-1.8	0.0	-1.3	-2.2	-3.0
64	0.4	-0.5	0.6	-0.6	0.5	-0.2	0.9	1.1	0.3	-0.3
68	0.2	0.5	-0.7	-1.1	0.4	0.1	-0.1	0.1	-0.7	-0.7
80	0.2	-6.9	-12.7	2.3	0.4	-1.5	-3.0	9.4	5.0	-3.6
82	1.1	1.0	-0.9	0.1	0.3	0.5	1.3	2.7	0.8	0.6
85	-2.1	-1.4	-3.0	-3.1	-2.0	-2.0	-1.4	-2.7	-2.1	-2.2
88	-1.1	-0.3	-1.4	-1.2	0.2	-0.4	0.2	-4.9	-0.3	-0.8
91	-0.7	1.3	-1.8	0.3	0.0	0.9	1.1	0.7	-0.4	0.3
94a	0.7	0.1	0.2	0.1	-0.2	-0.2	0.4	0.2	-0.4	0.3
94b	2.2	1.9	0.9	0.8	2.3	2.0	0.9	1.4	1.2	0.3
98	-0.9	0.5	-0.9	-0.3	0.0	-0.7	0.1	1.6	-0.1	-1.8

Table 6.2.3.2: Z-scores for the determination of oil in rapeseed samples by local NIR models

6.2.4 Moisture determination using local NIR prediction models

Predictions of the moisture content of each sample were made by the different laboratories using different instruments and their respective prediction models. A summary of the results of the statistical evaluation are given in table 6.2.4.1 – for detailed results see section 11 in Supplementary material WGN2021.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	7.40	6.51	7.12	7.05	6.93	7.22	6.56	7.57	7.20	7.39
3	0.02	0.06	0.16	0.15	-0.03	0.10	-0.01	0.21	0.08	0.08
4	0.26	0.24	0.80	0.24	0.22	0.25	0.20	0.49	0.18	0.28
5	3.50	3.73	11.25	3.41	3.11	3.49	2.98	6.42	2.43	3.74

Table 6.2.4.1 - Results of statistical analysis for the determination of the moisture content in <u>rapeseed</u> by local NIR predictions

Legend to tables: 1 = sample, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % H2O), 5 = relative standard deviation of reproducibility (in %).

Z- Values for moisture content by local NIR prediction models:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.16 % as for reference analyses has been applied.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 (marked in yellow in tables below) and unsatisfactory for absolute values above 3.

There are an unusually large number of deviating results this year. We have some labs that deviate systematically such as 35a-35d with a positive bias. The results from lab 35e-35f based on NIR reflectance also show a systematic shift, but with a negative bias.
Other labs with indication of systematic shifts are 1, 8b, 11f, 15a, 27b. It is also clear that we may have some sample problems this year with a larger degree of inhomogeneity. This is observed by a larger number of red and yellow marked results for samples R3 and R8.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-2.2	-3.5	1.6	-1.1	-2.7	-2.6	-1.7	1.0	-1.9	-1.0
2	-0.2	-0.3	-2.2	0.8	0.9	1.2	0.8	1.0	1.0	1.5
4a	0.6	-1.3	-3.9	-0.9	-0.8	-0.1	0.3	-2.3	0.6	-1.2
4b	0.2	0.7	-3.1	0.2	0.1	0.2	-0.4	3.5	0.3	0.1
5	-1.3	0.5	-3.2	-1.6	-0.8	-2.0	-0.4	-0.4	-1.9	-2.5
6	-0.8	-0.4	4.9	0.6	-1.4	-0.8	0.5	-0.1	0.2	-1.5
8a	1.9	1.5	4.6	2.5	0.8	2.7	2.1	8.3	1.9	2.2
8b	2.2	3.4	2.4	2.5	3.0	2.7	1.8	2.7	1.3	3.2
11a	-0.6	0.5	-0.6	-0.1	0.0	-0.7	0.3	-0.9	0.6	-0.8
11f	-2.8	-1.6	-4.1	-2.2	-0.9	-2.5	-0.4	-6.8	-4.1	-2.9
12	0.6	-0.7	-0.1	-1.6	-2.0	-2.0	-1.6	-3.5	0.6	-0.6
15a	-2.5	-0.1	-4.5	-2.5	-1.4	-3.2	-1.3	-2.0	-1.6	-3.7
15b	-0.6	-0.7	-2.6	-1.6	0.5	-2.0	-1.6	-1.0	-1.2	-2.5
17a	2.2	-1.0	-0.7	-0.9	-0.5	0.2	-1.0	3.3	0.3	1.0
17b	-1.3	-1.6	-4.2	-0.6	-1.4	0.2	-1.3	-1.4	0.3	-0.6
18	-0.6	0.5	-3.2	-0.9	0.5	-0.1	-0.4	-1.0	1.3	1.3
19	-1.0	0.2	-3.5	0.0	1.1	0.6	-0.4	3.6	-1.2	0.5
25	-1.3	-1.3	4.9	-1.6	-2.0	-0.7	-0.4	4.0	-0.6	-0.6
27a	1.4	1.4	-3.4	2.1	1.8	0.0	-0.2	-1.5	-0.6	0.0
27b	2.5	2.0	-0.3	2.1	5.2	2.0	2.3	0.8	3.1	3.1
30a	3.1	-1.3	4.3	-0.9	-0.2	0.5	1.5	5.2	2.5	1.3
30e	-1.3	-0.1	-2.6	1.6	1.7	-0.1	-0.4	1.5	-1.9	-1.8
30f	0.4	1.5	1.2	0.9	1.6	-0.5	1.3	-0.4	0.2	0.5
31	0.0	0.5	-0.7	0.3	0.5	0.5	0.3	-0.4	0.0	0.0
33	0.6	-0.1	4.3	-0.3	-0.2	-0.1	1.5	1.5	-0.6	-1.2
35a	3.1	2.4	13.0	2.2	1.1	3.0	0.9	4.6	1.9	2.5
35b	2.5	1.2	11.8	3.4	1.7	2.4	2.1	3.3	3.1	1.9
35c	1.9	1.2	11.1	1.6	1.1	3.6	2.1	2.7	-18.7	2.5
35d	5.6	2.4	13.6	1.6	1.7	1.1	5.3	4.0	4.4	3.2
35e	-5.3	-6.7	-3.6	-6.9	-6.2	-7.5	-5.7	-6.3	-6.9	-7.8
35f	-3.1	-3.8	-3.2	-4.1	-2.7	-4.5	-2.9	-2.3	-4.4	-5.0
64	-0.1	0.2	-1.1	-0.4	-0.1	-0.7	-0.2	-1.1	-0.1	0.3
68	-1.3	-0.1	-2.6	-1.6	0.5	-0.7	-1.6	-4.2	-0.6	-2.5
80	0.4	-0.6	-3.1	0.2	0.8	-0.2	-1.7	1.0	0.3	0.9
82	1.2	1.2	-4.5	0.9	1.1	1.1	0.3	1.5	0.6	0.7
85	-1.3	-0.7	-5.1	-0.3	-0.8	-0.7	-1.6	-4.8	-1.2	-0.6
88	-0.6	-0.1	-1.4	-0.3	-0.2	-0.1	0.3	-0.4	0.0	-0.6
91	0.6	-0.7	-0.7	-0.9	0.5	-0.7	-0.4	-1.7	0.6	0.0
94a	0.0	1.8	-0.7	0.3	0.5	-0.7	0.3	1.5	0.0	-1.2
94b	-0.6	-0.1	-3.2	-0.3	-1.4	-1.4	-0.4	2.1	-0.6	-0.6
98	-1.9	-2.6	-5.1	-2.8	-2.0	0.5	-1.6	-6.0	-0.6	-0.6

Table 6.2.4.2: Z-scores for the determination of moisture in rapeseed samples by local NIR models

6.2.5 Oil content by the ANN model RA002635 (RAOI0035)

Thirty-nine different set of scans were submitted by laboratories using different instruments. They were evaluated by FOSS using the ANN model RA002635 (RAOI0035). A summary of the results of the statistical evaluation are given in table 6.2.5.1 – see section 12 in Supplementary material WGN2021 for an example.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	46.40	49.62	48.25	48.65	48.68	49.00	50.00	42.12	46.56	46.97
3	0.98	0.22	1.00	0.19	-0.25	0.16	-0.33	1.52	0.62	0.51
4	0.31	0.25	0.50	0.26	0.38	0.42	0.26	0.26	0.24	0.35
5	0.66	0.50	1.04	0.54	0.78	0.86	0.52	0.62	0.51	0.75

Table 6.2.5.1 - Results of statistical analysis for the determination of the oil content in <u>rapeseed</u> by the ANN model RA002635 (RAOI0035)

Legend to tables: 1 = sample, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % Oil), 5 = relative standard deviation of reproducibility (in %).

Z- Values for oil by ANN RAOI0035 prediction model:

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.55 % has been used as for the oil reference analyses.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 and unsatisfactory for absolute values above 3.

Results show very good agreement among all Infratec instruments with only one red and three yellow marked sample results. For lab 5, 27b and 85, we could observe a large deviation for their local models, but it is clear from the unadjusted global model that it is not the spectra nor the latest model. In fact, it is most likely an incorrect adjustment applied, or a moisture compensation enabled. This also shows that the prediction model for oil in rapeseed (RAOI0035) has very good transferability (i.e. ability to handle instrument variations).

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	0.4	0.4	1.0	0.4	-0.1	0.7	-0.8	1.2	0.6	1.2
2	0.2	0.8	1.5	0.4	-0.4	0.6	0.1	-0.1	0.5	0.6
4a	-1.0	-0.8	-0.4	-0.5	0.1	-0.8	-0.1	0.0	-0.2	-1.0
4b	0.1	-0.3	0.4	0.3	-1.0	0.9	0.9	0.6	0.0	-0.8
5	0.4	0.3	1.3	0.5	0.7	0.3	-0.3	0.0	0.2	0.1
6	-0.1	0.7	-0.1	0.3	0.0	0.0	-0.1	0.5	0.1	0.4
8a	0.0	-0.5	-0.5	-0.3	0.2	-0.3	-0.1	0.3	0.4	0.4
8b	0.5	-0.2	0.6	0.6	-0.8	-0.2	0.2	0.3	0.5	-0.4
11a	0.3	-0.6	-0.3	0.1	0.4	-0.8	0.1	0.4	0.3	-0.1
11b	0.5	-0.4	0.0	0.4	0.1	-0.4	-0.3	0.7	0.2	0.2
11d	0.6	0.0	1.4	0.5	0.0	0.6	-0.6	-0.2	-0.3	0.2
11e	-0.1	0.1	0.9	0.2	-0.5	0.1	0.4	0.1	0.2	-0.1
12	-1.3	-0.4	-2.1	-0.2	0.4	-0.5	-0.5	-0.8	-1.1	-0.8
15a	-0.2	0.4	0.9	-0.7	-0.3	-0.5	-0.5	-0.6	0.0	-0.1
15b	0.2	0.2	1.2	0.8	0.1	-0.1	0.0	-0.1	0.3	0.9
17	0.6	0.3	0.3	-0.3	0.2	-0.7	0.0	0.1	-0.4	-0.1
18	0.2	-0.1	0.6	-0.5	0.1	0.0	0.7	-0.9	0.1	0.0
19	0.0	0.1	-0.6	-0.2	-0.4	0.2	-0.5	0.2	0.2	0.2
25	0.5	0.6	0.2	0.7	-0.3	0.0	0.5	0.5	0.8	0.1
27a	-0.9	-0.1	-1.0	-0.1	0.4	-1.2	-0.5	0.0	-1.1	-0.3
27b	0.4	-0.2	1.1	1.2	-2.1	0.6	-0.3	0.9	0.3	1.8
30a	-0.2	0.3	-0.4	0.4	0.2	0.5	0.1	0.2	0.0	0.1
30e	0.3	-0.1	0.6	-0.3	1.0	-1.1	0.7	0.0	0.5	-1.1
30f	-0.2	0.6	-0.5	-0.3	1.4	1.1	-1.2	-0.9	0.0	-0.4
31	0.4	-0.3	0.3	-0.6	0.6	2.1	-3.2	0.1	0.0	0.5
33	1.3	-0.1	-1.5	0.3	1.1	0.3	-0.2	0.2	0.0	1.2
35a	-0.5	-0.6	-0.7	-0.3	-0.4	-1.8	0.4	-0.5	-0.5	-0.4
35b	0.0	-0.4	-0.4	0.0	-0.6	0.3	0.0	0.0	0.2	-0.1
35c	-0.2	-0.3	-0.8	-0.4	-0.6	-0.2	-0.3	-0.1	0.0	-0.6
35d	0.2	-0.6	-0.8	-0.3	-0.5	-0.5	-0.1	-0.3	0.2	-0.4
64	-0.5	-0.4	0.2	-0.4	0.5	-0.3	0.3	-0.1	-0.3	-0.1
68	-0.4	0.2	-1.6	-0.5	0.3	0.2	-0.2	-0.2	-0.7	0.3
80	0.7	-0.3	0.9	-0.2	0.1	0.9	0.4	0.0	0.6	0.3
82	-0.2	0.4	-0.7	-0.3	-1.2	-1.0	0.5	-0.5	-0.3	-0.2
85	-1.1	0.1	-1.6	-1.1	-0.1	-0.8	0.2	-0.9	-0.4	-0.4
88	-0.4	0.0	0.8	-0.4	0.4	0.9	0.9	0.4	0.3	0.4
94a	0.4	-0.2	0.4	0.5	-0.9	-0.1	0.5	-0.1	-0.6	0.4
94b	0.1	0.5	0.0	0.0	1.1	1.2	-0.4	0.0	-0.4	-0.7
98	-1.2	1.3	-0.9	0.3	0.5	-0.2	-0.1	-0.5	-0.1	-1.1

Table 6.2.5.2: Z-scores for the determination of oil in rapeseed samples by ANN RAOI0035

6.2.6 Moisture by ANN model RA002432 (RAMO0026)

Thirty-nine different set of scans were submitted by laboratories using different instruments were evaluated by the FOSS ANN model RA002635 (RAMO0026). A summary of the results of the statistical evaluation are given in table 6.2.6.1 – see section 13 in Supplementary material WGN2021 for an example.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	7.34	6.54	6.85	6.94	6.89	7.03	6.52	7.36	7.11	7.12
3	-0.05	0.08	-0.11	0.04	-0.07	-0.09	-0.04	0.00	-0.01	-0.20
4	0.17	0.16	0.29	0.18	0.21	0.22	0.19	0.31	0.17	0.15
5	2.4	2.5	4.2	2.6	3.0	3.2	3.0	4.2	2.4	2.1

Table 6.2.6.1 - Results of statistical analysis for the determination of the moisture content in rapeseed by ANN model RA002635 (RAMO0026)

Legend to tables: 1 = sample, 2 = average value after elimination of outliers, 3 = deviation from BETV (best estimate of true value, as established by reference analysis), 4 = standard deviation of reproducibility (in % H2O), 5 = relative standard deviation of reproducibility (in %).

Z- Values for moisture content by ANN RAMO0026 prediction model

The z-score is a performance criterion for the participating laboratories. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (= mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The same fixed value of s_R = 0.16 % as for reference analyses has been applied.

Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 and unsatisfactory for absolute values above 3.

The results show that there are one or more red marked results for labs (8a, 25, 27a, 27b, 31, 33, 35a and 94b). For lab 27a, the local model was relatively ok, which means it has been adjusted correctly, whereas the other instrument 27b show positive shifts for both hence an adjustment is required to become aligned.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-1.2	-0.1	0.4	0.8	-0.6	-2.2	0.4	0.1	-0.9	0.6
2	-0.7	-0.2	-0.7	0.4	0.7	0.4	-0.8	1.1	0.3	0.3
4a	0.9	-0.4	-0.5	0.0	-0.3	0.5	0.3	-1.2	0.9	-0.3
4b	0.8	0.8	1.5	0.5	0.1	0.0	-0.4	1.1	0.7	-0.4
5	-0.5	0.3	-1.1	-0.1	0.3	-0.4	0.1	0.6	-0.6	-0.6
6	-0.2	-0.5	-0.7	0.9	-2.4	-0.4	-1.1	-1.5	1.0	-0.4
8a	0.8	0.7	3.2	2.3	0.6	2.6	1.6	6.3	1.4	3.2
8b	-0.5	0.5	-0.2	-0.9	0.9	0.1	-0.8	0.9	-0.3	-0.1
11a	-0.2	0.3	1.1	0.6	0.3	0.4	0.5	0.4	1.2	0.9
11b	0.8	0.1	1.2	0.9	1.8	1.3	0.3	1.8	0.6	0.9
11d	-2.5	-0.2	-2.3	-1.8	-0.3	-2.4	-1.8	-0.1	-2.0	-0.9
11e	-2.1	-1.5	-2.9	-2.0	-2.4	-2.5	-2.2	-0.7	-1.2	-1.9
12	2.1	-0.3	1.6	0.1	-1.3	-0.4	0.4	-2.2	1.3	0.5
15a	-0.7	-0.3	-2.0	-0.8	0.3	-1.5	-0.2	-0.4	-0.3	-1.3
15b	0.5	0.0	-0.4	0.1	1.0	-0.1	-0.9	0.6	0.7	-0.2
17	-1.0	-0.9	-1.3	0.2	-0.5	1.1	-0.3	0.3	0.8	0.1
18	0.0	0.5	-1.2	-0.9	1.6	-1.4	-1.0	-0.4	0.4	-0.5
19	-0.6	0.1	0.0	0.5	0.6	1.1	0.3	2.1	-0.3	1.3
25	0.6	0.9	2.3	0.6	-0.8	0.9	1.0	4.3	0.0	1.4
27a	6.2	2.2	3.3	4.2	3.0	3.4	2.0	0.4	3.8	4.0
27b	5.0	2.6	2.1	2.5	4.4	2.6	2.7	2.6	5.5	4.2
30a	0.4	-0.3	-0.2	-0.8	-0.1	-0.8	0.7	-0.8	-0.2	0.0
30e	-1.9	-0.7	-2.9	0.7	0.9	0.1	-0.7	1.3	-2.3	-0.7
30f	-0.1	-0.3	1.0	-0.2	-0.2	-0.3	0.3	-2.0	-0.6	0.6
31	0.4	0.2	-0.1	-0.2	0.5	-3.0	2.9	1.7	0.2	-0.3
33	0.0	1.2	3.9	1.0	1.4	2.2	2.2	2.1	1.3	2.2
35a	-1.0	-2.7	-3.5	-2.9	-2.6	-1.9	-2.5	-4.9	-2.7	-4.0
35b	-1.0	-2.1	-1.4	-0.1	-1.4	-1.0	-0.5	-0.2	-1.3	-1.0
35c	-1.1	-1.3	-1.5	-0.4	-2.6	-0.5	-0.1	-2.0	-1.1	0.0
35d	0.5	0.2	0.8	0.0	0.9	-0.5	0.2	-1.4	1.2	0.7
64	0.4	-0.1	-0.5	-0.3	0.4	0.3	0.8	1.5	0.3	1.4
68	2.1	1.6	2.9	1.4	2.2	0.7	0.4	-1.8	0.8	-1.0
80	0.5	0.5	-0.3	-0.3	1.4	0.1	-0.4	0.3	-0.1	-0.1
82	0.3	-0.2	0.9	0.0	-0.1	0.8	-1.2	-1.4	0.4	0.0
85	2.0	-0.4	0.2	0.2	-0.6	-0.5	-1.2	-2.8	-0.3	-0.4
88	-0.1	-1.1	-2.2	-2.0	-1.7	-0.1	-1.0	-0.3	-1.7	-1.7
94a	0.0	0.9	0.9	0.1	0.0	0.1	0.0	1.4	0.5	-0.6
94b	0.5	0.7	-1.3	1.3	-0.6	0.5	0.4	3.8	0.4	1.8
98	1.7	-0.8	-0.3	-1.2	-0.4	0.6	-0.8	-4.4	1.2	-0.3

Table 6.2.6.2: Z-scores for the determination of moisture in rapeseed samples by ANN RAMO0026

6.3 Summary and comments for oil and moisture in Rapeseed

WGN 2021 **all samples** *(2020 harvest)*	**Ref. methods**	**Local models**	**FOSS ANN**
Oil, range	**40.6 % - 50.3 %**		
Mean (%)	**47.16**	**47.38**	**47.62**
deviation from mean		**0.22**	**0.46**
SD reproducibility	**0.70**	**0.81**	**0.32**
RSD reproducibility	**1.5**	**1.7**	**0.7**
Moisture, range	**6.5 % - 7.4 %**		
Mean (%)	**7.01**	**7.09**	**6.97**
deviation from mean		**0.08**	**-0.04**
SD reproducibility	**0.17**	**0.31**	**0.21**
RSD reproducibility	**2.4**	**4.4**	**2.9**

Table 6.3.1: Summary of results for oil and moisture in rapeseed

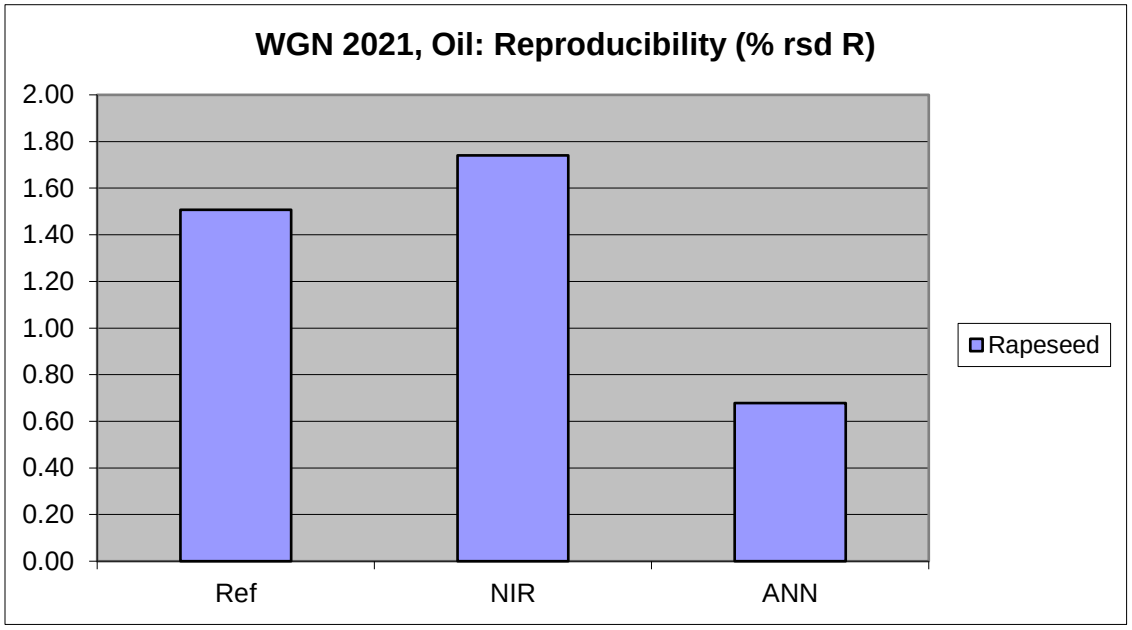


Fig. 6.3.1a: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model RA002635 (RAOI0035) (ANN) for the determination of **oil in rapeseed**.

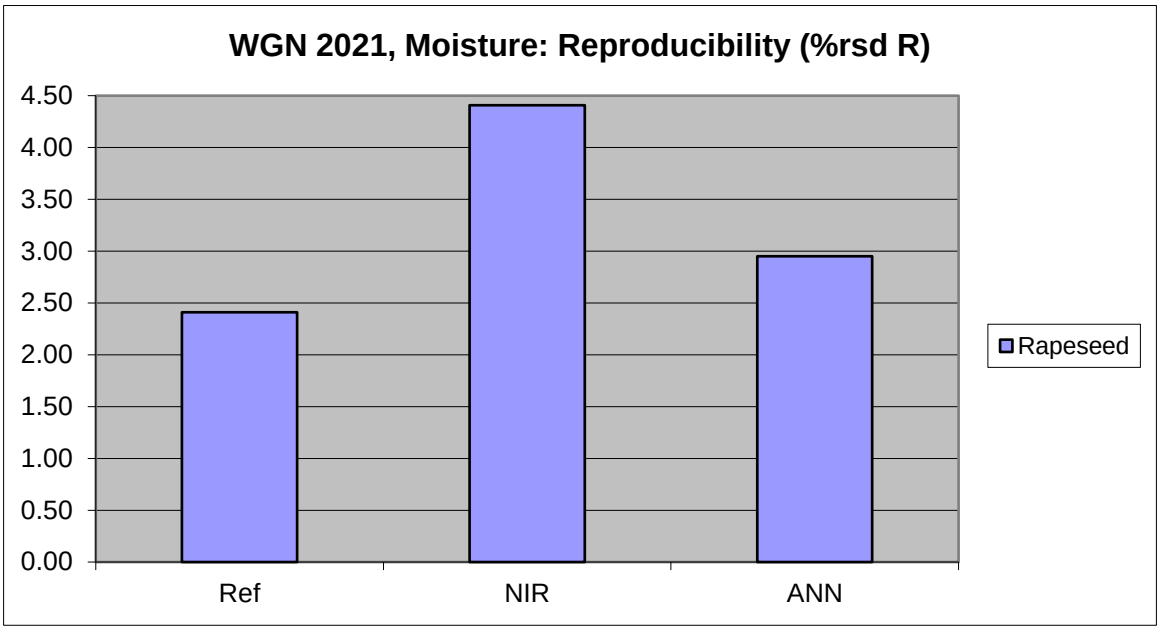


Fig. 6.3.1b: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model RA002635 (RAMO0026) (ANN) for the determination of **moisture in rapeseed**.

Reproducibility for global FOSS ANN models is better than reference methods for oil, but slightly worse for moisture. For local NIR models, reproducibility is slightly worse than reference method for oil, even more for moisture. This suggests that the locally adjusted models have been corrected to reference methods for moisture to a larger degree in some cases giving rise to a larger spread in the results. However, based on the good agreement among reference methods, it does not seem that the adjustments performed has been fully justified.

Figures 6.3.2a and 6.3.2.b show the differences between predicted values and the best estimate of the true value as determined by reference analyses. It shows in general very good agreement, where all samples are within the error limits of the reference methods for both oil and moisture.

The stability graphs for moisture and oil (Figures 6.3.3a and 6.3.3.b, respectively) show that current FOSS ANN global model RA002635 is well aligned with the average reference methods. It also shows that on average the adjusted local models agree well with the reference BETV.

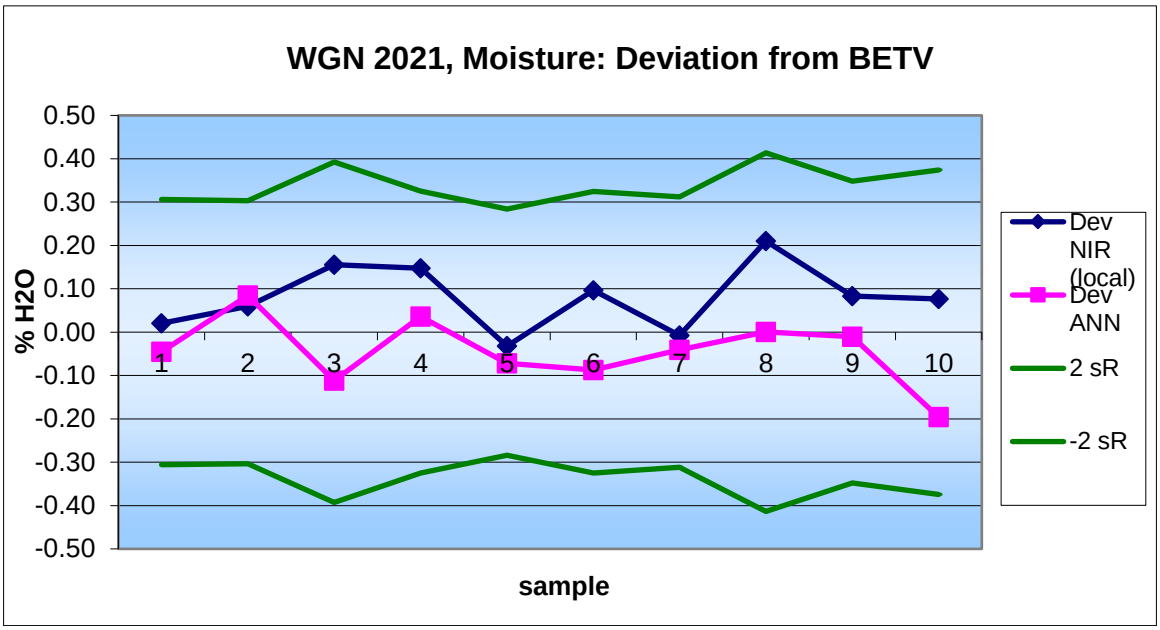


Fig. 6.3.2a: Deviations between predicted **moisture** values and the best estimate of the true value

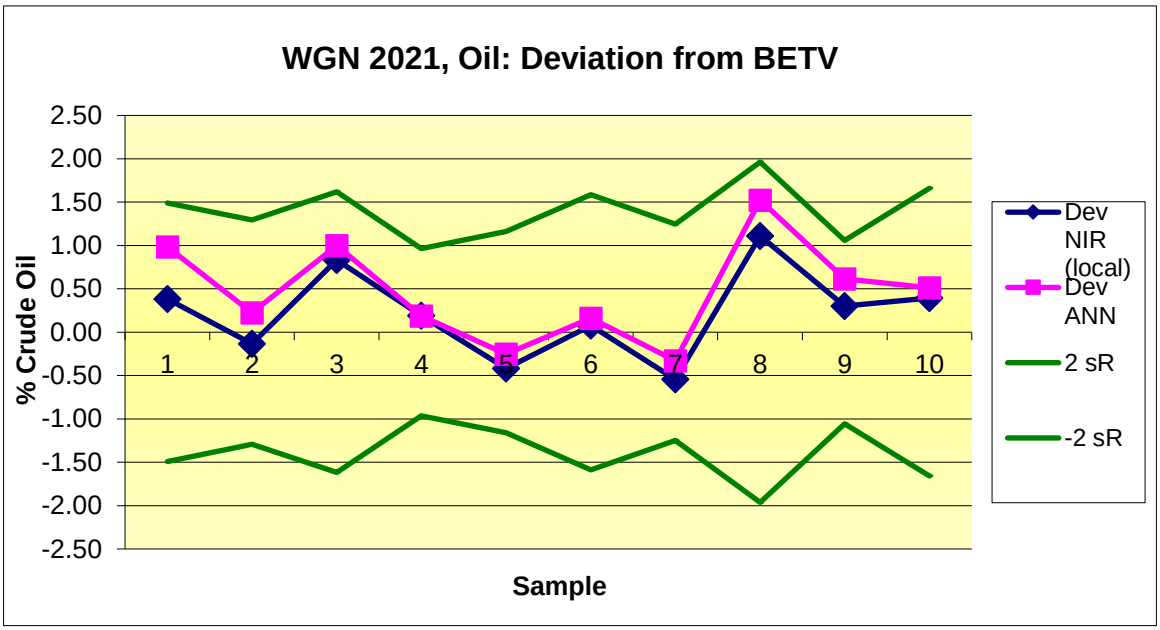


Fig. 6.3.2b: Deviations between predicted **oil** values and the best estimate of the true value

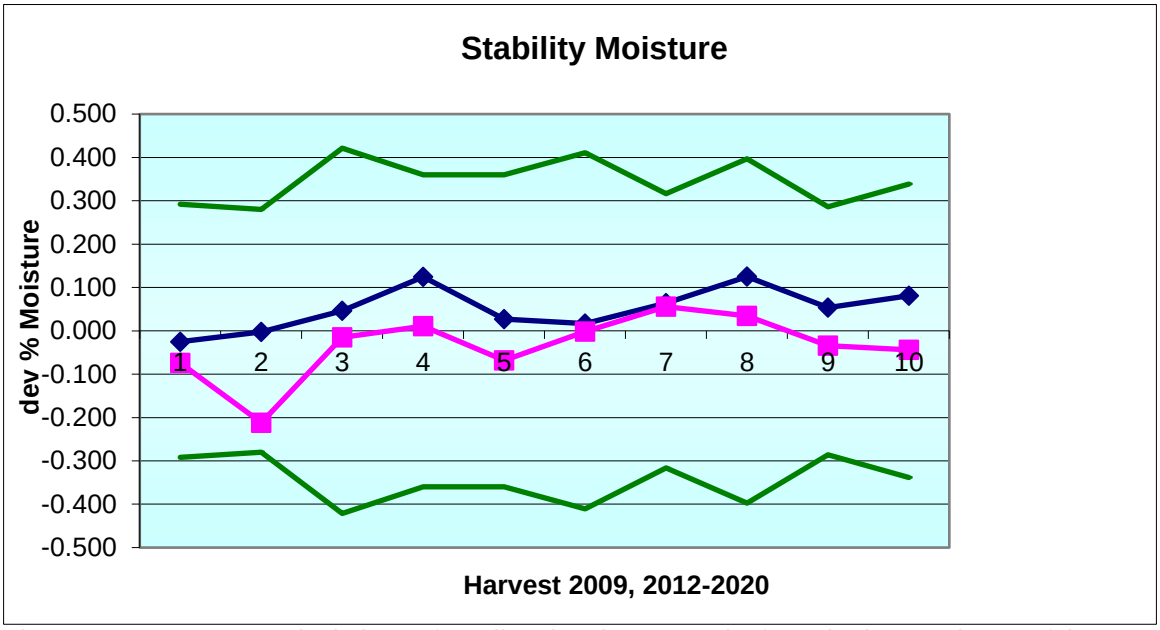


Figure 6.3.3 a: Average deviations of predicted moisture results from the best estimate of the true value for eight years of harvest (2009 and 2012-2020). Blue=Local and Pink =ANN.

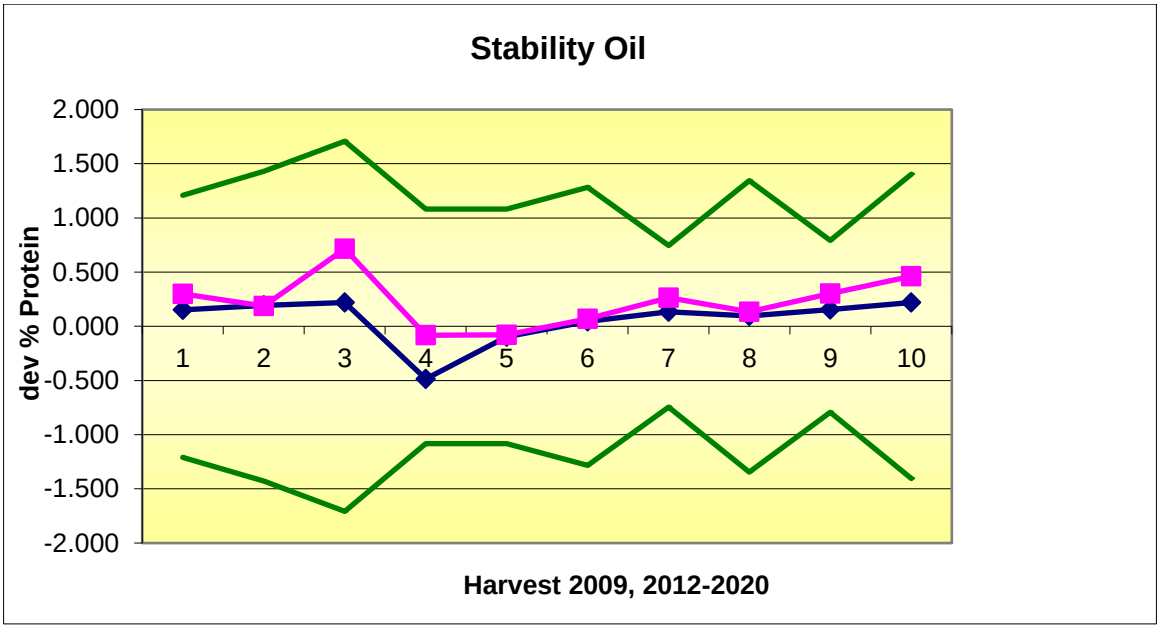


Figure 6.3.3 b: Average deviations of predicted oil results from the best estimate of the true value for eight years of harvest (2009 and 2012-2020). Blue=Local and Pink = ANN.

7 Results for other parameters in Wheat & Barley

On voluntary basis participants shared results of their reference methods on other parameters for wheat and barley which are compiled in this section. The table below shows the parameters and the number of labs reporting results for the WGN2021 exercise.

Parameter	# labs reporting (ref + pred)
TWM (Mass per hectolitre)	24 + 40
Falling number	21
Zeleny	6 + 23
Wet gluten	14 + 30
Starch in wheat	9 + 23
Starch in barley	2+12
Hardness	5 + 9

For Wet gluten, Zeleny, Starch and Hardness results on basis of NIR prediction models were submitted or predicted by FOSS using latest models on submitted scan files. The latter mainly for labs that reported reference values, but not predicted value

7.1 Mass per hectolitre

In total twenty-four participants reported reference results for the test weight (mass per hectolitre, kg/hL). There were also reported TWM results from 40 instruments.

7.1.1 Reference method

Seventeen participants were using a 1 L device according to ISO 7971-3 (labs 1, 2, 4, 17, 18, 19, 30a, 33, 35, 64, 68, 77a, 80, 81, 88, 94 and 98). One participant (lab 15) used a 1 Liter device according to ISO 7971-2. Six participants used 250 ml device according to ISO 7971-3 (labs 1, 5, 8, 10, 12 and 25). One participant used ½ L device according to an In-house Franklin drop weight chondrometer (27). Four labs (15, 17, 80 and 88) reported that there was not enough amount of sample for their 1 L device for a few of the samples marked as N/A in the tables below. For Wheat, lab 10 shows a positive systematic shift whereas all other labs are well aligned. The average values are to be considered the best estimate of the true value given in table 7.1.1.1. For Barley, only one lab show tendency for a negative bias, but barely significant. The average values are to be considered the best estimate of the true value also for barley and given in table 7.1.1.2.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	79.6	80.6	85.4	79.9	80.4	81.1	82.6	83.3	79.2	83.5

Table 7.1.1.1 Results of statistical analysis for the determination of the mass per hectolitre of wheat samples by reference methods

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	67.4	65.4	73.3	74.1	70.2	72.4	69.9	69.5	64.0	73.0

Table 7.1.1.2 Results for the determination of the mass per hectolitre of barley samples by reference methods

Legend to tables: 1 = sample no, 2 = average value

a) Wheat samples: compilation of results and z-scores

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
1	79.0	80.6	85.4	80.0	80.1	80.9	82.5	83.1	79.4	83.3	81.4	-0.20
2	79.3	79.9	84.7	79.3	80.4	81.1	81.8	82.5	78.8	82.9	81.1	-0.56
4	80.2	81.0	85.8	80.5	80.6	81.5	83.1	83.6	79.6	84.0	82.0	0.35
5	79.6	80.5	85.4	80.1	80.3	80.7	82.4	83.1	79.2	83.1	81.4	-0.19
8	79.9	80.6	85.6	80.2	80.4	81.3	82.7	83.3	79.6	83.3	81.7	0.06
10	80.8	82.0	87.3	80.9	81.6	83.4	83.5	84.8	80.6	85.1	83.0	1.37
12	80.2	80.9	85.8	80.5	80.6	81.6	83.0	83.7	79.1	84.0	81.9	0.30
15	79.4	N/A	N/A	79.8	80.2	N/A	82.7	83.3	N/A	83.5	81.5	-0.15
17	N/A	80.7	85.2	79.7	N/A	N/A	82.7	83.3	N/A	83.6	82.5	0.90
18	79.6	80.5	84.9	79.6	80.3	80.6	82.6	82.9	79.0	83.4	81.3	-0.29
19	79.7	80.9	85.7	80.1	80.7	81.3	82.8	83.4	78.9	83.5	81.7	0.06
25	79.0	80.2	84.9	79.8	79.8	80.8	82.5	83.2	79.0	83.1	81.2	-0.40
27	79.6	80.4	85.6	79.7	80.3	80.7	82.3	83.1	78.7	83.6	81.4	-0.24
33	79.2	80.3	85.2	79.4	80.3	81.4	82.0	82.9	79.0	83.2	81.3	-0.34
35	79.3	80.3	85.2	79.3	80.3	81.6	82.2	83.0	79.1	83.2	81.4	-0.28
64	79.7	80.6	85.2	80.0	80.1	81.1	82.7	83.2	79.6	83.4	81.6	-0.07
68	79.6	80.8	85.5	80.1	80.5	81.0	82.9	83.5	79.1	83.5	81.7	0.02
77a	79.5	80.7	86.0	79.8	80.4	80.8	83.1	83.8	79.8	83.6	81.8	0.12
80	79.7	80.7	85.5	80.1	80.6	81.3	82.7	83.6	N/A	83.6	82.0	0.35
81	80.0	80.9	85.6	80.1	80.5	81.5	82.9	83.3	79.0	83.3	81.7	0.08
88	79.2	80.1	84.8	79.3	80.0	80.3	82.2	82.8	N/A	83.2	81.3	-0.31
94	79.1	80.0	84.9	79.5	80.0	80.5	82.0	82.9	78.7	82.9	81.0	-0.58
98	79.6	80.8	85.6	79.8	80.4	80.6	82.9	83.4	79.1	84.4	81.7	0.02
Average	79.6	80.6	85.4	79.9	80.4	81.1	82.6	83.3	79.2	83.5	81.6	0.0
sd	0.4	0.4	0.5	0.4	0.4	0.6	0.4	0.4	0.5	0.5	0.4	0.4
min	79.0	79.9	84.7	79.3	79.8	80.3	81.8	82.5	78.7	82.9	81.0	-0.6
max	80.8	82.0	87.3	80.9	81.6	83.4	83.5	84.8	80.6	85.1	83.0	1.4

Z-scores kg/hL, wheat:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-1.2	0.0	-0.1	0.2	-0.6	-0.5	-0.2	-0.4	0.3	-0.4
2	-0.5	-1.4	-1.4	-1.1	0.0	-0.2	-1.7	-1.6	-0.8	-1.3
4	1.2	0.8	0.7	1.2	0.4	0.7	1.0	0.6	0.7	1.0
5	0.0	-0.2	-0.1	0.4	-0.2	-0.9	-0.4	-0.4	-0.1	-0.8
8	0.6	0.0	0.3	0.5	0.1	0.2	0.2	0.0	0.8	-0.4
10	2.4	2.8	3.7	2.0	2.4	4.5	1.8	3.0	2.7	3.2
12	1.2	0.7	0.6	1.2	0.4	0.8	0.8	0.8	-0.3	1.0
15	-0.4	N/A	N/A	-0.2	-0.4	N/A	0.2	0.0	N/A	0.0
17	N/A	0.2	-0.5	-0.4	N/A	N/A	0.2	0.0	N/A	0.2
18	0.0	-0.2	-1.1	-0.6	-0.2	-1.1	0.0	-0.8	-0.5	-0.2
19	0.2	0.5	0.5	0.5	0.7	0.4	0.3	0.2	-0.7	-0.1
25	-1.2	-0.8	-1.1	-0.2	-1.2	-0.7	-0.2	-0.2	-0.5	-0.8
27	-0.1	-0.5	0.3	-0.4	-0.1	-0.8	-0.7	-0.3	-1.1	0.1
33	-0.8	-0.6	-0.5	-1.0	-0.2	0.5	-1.2	-0.8	-0.5	-0.6
35	-0.6	-0.6	-0.5	-1.2	-0.2	0.9	-0.8	-0.6	-0.3	-0.6
64	0.2	0.0	-0.5	0.2	-0.6	-0.1	0.2	-0.2	0.7	-0.2
68	0.0	0.4	0.1	0.4	0.2	-0.3	0.6	0.4	-0.3	0.0
77a	-0.1	0.1	1.1	-0.2	0.1	-0.6	1.0	1.0	1.1	0.1
80	0.2	0.2	0.1	0.4	0.4	0.3	0.2	0.6	N/A	0.2
81	0.8	0.6	0.3	0.4	0.2	0.7	0.6	0.0	-0.5	-0.4
88	-0.8	-1.0	-1.3	-1.2	-0.8	-1.7	-0.8	-1.0	N/A	-0.6
94	-1.1	-1.1	-1.2	-0.8	-0.8	-1.2	-1.3	-0.8	-1.0	-1.2
98	0.0	0.4	0.3	-0.2	0.0	-1.1	0.6	0.2	-0.3	1.8

The z-values for the mass per hectolitre have been determined by dividing the difference between the reported values by the average value for each sample by a value of 0.5.

b) Barley samples: compilation of results

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
1	67.3	65.4	73.6	74.4	70.0	72.7	70.4	69.6	64.4	73.2	70.1	0.2
2	68.0	65.7	73.1	73.6	70.3	72.4	70.3	70.0	64.7	73.2	70.1	0.3
4	67.2	65.2	73.2	74.2	70.1	72.5	70.0	69.5	63.9	73.1	69.9	0.0
5	67.3	65.8	73.7	74.3	70.0	72.1	69.6	68.9	63.6	72.7	69.8	-0.1
8	67.3	65.6	73.7	74.3	70.0	72.6	70.2	69.7	64.4	73.2	70.1	0.2
12	67.5	65.5	73.1	74.4	70.2	72.5	69.9	69.8	63.9	72.9	70.0	0.1
15	67.3	65.4	73.5	74.4	70.2	N/A	69.6	69.3	64.1	72.8	69.6	-0.3
17	67.6	65.6	73.5	74.3	70.2	N/A	69.8	69.5	64.0	N/A	69.3	-0.6
18	67.3	65.2	73.2	73.6	69.9	72.1	69.3	69.6	64.0	73.0	69.7	-0.1
19	67.3	65.2	73.1	73.9	70.0	72.4	70.1	69.6	63.9	72.9	69.8	0.0
25	67.1	64.6	73.0	73.1	70.0	71.8	70.1	68.8	63.8	72.4	69.5	-0.4
27	67.3	65.1	73.3	74.0	70.0	72.4	69.1	69.4	64.0	72.8	69.7	-0.1
30a	67.4	65.8	73.5	74.7	70.2	72.7	70.0	69.7	64.3	73.2	70.2	0.3
33	67.6	65.7	73.2	74.0	70.4	72.6	70.2	70.1	64.4	73.3	70.2	0.3
35	67.6	65.3	73.4	74.1	70.5	72.8	70.3	69.9	64.0	73.6	70.2	0.3
64	67.3	65.3	73.3	74.1	70.3	72.1	70.0	69.6	63.9	72.8	69.9	0.0
68	67.6	65.7	73.6	74.3	70.5	72.5	69.9	69.6	64.3	73.2	70.1	0.3
77a	67.5	65.8	73.5	74.5	70.4	72.7	70.4	69.5	64.8	73.3	70.2	0.4
88	66.4	64.4	72.4	73.3	69.4	71.6	68.9	68.6	63.2	72.2	69.0	-0.8
94	67.6	65.7	73.5	73.8	70.3	72.3	70.0	69.4	63.4	72.9	69.9	0.0
98	67.5	65.5	73.6	74.1	70.4	72.5	70.1	69.6	64.1	72.9	70.0	0.2
Average	67.4	65.4	73.3	74.1	70.2	72.4	69.9	69.5	64.0	73.0	69.9	0.0
sd	0.3	0.4	0.3	0.4	0.2	0.3	0.4	0.4	0.4	0.3	0.3	0.3
min	66.4	64.4	72.4	73.1	69.4	71.6	68.9	68.6	63.2	72.2	69.0	-0.8
max	68.0	65.8	73.7	74.7	70.5	72.8	70.4	70.1	64.8	73.6	70.2	0.4

Overall good results for barley and no red marked z-scores below.

Z-scores kg/hL barley:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	-0.2	0.0	0.5	0.7	-0.3	0.7	1.0	0.2	0.7	0.5
2	1.2	0.5	-0.6	-0.9	0.3	0.0	0.7	1.0	1.4	0.4
4	-0.4	-0.4	-0.3	0.3	-0.1	0.2	0.2	-0.1	-0.3	0.3
5	-0.2	0.8	0.7	0.5	-0.3	-0.5	-0.6	-1.2	-0.9	-0.5
8	-0.2	0.3	0.7	0.5	-0.3	0.4	0.6	0.4	0.6	0.4
12	0.3	0.2	-0.5	0.6	0.0	0.2	0.1	0.5	-0.3	-0.1
15	-0.2	0.0	0.3	0.7	0.1	N/A	-0.7	-0.5	0.0	-0.4
17	0.4	0.4	0.3	0.5	0.1	N/A	-0.2	0.0	-0.1	N/A
18	-0.2	-0.4	-0.3	-0.9	-0.5	-0.5	-1.2	0.2	-0.1	0.1
19	-0.2	-0.4	-0.5	-0.4	-0.3	0.0	0.3	0.2	-0.3	-0.2
25	-0.6	-1.6	-0.7	-1.9	-0.3	-1.1	0.4	-1.4	-0.5	-1.1
27	-0.1	-0.6	0.0	-0.1	-0.2	0.1	-1.6	-0.2	-0.2	-0.4
30a	0.0	0.8	0.3	1.3	0.1	0.7	0.2	0.4	0.5	0.5
33	0.4	0.6	-0.3	-0.1	0.5	0.5	0.6	1.2	0.7	0.7
35	0.4	-0.2	0.1	0.1	0.7	0.9	0.8	0.8	-0.1	1.3
64	-0.2	-0.2	-0.1	0.1	0.3	-0.5	0.2	0.2	-0.3	-0.3
68	0.4	0.6	0.5	0.5	0.7	0.3	0.0	0.2	0.5	0.5
77a	0.2	0.8	0.3	0.9	0.5	0.6	0.9	0.0	1.5	0.6
88	-2.0	-2.0	-1.9	-1.5	-1.5	-1.5	-2.0	-1.8	-1.7	-1.5
94	0.4	0.5	0.4	-0.5	0.2	-0.2	0.1	-0.1	-1.3	-0.2
98	0.2	0.2	0.5	0.1	0.5	0.3	0.4	0.2	0.1	-0.1

7.1.2 Mass per hectolitre by Infratec TWM

The average results for TWM is considered to be the best estimate of true value and deviation to reference methods given in tables 7.1.2.1 and 7.1.2.2 for wheat and barley, respectively.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	79.5	80.4	85.0	79.4	80.3	81.2	82.3	83.3	79.2	83.3
3	0.0	-0.1	-0.3	-0.4	0.0	0.2	-0.2	0.1	0.1	-0.1

Table 7.1.2.1 Results for the determination of the mass per hectolitre of wheat samples by Infratec TWM

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	67.2	65.2	73.2	73.9	69.7	72.1	69.8	69.2	64.0	72.7
3	-0.2	-0.4	-0.1	-0.2	-0.3	-0.2	-0.1	-0.2	-0.2	-0.2

Table 7.1.2.2 Results for the determination of the mass per hectolitre of barley samples by Infratec TWM

Legend to tables: 1 = sample no, 2 = average value, 3 = deviation from BETV (best estimate of true value, as established by reference analysis)

a) Wheat: Compilation of results:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
1	79.8	80.9	85.6	80.0	80.7	81.6	82.8	83.5	79.7	83.6	81.8	0.3
2	80.1	80.6	85.6	79.7	80.9	81.6	82.9	83.6	79.6	83.7	81.8	0.3
4a	79.7	80.9	85.0	79.7	80.4	81.4	82.7	83.1	79.4	83.1	81.5	0.0
4b	79.8	80.3	85.1	79.6	80.6	81.3	82.8	83.3	79.4	83.6	81.6	0.1
5	79.2	80.2	85.1	79.3	80.1	81.2	82.3	83.0	79.0	83.3	81.3	-0.2
8a	80.1	80.7	85.5	79.8	80.5	81.4	82.8	83.3	79.6	83.5	81.7	0.2
8b	80.1	80.5	85.3	79.8	80.7	81.6	82.5	83.4	79.7	83.5	81.7	0.2
10	81.2	82.3	87.0	81.0	82.0	83.1	84.0	84.7	81.0	84.8	83.1	1.6
11d	80.3	81.1	85.9	80.2	81.1	82.3	83.4	83.9	80.1	84.0	82.2	0.7
11e	80.4	81.4	86.1	80.5	81.0	82.4	83.5	84.2	80.1	84.2	82.4	0.9
11f	77.7	78.8	83.5	77.6	78.5	79.9	81.3	81.6	78.3	81.6	79.9	-1.6
12	80.6	81.2	85.9	80.3	81.1	82.3	83.3	84.0	79.7	84.1	82.3	0.8
15	79.8	81.0	85.4	79.8	80.9	81.6	82.9	83.7	79.8	83.9	81.9	0.4
17a	79.9	80.8	85.2	79.9	80.5	81.6	82.7	83.5	80.0	83.7	81.8	0.3
17b	80.0	80.8	85.4	79.9	80.9	81.8	82.9	83.5	80.1	83.6	81.9	0.4
18	79.6	80.6	84.8	79.7	80.6	81.1	82.7	83.1	78.9	83.6	81.5	0.0
25	79.6	80.5	85.2	79.4	80.3	81.1	82.6	83.3	79.8	83.6	81.5	0.0
30a	80.1	80.8	85.4	79.7	80.8	81.8	82.9	83.4	79.6	83.6	81.8	0.3
30e	78.8	N/A	82.8	78.8	79.5	81.0	79.9	81.7	N/A	N/A	80.4	-1.1
30i	78.9	N/A	N/A	78.8	79.6	80.8	80.2	81.1	N/A	82.7	80.3	-1.2
66	79.1	80.3	84.8	79.3	79.9	81.1	82.0	82.9	78.5	83.1	81.1	-0.4
68	80.4	81.4	86.2	80.4	81.4	82.0	83.3	83.9	80.5	84.2	82.4	0.9
77a	79.6	80.5	85.8	79.5	80.4	81.3	83.0	83.7	79.3	84.3	81.7	0.2
80	79.7	80.7	85.4	79.8	80.7	81.5	82.8	83.2	79.5	83.5	81.7	0.2
81	76.0	76.8	81.4	76.1	76.9	77.9	78.9	79.3	75.9	79.8	77.9	-3.6
82	79.7	80.8	85.3	79.7	80.5	81.5	82.7	83.3	79.4	83.6	81.7	0.2
85	79.2	80.3	85.3	79.5	80.3	81.1	82.3	83.2	78.9	83.6	81.4	-0.1
88	79.1	80.2	84.6	79.2	80.0	80.4	82.1	82.6	N/A	83.2	81.3	-0.2
91	79.7	80.8	85.3	79.6	80.6	81.5	82.6	83.3	79.3	83.5	81.6	0.1
94a	79.2	79.8	84.6	79.3	80.2	80.9	81.9	82.9	78.9	83.2	81.1	-0.4
94b	80.0	81.2	85.9	80.3	81.1	81.7	82.8	83.5	79.7	84.1	82.0	0.5
97	78.8	79.4	84.0	78.7	79.5	80.4	81.3	91.9	77.8	82.3	81.4	-0.1
98	80.1	80.7	85.5	80.0	80.7	81.5	82.8	83.5	79.1	83.7	81.8	0.3
Average	79.6	80.5	85.1	79.5	80.4	81.3	82.4	83.4	79.3	83.4	81.5	0.0
sd	0.9	0.9	1.0	0.9	0.9	0.9	1.0	1.8	0.9	0.9	0.9	0.9
min	76.0	76.8	81.4	76.1	76.9	77.9	78.9	79.3	75.9	79.8	77.9	-3.6
max	81.2	82.3	87.0	81.0	82.0	83.1	84.0	91.9	81.0	84.8	83.1	1.6

Z scores for wheat:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.6	1.0	1.2	1.1	0.8	0.8	1.0	0.4	0.9	0.6
2	1.2	0.5	1.1	0.5	1.3	0.8	1.1	0.7	0.7	0.8
4a	0.4	1.0	0.0	0.5	0.2	0.4	0.8	-0.4	0.3	-0.4
4b	0.6	-0.2	0.2	0.3	0.7	0.2	1.1	0.1	0.4	0.6
5	-0.6	-0.4	0.2	-0.3	-0.4	0.0	0.0	-0.6	-0.5	0.0
8a	1.2	0.6	0.9	0.7	0.4	0.4	0.9	0.0	0.6	0.4
8b	1.1	0.2	0.6	0.6	0.7	0.7	0.4	0.1	0.9	0.4
10	3.4	3.8	4.0	3.1	3.4	3.8	3.4	2.8	3.5	3.0
11d	1.7	1.5	1.8	1.5	1.5	2.1	2.2	1.3	1.7	1.4
11e	1.8	1.9	2.2	2.2	1.5	2.3	2.3	1.8	1.6	1.7
11f	-3.5	-3.2	-3.0	-3.7	-3.7	-2.7	-2.0	-3.4	-1.9	-3.4
12	2.2	1.7	1.9	1.8	1.6	2.1	2.0	1.5	1.0	1.6
15	0.6	1.2	0.8	0.7	1.2	0.8	1.2	0.8	1.1	1.2
17a	0.7	0.8	0.4	0.8	0.4	0.8	0.7	0.3	1.5	0.8
17b	1.0	0.7	0.8	0.8	1.2	1.1	1.2	0.4	1.6	0.5
18	0.2	0.4	-0.4	0.5	0.6	-0.2	0.8	-0.4	-0.7	0.6
25	0.2	0.2	0.4	-0.1	0.0	-0.2	0.6	0.0	1.1	0.6
30a	1.2	0.8	0.8	0.5	1.0	1.2	1.2	0.2	0.7	0.6
30h	-1.4	N/A	-4.4	-1.3	-1.6	-0.4	-4.8	-3.2	N/A	N/A
30i	-1.3	N/A	N/A	-1.3	-1.3	-0.9	-4.1	-4.4	N/A	-1.2
66	-0.8	-0.2	-0.4	-0.3	-0.8	-0.2	-0.6	-0.8	-1.5	-0.4
68	1.8	2.0	2.4	1.9	2.2	1.6	2.0	1.2	2.5	1.8
77a	0.2	0.2	1.6	0.1	0.2	0.2	1.4	0.8	0.1	2.0
80	0.4	0.5	0.7	0.6	0.8	0.6	1.0	-0.1	0.4	0.3
81	-7.0	-7.2	-7.2	-6.7	-6.8	-6.6	-6.8	-8.0	-6.7	-7.0
82	0.4	0.8	0.6	0.5	0.4	0.6	0.8	0.0	0.3	0.6
85	-0.6	-0.2	0.6	0.1	0.0	-0.2	0.0	-0.2	-0.7	0.6
88	-0.8	-0.4	-0.8	-0.5	-0.6	-1.6	-0.4	-1.4	N/A	-0.2
91	0.4	0.8	0.6	0.3	0.6	0.6	0.6	0.0	0.1	0.4
94a	-0.6	-1.2	-0.8	-0.3	-0.2	-0.6	-0.8	-0.8	-0.7	-0.2
94b	1.1	1.5	1.8	1.8	1.6	0.9	0.9	0.5	0.8	1.5
97	-1.4	-2.0	-2.0	-1.5	-1.6	-1.6	-2.0	17.2	-2.9	-2.0
98	1.2	0.6	1.0	1.1	0.8	0.6	1.0	0.4	-0.3	0.8

The z-values for the mass per hectolitre have been determined by dividing the difference between the reported values by the average value for each sample by a value of 0.5.

Most labs have good control of their TWM for wheat. However, lab 10 has a positive systematic shift, which means it has been adjusted against the reference method that have a similar positive bias. In order to be aligned with the other labs, the reference method must first be calibrated and then the TWM should be adjusted accordingly. Lab 11f has a negative systematic shift and should be adjusted accordingly.

b) Barley: Compilation of results and z-scores TWM

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
1	67.3	65.0	73.0	73.7	69.9	71.9	70.0	69.2	63.7	72.6	69.6	-0.1
2	67.2	64.9	73.3	73.8	69.9	72.0	69.7	69.3	63.6	72.7	69.6	-0.1
4a	67.2	65.1	73.3	74.4	69.9	72.1	70.5	69.7	64.2	73.2	70.0	0.3
4b	67.5	65.3	73.4	74.2	70.4	72.4	70.3	69.6	64.1	73.1	70.0	0.3
5	67.4	65.2	73.4	74.0	70.1	72.3	69.9	69.3	63.7	72.8	69.8	0.1
6	67.0	64.4	72.6	73.4	69.2	71.9	69.6	68.7	63.6	72.3	69.3	-0.4
8a	67.6	65.2	73.6	74.3	70.2	72.6	70.1	69.7	64.2	73.3	70.1	0.3
8b	67.3	64.9	73.1	74.0	69.9	72.0	69.8	69.5	63.5	72.9	69.7	0.0
11d	67.6	65.3	73.4	73.9	70.4	72.3	69.9	69.4	63.9	72.8	69.9	0.2
11e	67.7	65.6	73.5	74.0	70.4	72.4	70.1	69.6	64.4	73.1	70.1	0.4
11f	64.1	62.1	69.7	70.7	67.2	69.1	67.0	66.5	60.9	69.5	66.7	-3.0
12	68.1	66.0	73.7	74.5	70.6	73.0	70.6	70.0	64.1	73.5	70.4	0.7
15	67.4	64.9	73.5	74.5	70.3	72.6	69.8	69.6	64.0	72.8	69.9	0.2
17a	67.6	65.2	73.4	73.9	69.8	72.4	69.8	69.2	63.8	72.5	69.7	0.0
18	67.3	65.2	73.2	73.6	69.9	72.1	69.3	69.6	64.0	73.0	69.7	0.0
25	67.2	64.7	73.2	73.6	69.6	72.0	69.7	69.4	63.1	72.8	69.5	-0.2
30a	67.3	64.6	73.4	74.2	70.1	72.5	69.8	69.4	63.8	72.6	69.8	0.1
30b	66.6	65.2	72.8	73.9	69.3	72.2	69.3	68.9	63.6	72.5	69.4	-0.3
30c	66.8	65.8	74.0	74.7	70.0	72.9	70.5	70.0	64.5	73.6	70.3	0.6
30d	67.8	65.5	74.1	74.7	70.0	72.8	70.3	69.7	64.6	73.6	70.3	0.6
30h	66.7	64.6	73.5	73.9	69.1	72.2	70.1	68.8	63.7	73.2	69.6	-0.1
30h	67.8	65.5	74.1	74.7	70.0	72.8	70.3	69.7	64.6	73.6	70.3	0.6
30h	66.7	64.9	73.1	73.9	69.2	72.1	69.7	69.1	64.1	72.7	69.5	-0.2
30i	67.1	64.9	72.8	73.9	69.4	72.1	69.6	N/A	63.9	73.1	69.6	-0.1
30j	67.8	65.5	74.1	74.7	70.0	72.8	70.3	69.7	64.6	73.6	70.3	0.6
68	67.2	65.2	73.3	74.0	70.4	72.4	69.8	69.5	63.5	73.0	69.8	0.1
80	67.9	65.2	73.7	74.3	70.3	72.8	69.9	69.7	64.1	73.0	70.1	0.4
82	67.4	65.4	73.4	74.1	70.3	72.5	69.8	69.4	64.2	73.0	70.0	0.2
85	67.0	64.8	72.9	73.7	69.6	72.1	69.5	69.1	63.7	72.3	69.5	-0.2
88	66.2	64.3	72.2	73.1	69.3	71.4	68.8	68.5	63.1	72.0	68.9	-0.8
91	67.3	65.0	73.3	73.7	70.0	72.4	70.0	69.4	63.9	72.7	69.8	0.1
94a	67.5	65.1	73.2	73.6	70.1	72.3	69.9	69.9	64.0	72.8	69.8	0.1
94b	68.1	66.0	73.6	74.0	70.3	72.2	70.1	69.6	63.9	72.8	70.1	0.4
97	67.2	64.4	72.5	73.4	69.4	71.7	69.3	68.7	63.8	71.9	69.2	-0.5
98	66.8	64.4	72.7	73.6	69.4	71.6	69.9	69.1	63.3	72.2	69.3	-0.4
Average	67.2	65.0	73.2	73.9	69.8	72.2	69.8	69.3	63.8	72.8	69.7	0.0
sd	0.7	0.7	0.7	0.7	0.6	0.7	0.6	0.6	0.6	0.7	0.6	0.6
min	64.1	62.1	69.7	70.7	67.2	69.1	67.0	66.5	60.9	69.5	66.7	-3.0
max	68.1	66.0	74.1	74.7	70.6	73.0	70.6	70.0	64.6	73.6	70.4	0.7

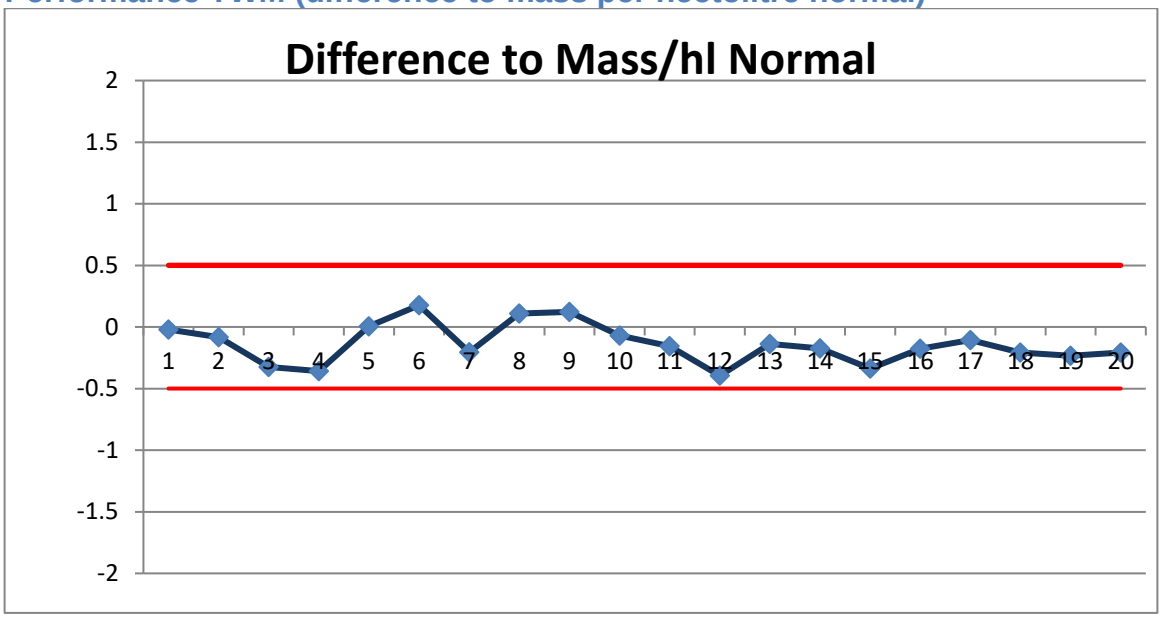
Z –scores for TWM / barley:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	0.2	-0.4	-0.4	-0.4	0.4	-0.4	0.4	-0.1	-0.6	-0.2
2	0.0	-0.7	0.2	-0.1	0.4	-0.1	-0.3	0.2	-0.9	0.0
4a	0.0	-0.2	0.2	1.0	0.4	0.0	1.4	0.9	0.4	1.0
4b	0.6	0.2	0.4	0.5	1.4	0.5	1.0	0.7	0.1	0.8
5	0.4	0.0	0.4	0.2	0.8	0.4	0.2	0.1	-0.6	0.2
6	-0.4	-1.6	-1.2	-1.0	-1.1	-0.4	-0.4	-1.1	-0.8	-0.8
8a	0.8	0.0	0.8	0.8	0.9	0.9	0.5	0.8	0.3	1.1
8b	0.2	-0.6	-0.2	0.1	0.3	-0.2	0.0	0.4	-1.1	0.3
11d	0.7	0.2	0.4	0.1	1.4	0.4	0.2	0.4	-0.3	0.3
11e	1.0	0.8	0.6	0.2	1.4	0.5	0.5	0.8	0.7	0.9
11f	-6.3	-6.3	-7.0	-6.5	-5.0	-6.0	-5.7	-5.5	-6.2	-6.4
12	1.8	1.5	1.1	1.1	1.8	1.9	1.7	1.5	0.2	1.6
15	0.4	-0.6	0.6	1.2	1.2	1.0	0.0	0.7	0.0	0.2
17a	0.8	-0.1	0.4	0.0	0.2	0.5	-0.1	-0.1	-0.4	-0.4
18	0.2	0.0	0.0	-0.6	0.4	0.0	-1.0	0.7	0.0	0.6
25	0.0	-1.0	0.0	-0.6	-0.2	-0.2	-0.2	0.3	-1.8	0.2
30a	0.2	-1.2	0.4	0.6	0.8	0.8	0.0	0.3	-0.4	-0.2
30b	-1.2	0.0	-0.8	0.0	-0.8	0.2	-1.0	-0.7	-0.8	-0.4
30c	-0.8	1.1	1.5	1.5	0.7	1.7	1.5	1.5	0.9	1.8
30d	1.2	0.6	1.7	1.7	0.6	1.5	1.0	0.8	1.1	1.7
30h	-1.0	-1.2	0.6	0.0	-1.2	0.2	0.6	-0.9	-0.6	1.0
30h	1.2	0.6	1.7	1.7	0.6	1.5	1.0	0.8	1.1	1.7
30h	-1.0	-0.6	-0.3	0.0	-1.0	0.0	-0.3	-0.3	0.2	0.0
30i	-0.3	-0.6	-0.7	0.0	-0.6	0.0	-0.4	N/A	-0.2	0.8
30j	1.2	0.6	1.7	1.7	0.6	1.5	1.0	0.8	1.1	1.7
68	0.0	0.0	0.2	0.2	1.4	0.6	0.0	0.5	-1.0	0.6
80	1.3	-0.1	0.9	0.8	1.2	1.5	0.3	1.0	0.2	0.7
82	0.4	0.4	0.4	0.4	1.2	0.8	0.0	0.3	0.4	0.6
85	-0.4	-0.8	-0.6	-0.4	-0.2	0.0	-0.6	-0.3	-0.6	-0.8
88	-2.0	-1.8	-2.0	-1.6	-0.8	-1.4	-2.0	-1.5	-1.8	-1.4
91	0.2	-0.4	0.2	-0.4	0.6	0.6	0.4	0.3	-0.2	0.0
94a	0.6	-0.2	0.0	-0.6	0.8	0.4	0.2	1.3	0.0	0.2
94b	1.7	1.6	0.7	0.2	1.2	0.3	0.6	0.8	-0.2	0.1
97	0.0	-1.6	-1.4	-1.0	-0.6	-0.8	-1.0	-1.1	-0.4	-1.6
98	-0.8	-1.6	-1.0	-0.6	-0.6	-1.0	0.2	-0.3	-1.4	-1.0

The z-values for the mass per hectolitre have been determined by dividing the difference between the reported values by the average value for each sample by a value of 0.5.

In the same way as for wheat, the labs have also good control of their TWM for barley measurements. Only lab 11f show a significant negative bias as was also the case for wheat.

Performance TWM (difference to mass per hectolitre normal)



The overall performance of Infratec TWM results as compared to mass per hectolitre by reference method is good as can be observed from the figure above. Even the Durum wheat sample (W9) appear within the error limits, which has not always been the case in the past.

7.2 Falling number

Twenty-one participants reported results for this parameter using ICC 107/1 (8 participants) and ISO 3093 (13 participants). No predictions were performed.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
2	307	366	481	449	293	353	429	386	463	314	384	-8
4	294	393	427	433	272	345	411	387	417	357	374	-18
5	329	452	547	533	310	N/A	N/A	N/A	N/A	N/A	434	42
8	337	384	541	483	335	410	454	418	524	379	426	34
12	304	353	451	444	276	386	427	404	458	371	387	-4
15	292	414	507	481	301	333	433	438	463	373	404	12
17	315	400	473	438	290	361	416	396	462	355	391	-1
18	301	454	387	485	320	388	483	457	458	432	417	25
25	306	467	462	439	285	383	441	414	430	368	400	8
30	298	379	432	423	292	349	432	373	446	350	377	-14
33	296	420	462	440	314	385	442	415	476	378	403	11
35	306	393	491	439	249	389	430	419	484	375	398	6
64	315	401	473	452	316	390	425	422	454	367	402	10
66	284	388	404	389	253	372	364	372	405	351	358	-34
68	293	349	408	408	263	359	390	376	445	356	365	-27
80	300	419	430	431	312	395	433	362	449	381	391	-1
81	346	429	439	481	317	360	442	411	496	405	413	21
82	309	390	446	429	289	370	417	400	451	362	386	-6
88	268	289	394	390	261	304	368	333	391	286	328	-63
91	299	400	449	427	278	373	442	412	440	355	388	-4
94	303	414	473	455	309	381	421	412	495	386	405	13
Average	**305**	**398**	**456**	**445**	**292**	**369**	**425**	**400**	**455**	**365**	**392**	
sd	17.3	39.6	43.0	33.7	23.9	24.6	27.3	28.2	31.3	29.9	23.7	
Min	268	289	387	389	249	304	364	333	391	286	328	
Max	346	467	547	533	335	410	483	457	524	432	434	

Z - values

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	0.1	-1.3	1.0	0.2	0.0	-0.7	0.2	-0.6	0.3	-2.0
4	-0.4	-0.2	-1.2	-0.5	-0.8	-1.0	-0.6	-0.5	-1.5	-0.3
5	1.0	2.2	3.6	3.5	0.7	N/A	N/A	N/A	N/A	N/A
8	1.3	-0.6	3.4	1.5	1.7	1.6	1.2	0.7	2.7	0.5
12	0.0	-1.8	-0.2	0.0	-0.6	0.7	0.1	0.1	0.1	0.2
15	-0.5	0.6	2.0	1.4	0.4	-1.5	0.3	1.5	0.3	0.3
17	0.4	0.1	0.7	-0.3	-0.1	-0.3	-0.4	-0.2	0.3	-0.4
18	-0.2	2.2	-2.8	1.6	1.1	0.7	2.3	2.3	0.1	2.7
25	0.0	2.8	0.2	-0.2	-0.3	0.5	0.6	0.5	-1.0	0.1
30	-0.3	-0.8	-1.0	-0.9	0.0	-0.8	0.3	-1.1	-0.4	-0.6
33	-0.4	0.9	0.2	-0.2	0.9	0.6	0.7	0.6	0.8	0.5
35	0.0	-0.2	1.4	-0.2	-1.7	0.8	0.2	0.7	1.1	0.4
64	0.4	0.1	0.7	0.3	1.0	0.8	0.0	0.9	-0.1	0.1
66	-0.8	-0.4	-2.1	-2.3	-1.6	0.1	-2.4	-1.1	-2.0	-0.6
68	-0.5	-2.0	-1.9	-1.5	-1.2	-0.4	-1.4	-1.0	-0.4	-0.4
80	-0.2	0.8	-1.0	-0.6	0.8	1.0	0.3	-1.5	-0.3	0.6
81	1.6	1.2	-0.7	1.4	1.0	-0.4	0.7	0.4	1.6	1.6
82	0.2	-0.3	-0.4	-0.6	-0.1	0.0	-0.3	0.0	-0.2	-0.1
88	-1.5	-4.4	-2.5	-2.2	-1.2	-2.6	-2.3	-2.7	-2.6	-3.2
91	-0.2	0.1	-0.3	-0.7	-0.6	0.1	0.7	0.5	-0.6	-0.4
94	-0.1	0.6	0.7	0.4	0.7	0.5	-0.2	0.5	1.6	0.8

For the calculation of the z-scores a fixed value of s_R = 25 has been chosen in accordance with ISO/ICC standards.
Lab 5 only submitted results for W1-W5, and two of them are red marked and one yellow marked, so maybe some problems with the method. Lab 88 show a negative systematic shift with two samples red marked hence an indicator that a correction might be required. For the other labs, there are some yellow marked and one red marked (lab 8), but it seems to be more random rather than systematic at least in a significant way.

7.3 Sedimentation index (Zeleny number)

The degree of sedimentation of flour suspended in a lactic acid solution during a standard time interval is taken as a measure of the baking quality.

Six participants submitted reference results for this parameter using ICC 116/1 (8 and 94) and ISO 5529 (2, 33, 68 and 98). Twenty-three participants predicted the sedimentation index using ANN prediction models WHZE16 (4b, 17a, 18, 19 and 73) or WHZE22 (1, 2, 4a, 8, 11, 17b, 25, 33, 64 and 98). Labs submitting reference results, but no predicted have got their spectra re-predicted with the latest model version WHZE22 (66, 68, 82 and 85).

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
2	46	61	53	42	40	59	35	63	10	47	**46**	-5
8	44	61	54	43	37	56	34	67	19	46	**46**	-4
33	46	62	58	45	41	60	36	66	11	52	**48**	-2
68	55	67	64	53	51	64	40	71	19	60	**62**	12
94	45	61	52	44	41	53	37	57	12	47	**45**	-5
98	55	69	65	55	46	57	37	63	35	67	**55**	5
AvG.	**49**	**63**	**58**	**47**	**43**	**58**	**37**	**64**	**18**	**53**	**50**	

Predicted values

1	49	63	47	45	45	47	44	56	50	47	**49**	6
2	42	58	37	38	38	42	36	50	44	40	**43**	-1
4a	43	61	37	39	40	42	36	50	43	40	**43**	-1
4b	40	54	35	33	36	43	36	45	32	38	**39**	-5
8a	41	59	35	36	38	43	35	50	43	38	**42**	-2
8b	42	58	38	38	39	41	35	50	44	40	**43**	-1
11a	43	60	38	38	39	44	37	51	45	41	**44**	0
11b	42	59	37	37	39	43	38	49	43	41	**43**	-1
11d	42	58	39	37	38	41	36	49	43	41	**42**	-1
11e	41	58	37	36	38	41	36	49	43	40	**42**	-2
17a	47	63	40	40	43	49	41	54	39	45	**46**	2
17b	47	64	42	43	43	47	40	55	48	45	**47**	4
18	39	58	38	37	39	41	35	48	43	40	**42**	-2
19	42	59	39	39	40	43	36	52	44	41	**44**	0
25	40	59	35	35	38	42	34	48	42	39	**41**	-3
33	43	51	43	41	37	40	35	48	41	43	**42**	-2
64	41	60	37	37	39	42	36	50	44	40	**43**	-1
66	42	59	36	36	39	50	35	41	42	39	**42**	-2
68	54	67	52	50	51	56	48	63	46	55	**54**	10
73	42	62	36	38	39	45	38	51	35	42	**43**	-1
82	43	60	39	39	39	42	36	51	44	42	**44**	0
85	34	48	32	31	32	33	30	40	37	35	**35**	-9
98	54	70	53	50	50	56	50	63	48	55	**55**	11
AvG.	**43**	**59**	**39**	**39**	**40**	**44**	**37**	**50**	**43**	**42**	**44**	

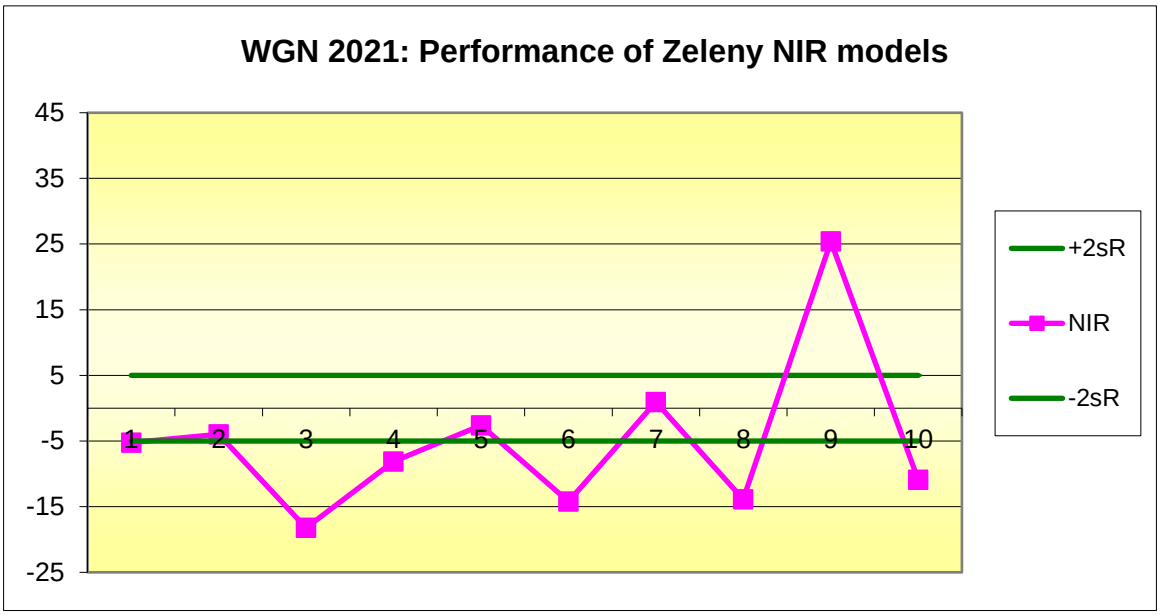


Figure 7.3.1: Deviations of average predicted values against average reference values.

It is a significant deviation between the predicted and reference value for W3, W6, W8 and W9. The deviation for the Durum Wheat sample (W9) is not surprising, but the other could partly be explained due to a systematic shift of -6 pushing these three outside the lower limit.

7.4 Wet gluten

Fourteen participants reported reference values for wet gluten using ICC 155 (8, 12 and 73), ISO 21415-2 (4, 17, 30a, 33, 68, 82, 88 and 98), PN-77_A-74041 (18), LVS 278 (19) and AACC 38-12.02 (35) methods. Thirty sets of results from twenty-one participants also predicted the wet gluten result using model versions 24, 25, 27, 29, 32, 33, 34, 36 or 37. Labs submitting reference results, but no predicted have got their spectra re-predicted with the latest model version WHGL37 (labs 30a, 35 and 88).

Compilation of reported results (wheat samples):

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev
4	27.3	33.6	29.6	25.9	27.4	28.9	23.5	30.0	22.6	29.5	27.8	1.8
8	25.2	32.1	28.5	22.5	22.7	25.6	20.2	28.2	22.3	26.3	25.3	-0.7
12	26.7	34.1	28.9	24.1	27.6	28.7	23.9	30.1	22.4	28.4	27.5	1.4
17	26.6	31.6	29.0	24.4	26.1	27.1	21.9	29.6	21.2	28.0	26.6	0.5
18	27.9	34.6	28.2	26.4	27.8	28.3	25.6	29.2	N/A	28.4	28.5	2.4
19	25.5	31.9	26.6	24.8	25.8	26.4	21.4	29.0	22.3	26.0	26.0	-0.1
30a	26.3	32.3	29.1	23.8	26.5	27.8	23.0	29.8	21.1	28.7	26.8	0.8
33	26.8	33.2	31.1	24.7	28.2	28.7	22.3	30.4	21.3	29.4	27.6	1.5
35	27.1	33.4	31.9	24.8	29.1	28.4	22.8	31.3	21.4	31.1	28.1	2.1

68	27.9	33.0	30.1	25.4	27.8	29.5	24.2	31.5	24.0	29.7	28.3	2.2
73	28.6	36.9	25.2	27.2	27.7	26.1	26.9	30.6	22.5	32.6	28.4	2.4
82	26.4	32.9	29.9	23.6	27.3	27.6	22.6	30.6	21.1	28.5	27.1	1.0
88	24.3	29.5	27.3	21.8	23.5	25.2	20.4	27.3	19.4	25.9	24.5	-1.6
98	27.1	31.7	27.5	23.5	26.0	27.2	23.3	28.4	22.2	27.3	26.4	0.3
Average	26.7	32.9	28.8	24.5	26.7	27.5	23.0	29.7	21.8	28.6	27.1	1.0
sd	1.1	1.7	1.8	1.5	1.8	1.3	1.8	1.2	1.1	1.9	1.2	1.2
Min	24.3	29.5	25.2	21.8	22.7	25.2	20.2	27.3	19.4	25.9	24.5	-1.6
Max	28.6	36.9	31.9	27.2	29.1	29.5	26.9	31.5	24.0	32.6	28.5	2.4

Predicted values

1	29.0	32.0	28.9	27.1	27.9	27.8	26.9	30.3	27.6	28.5	**28.6**	1.5
2	27.5	32.4	26.1	25.3	26.4	26.9	26.1	28.7	25.7	26.7	**27.2**	0.0
4a	27.8	32.6	26.5	25.9	27.2	28.0	26.9	29.0	25.6	26.8	**27.6**	0.5
4b	27.8	32.3	27.3	25.3	26.5	27.5	25.6	29.0	24.8	27.0	**27.3**	0.2
8a	28.3	31.6	28.3	26.4	27.0	27.6	25.8	29.8	27.1	27.5	**27.9**	0.8
8b	27.9	30.2	28.2	26.2	26.4	26.5	24.8	29.2	27.1	27.6	**27.4**	0.2
11a	27.2	32.9	25.4	24.4	26.1	27.4	25.2	28.5	24.7	26.2	**26.8**	-0.4
11b	27.2	32.9	26.2	23.9	26.4	27.4	25.6	27.9	24.0	26.3	**26.8**	-0.4
11d	26.8	31.5	25.2	24.0	25.9	26.8	25.3	27.6	24.2	26.0	**26.3**	-0.8
11e	26.8	32.0	25.1	23.8	26.2	26.8	25.9	27.9	24.0	26.1	**26.5**	-0.7
12	25.8	30.1	23.7	23.1	24.7	25.2	23.3	27.3	23.4	25.2	**25.2**	-2.0
17a	27.4	31.9	25.9	24.8	26.9	27.1	24.7	28.6	24.7	26.6	**26.8**	-0.3
17b	25.9	30.8	24.9	24.2	25.6	25.6	24.2	27.5	24.8	25.1	**25.8**	-1.3
18	27.3	33.2	27.8	25.1	27.4	27.7	25.0	29.2	25.5	27.3	**27.6**	0.4
19	26.6	33.4	25.1	24.1	26.7	26.9	24.9	28.2	24.7	25.5	**26.6**	-0.5
25	27.2	31.4	26.5	25.1	26.2	27.0	25.1	28.6	26.1	27.0	**27.0**	-0.1
30a	27.5	32.5	25.3	24.4	26.0	27.3	25.0	28.5	24.3	26.6	**26.8**	-0.4
33	27.6	33.3	27.9	25.4	27.0	27.1	25.2	28.3	24.1	27.2	**27.3**	0.2
35a	26.9	32.3	25.0	23.9	26.8	26.8	24.9	28.2	24.1	26.4	**26.5**	-0.6
35b	26.8	32.3	25.3	23.9	26.1	26.8	25.2	28.0	24.4	26.2	**26.5**	-0.6
35c	26.7	31.7	25.6	23.8	26.3	27.1	25.5	28.1	24.2	26.2	**26.5**	-0.6
35d	28.2	31.9	26.0	24.2	26.8	27.3	25.7	27.8	24.2	26.2	**26.8**	-0.3
66	31.1	37.1	28.6	27.5	30.2	31.7	29.4	32.6	27.7	30.4	**30.6**	3.5
68	27.6	32.5	26.1	24.9	26.7	27.3	25.2	30.0	24.0	27.1	**27.1**	0.0
73	27.5	31.6	26.5	25.0	26.1	27.0	24.5	29.2	25.8	27.4	**27.1**	-0.1
80	25.9	24.8	29.2	25.5	27.1	26.8	24.2	25.1	34.0	27.2	**27.0**	-0.1

82	26.9	33.6	24.4	24.0	26.5	27.3	25.9	28.6	24.7	26.4	**26.8**	-0.3
85	28.7	36.7	26.4	25.6	28.6	29.4	27.0	30.4	27.5	28.4	**28.9**	1.7
88	26.8	33.1	25.5	24.2	26.3	27.1	25.4	28.4	24.4	26.7	**26.8**	-0.4
98	28.1	34.9	27.0	26.0	27.0	27.9	25.2	30.4	25.2	27.9	**28.0**	0.8
Average	**27.4**	**32.3**	**26.3**	**24.9**	**26.7**	**27.3**	**25.5**	**28.7**	**25.4**	**26.9**	**27.1**	

z-values:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
4	0.6	0.7	0.8	1.4	0.7	1.4	0.5	0.3	0.8	0.9
8	-1.5	-0.8	-0.3	-2.0	-4.0	-2.0	-2.8	-1.6	0.4	-2.3
12	0.0	1.2	0.1	-0.4	0.9	1.2	0.9	0.4	0.5	-0.2
17	-0.1	-1.3	0.2	-0.1	-0.6	-0.4	-1.1	-0.1	-0.6	-0.6
18	1.2	1.7	-0.6	1.9	1.1	0.8	2.6	-0.5	N/A	-0.2
19	-1.2	-1.0	-2.2	0.3	-0.9	-1.1	-1.6	-0.7	0.5	-2.6
30a	-0.4	-0.6	0.3	-0.7	-0.2	0.3	0.0	0.1	-0.7	0.1
33	0.1	0.3	2.3	0.2	1.5	1.2	-0.7	0.7	-0.5	0.8
35	0.4	0.5	3.1	0.3	2.4	0.9	-0.2	1.6	-0.4	2.5
68	1.2	0.1	1.3	0.9	1.2	1.9	1.2	1.8	2.2	1.1
73	1.9	4.0	-3.6	2.7	1.0	-1.4	3.9	0.9	0.7	4.0
82	-0.3	0.0	1.1	-0.9	0.6	0.1	-0.4	0.9	-0.7	-0.1
88	-2.4	-3.4	-1.5	-2.7	-3.2	-2.3	-2.6	-2.4	-2.4	-2.7
98	0.4	-1.2	-1.3	-1.0	-0.7	-0.3	0.3	-1.3	0.4	-1.3
p1	1.6	-0.3	2.6	2.2	1.2	0.5	1.4	1.6	2.2	1.6
p2	0.1	0.1	-0.2	0.4	-0.3	-0.4	0.6	0.0	0.3	-0.2
p4a	0.4	0.3	0.2	1.0	0.5	0.7	1.4	0.3	0.2	-0.1
p4b	0.4	0.0	1.0	0.4	-0.2	0.2	0.2	0.3	-0.6	0.1
p8a	0.9	-0.7	1.9	1.5	0.3	0.2	0.3	1.1	1.7	0.6
p8b	0.4	-2.2	1.8	1.3	-0.3	-0.8	-0.7	0.5	1.7	0.7
p11a	-0.3	0.6	-0.9	-0.5	-0.6	0.1	-0.3	-0.2	-0.7	-0.6
p11b	-0.3	0.6	-0.2	-0.9	-0.3	0.1	0.1	-0.8	-1.4	-0.6
p11d	-0.6	-0.8	-1.2	-0.9	-0.8	-0.5	-0.1	-1.1	-1.3	-0.9
p11e	-0.6	-0.4	-1.2	-1.1	-0.5	-0.5	0.4	-0.8	-1.4	-0.7
p12	-1.7	-2.2	-2.6	-1.8	-2.0	-2.1	-2.1	-1.4	-2.0	-1.7
p17a	0.0	-0.4	-0.5	-0.1	0.2	-0.3	-0.8	-0.1	-0.8	-0.3
p17b	-1.5	-1.5	-1.4	-0.7	-1.1	-1.8	-1.3	-1.2	-0.7	-1.8

p18	-0.1	0.9	1.5	0.2	0.7	0.4	-0.5	0.5	0.1	0.4
p19	-0.8	1.1	-1.2	-0.8	0.0	-0.4	-0.6	-0.5	-0.7	-1.4
p25	-0.2	-0.9	0.2	0.2	-0.5	-0.3	-0.4	-0.1	0.7	0.1
p30a	0.1	0.2	-1.0	-0.5	-0.7	0.0	-0.4	-0.2	-1.1	-0.3
p33	0.2	1.0	1.6	0.5	0.3	-0.2	-0.3	-0.4	-1.3	0.3
p35a	-0.6	0.0	-1.4	-0.9	0.1	-0.5	-0.6	-0.5	-1.3	-0.4
p35b	-0.7	0.0	-1.0	-1.0	-0.6	-0.5	-0.3	-0.7	-1.0	-0.6
p35c	-0.7	-0.7	-0.7	-1.1	-0.4	-0.3	0.1	-0.6	-1.2	-0.7
p35d	0.8	-0.4	-0.3	-0.7	0.1	0.0	0.3	-0.9	-1.2	-0.7
p66	3.7	4.8	2.3	2.6	3.5	4.4	3.9	3.9	2.2	3.5
p68	0.2	0.2	-0.2	0.0	0.0	0.0	-0.3	1.3	-1.4	0.3
p73	0.1	-0.7	0.2	0.1	-0.6	-0.3	-1.0	0.5	0.4	0.5
p80	-1.5	-7.5	2.9	0.6	0.4	-0.5	-1.2	-3.6	8.6	0.3
p82	-0.5	1.3	-1.9	-0.9	-0.2	0.0	0.4	-0.1	-0.7	-0.5
p85	1.3	4.4	0.1	0.7	1.9	2.1	1.5	1.7	2.1	1.5
p88	-0.6	0.8	-0.9	-0.7	-0.4	-0.2	0.0	-0.3	-1.1	-0.1
p98	0.7	2.6	0.7	1.1	0.3	0.6	-0.3	1.7	-0.2	1.0

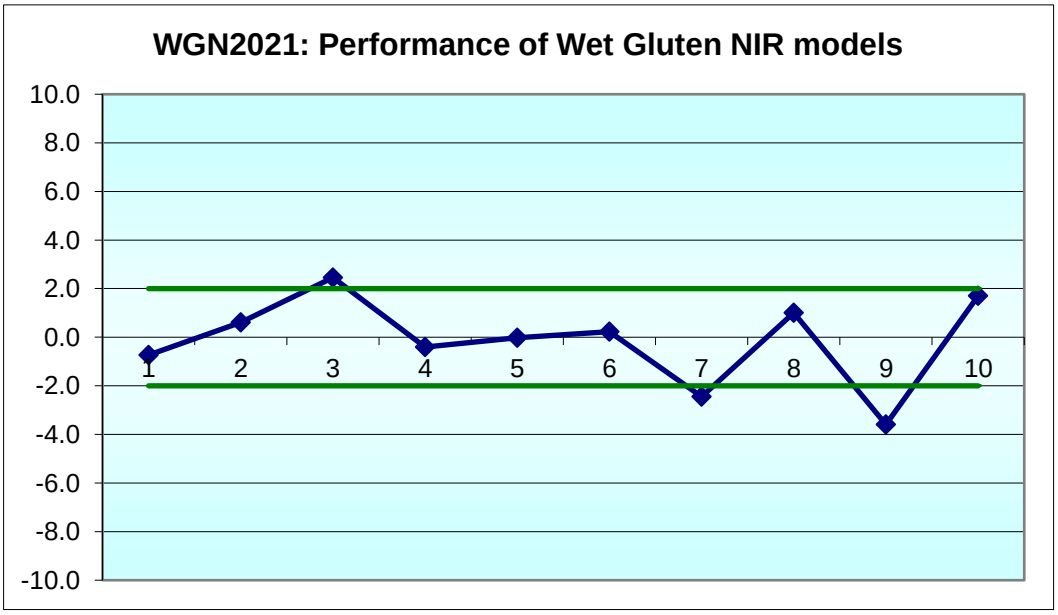


Fig. 7.4.1: Deviation of average results from prediction models against average values of reference results for wet gluten. Green lines = +/- 2 s_R.

The overall performance of the Infratec prediction models is good and falls within the error limits of the reference method, except for W3, W7 and W9 (the Durum wheat) which are just outside the limit.

7.5 Starch in wheat

Nine participants submitted results for starch in wheat determined by reference methods.
The methods used were:

S02	Lab 18	ICC 123/1 (polarimetric, HCl)
S03	Lab 4	EU regulation (EC) 152/2009 (polarimetric, HCl)
S04	Lab 8, 80, 81	EN ISO 10520 (Ewers)
S06	Lab 12, 68, 94	EN ISO 6493 (polarimetric, HCl)
S06	Lab 5	Enzymatic + HPLC

In addition, twenty-three sets of results from sixteen laboratories were also submitted by predicting with different models: WBST1 (4b, 17a, 18 and 25), WBST6 (4a, 8 and 81), WBST9 (17b and 66), WBST10 (19, 80 and 82), WBST14 (2) and WBST15 (5, 11, 12 and 94). Labs submitting reference results, but no predicted have got their spectra re-predicted with the latest model version WBST15 (lab 68).

Collation of data:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
4	68.9	67.8	69.0	68.5	68.9	68.3	68.9	69.4	68.0	69.7	68.7	0.8
5	62.4	62.2	64.2	64.1	65.0	65.2	66.0	65.9	67.1	66.8	64.9	-3.1
8	69.2	67.6	68.7	68.1	69.0	68.8	70.2	69.5	69.1	69.9	69.0	1.0
12	67.5	66.9	68.5	67.0	67.9	68.2	67.9	67.8	67.5	67.5	67.7	-0.3
18	69.3	69.1	68.2	67.6	68.6	69.0	69.2	69.2	69.5	69.7	68.9	1.0
68	67.3	66.7	67.4	66.4	65.0	65.7	68.0	64.9	63.0	66.1	66.1	-1.9
80	66.6	65.9	66.5	65.6	66.3	66.5	67.1	67.0	66.8	67.8	66.6	-1.3
81	68.9	68.1	68.9	68.9	69.7	69.5	71.3	69.6	69.8	71.0	69.6	1.6
94	70.3	69.1	70.3	69.2	70.4	70.1	71.1	70.4	70.1	71.0	70.2	2.2
AvG	**67.8**	**67.0**	**68.0**	**67.3**	**67.9**	**67.9**	**68.9**	**68.2**	**67.9**	**68.8**	**68.0**	
sd	2.3	2.1	1.8	1.7	2.0	1.7	1.8	1.9	2.2	1.8	1.8	
rsd	3.4	3.1	2.6	2.5	2.9	2.6	2.6	2.8	3.2	2.6	2.6	

Predicted values:

2	67.5	67.3	67.7	67.7	68.0	68.0	70.3	68.0	70.5	69.0	**68.4**	0.3
4a	68.0	67.1	69.0	68.4	68.2	67.4	68.8	67.4	67.6	68.8	**68.1**	-0.1
4b	65.9	64.6	66.4	66.3	66.2	64.2	66.0	64.8	64.6	65.7	**65.5**	-2.7
5	64.5	65.1	64.8	64.4	65.4	65.3	67.5	64.8	66.4	65.6	**65.4**	-2.7
8a	67.7	67.1	68.5	68.3	69.0	67.4	69.5	67.6	68.5	69.1	**68.2**	0.1
8b	68.9	68.5	69.7	69.1	69.1	68.6	69.2	69.3	69.8	69.8	**69.2**	1.1
11a	67.7	68.0	68.3	67.4	68.2	68.6	69.8	68.3	69.8	69.0	**68.5**	0.4
11b	67.1	67.4	67.9	67.0	67.7	68.1	69.5	67.9	69.3	68.6	**68.0**	-0.1

11d	67.5	68.1	67.9	67.6	68.4	68.6	70.2	68.4	70.2	69.0	**68.6**	0.5
11e	67.8	67.7	68.1	67.7	68.6	69.0	70.2	68.6	70.2	69.2	**68.7**	0.6
12	67.4	67.1	68.0	67.2	67.6	67.7	69.5	67.6	68.6	68.4	**67.9**	-0.2
17a	67.7	67.2	67.2	67.2	68.6	67.3	68.6	66.7	65.9	67.9	**67.4**	-0.7
17b	69.2	67.9	69.8	69.5	69.1	69.6	70.7	69.2	70.8	70.0	**69.6**	1.4
18	67.5	67.2	67.5	68.2	67.9	67.5	70.0	67.8	70.3	68.8	**68.3**	0.1
19	67.6	67.3	67.9	67.6	68.0	67.9	70.0	68.0	69.1	69.2	**68.3**	0.1
25	68.3	67.6	69.0	68.6	68.5	68.2	69.3	68.1	68.2	69.1	**68.5**	0.4
66	68.4	68.7	68.9	68.6	69.1	69.1	70.6	68.6	70.4	69.7	**69.2**	1.1
68	68.5	67.2	70.4	69.5	69.2	67.7	69.7	67.9	69.4	68.9	**68.8**	0.7
80	67.2	66.7	67.3	67.4	67.6	67.4	69.7	67.5	69.9	68.4	**67.9**	-0.2
81	67.7	68.3	68.7	68.0	68.8	68.7	70.4	68.8	70.2	69.6	**68.9**	0.8
82	67.7	67.8	68.1	67.6	67.9	68.0	69.9	68.0	69.6	68.8	**68.3**	0.2
94a	66.9	68.1	67.1	67.3	68.5	68.3	70.0	67.4	69.0	68.3	**68.1**	0.0
94b	66.5	66.8	66.6	66.1	67.0	66.4	69.1	66.5	67.9	67.5	**67.0**	-1.1

AvG	**67.5**	**67.3**	**68.0**	**67.7**	**68.1**	**67.8**	**69.5**	**67.7**	**69.0**	**68.6**	**68.1**	**0.0**

Z-Scores:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
4	1.1	0.8	1.0	1.2	1.0	0.4	0.1	1.2	0.1	0.8
5	-5.4	-4.8	-3.8	-3.2	-2.8	-2.7	-2.8	-2.3	-0.8	-2.0
8	1.4	0.5	0.7	0.8	1.2	0.9	1.3	1.3	1.2	1.1
12	-0.3	-0.1	0.5	-0.3	0.0	0.3	-1.0	-0.4	-0.4	-1.3
18	1.5	2.1	0.2	0.3	0.7	1.1	0.3	1.0	1.6	0.9
68	-0.5	-0.3	-0.6	-0.9	-2.9	-2.2	-0.9	-3.3	-4.9	-2.7
80	-1.3	-1.1	-1.4	-1.6	-1.6	-1.5	-1.7	-1.2	-1.1	-1.0
81	1.1	1.1	0.9	1.6	1.8	1.6	2.4	1.4	1.9	2.2
94	2.5	2.0	2.3	2.0	2.5	2.2	2.2	2.3	2.2	2.1
p2	0.0	-0.1	-0.4	0.0	-0.1	0.2	0.8	0.3	1.5	0.3
p4a	0.5	-0.2	1.0	0.7	0.1	-0.4	-0.7	-0.3	-1.4	0.2
p4b	-1.6	-2.7	-1.6	-1.4	-1.9	-3.6	-3.5	-2.9	-4.4	-2.9
p5	-3.0	-2.2	-3.2	-3.3	-2.7	-2.5	-2.0	-2.9	-2.6	-3.0
p8a	0.1	-0.3	0.4	0.6	0.8	-0.4	0.0	-0.1	-0.5	0.4
p8b	1.4	1.2	1.7	1.4	1.0	0.8	-0.3	1.6	0.8	1.2
p11a	0.1	0.6	0.3	-0.3	0.1	0.8	0.3	0.6	0.8	0.4
p11b	-0.5	0.1	-0.2	-0.6	-0.4	0.3	0.0	0.2	0.4	0.0
p11d	0.0	0.7	-0.1	-0.1	0.3	0.9	0.7	0.7	1.2	0.4
p11e	0.2	0.4	0.1	0.0	0.5	1.2	0.7	0.9	1.3	0.6
p12	-0.1	-0.2	0.0	-0.5	-0.5	-0.1	0.0	-0.1	-0.4	-0.2
p17a	0.1	-0.1	-0.9	-0.5	0.5	-0.5	-0.9	-1.0	-3.1	-0.8
p17b	1.6	0.5	1.8	1.8	1.0	1.8	1.2	1.5	1.8	1.3
p18	0.0	-0.1	-0.5	0.5	-0.2	-0.3	0.5	0.1	1.3	0.2
p19	0.1	0.0	-0.1	-0.1	-0.1	0.1	0.5	0.3	0.1	0.6
p25	0.8	0.3	1.0	0.9	0.4	0.4	-0.2	0.4	-0.8	0.5
p66	0.9	1.4	0.9	0.9	1.0	1.3	1.1	0.9	1.4	1.1
p68	1.0	-0.1	2.4	1.9	1.1	-0.1	0.2	0.2	0.4	0.2
p80	-0.3	-0.7	-0.7	-0.3	-0.5	-0.3	0.2	-0.2	0.9	-0.2
p81	0.2	1.0	0.7	0.3	0.7	0.9	0.9	1.1	1.2	1.0
p82	0.2	0.5	0.1	-0.1	-0.2	0.2	0.4	0.3	0.6	0.2
p94a	-0.6	0.8	-0.9	-0.4	0.4	0.5	0.5	-0.3	0.0	-0.3
p94b	-1.0	-0.5	-1.4	-1.6	-1.1	-1.4	-0.4	-1.2	-1.1	-1.1

P = predicted

Lab 5 show a significant negative bias on reference results, but is the only lab using enzymatic reference method. Therefore, their predicted values also show a negative bias which is explained by the adjustment to the reference method. The predicted values from lab 4b show significant negative bias and should be adjusted.

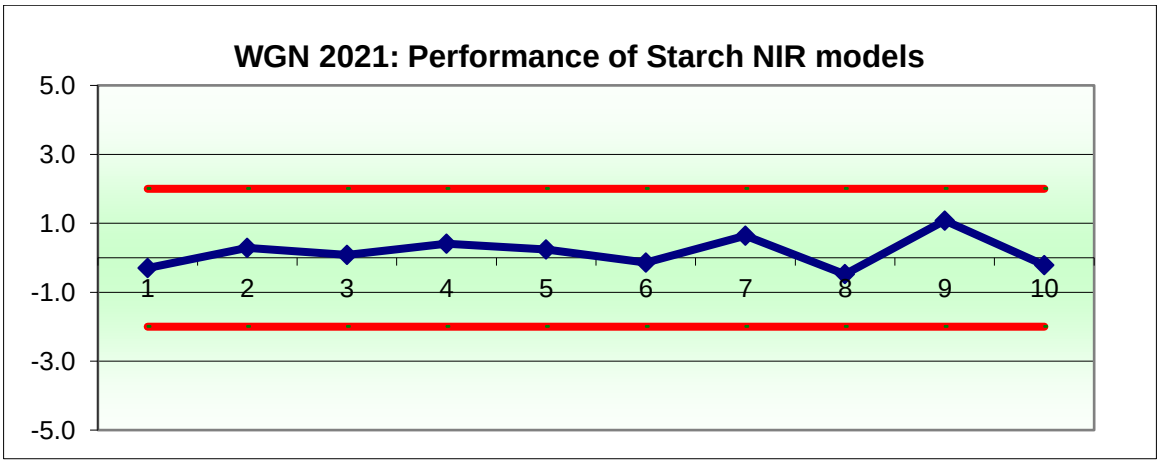


Fig. 7.5.1: Performance of average results of predictions against average reference values for starch in wheat. Red lines = +/- 2 s_R.

The overall performance of the starch NIR models is well aligned with all samples inside the limits.

7.6 Starch in barley

Two labs (5 and 12) submitted results by reference method. However, since lab 5 uses enzymatic method showing a negative bias for barley in the same way as for wheat, the average of the two might be a bit off. Twelve sets of predicted results from Eight participants were submitted for starch in barley. The models used were WBST1 (4b, 17a, 19, 82 and 84), WBST6 (4a), BAST12 (5 and 12) and WBST10 (11).

Collation of data:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
5	58.4	56.0	57.1	56.8	61.9	56.3	58.9	60.4	59.5	61.4	58.7	-1.6
12	61.9	58.5	61.5	59.2	62.2	65.8	60.2	64.4	60.4	64.2	61.8	1.6
AvG	**60.1**	**57.2**	**59.3**	**58.0**	**62.1**	**61.0**	**59.5**	**62.4**	**60.0**	**62.8**	**60.2**	**0.0**
sd	2.5	1.8	3.1	1.7	0.2	6.7	0.9	2.8	0.6	2.0	2.2	
rsd	4.1	3.1	5.3	3.0	0.3	11.0	1.5	4.5	1.1	3.1	3.7	

Predicted values:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
4a	61.5	61.2	63.1	62.4	63.4	65.3	63.3	63.8	61.7	63.7	**62.9**	0.8
4b	60.7	60.4	62.5	61.1	61.9	64.6	62.2	63.0	60.8	63.0	**62.0**	-0.1
5	61.1	59.3	60.4	60.0	62.3	63.1	60.5	59.8	59.2	60.8	**60.7**	-1.5
11a	63.2	59.2	63.0	60.6	64.0	65.8	62.0	61.7	60.8	63.2	**62.3**	0.2
11b	63.0	58.8	62.6	60.1	63.5	65.1	61.3	61.8	60.2	61.9	**61.8**	-0.3
11d	63.9	59.4	63.0	61.0	64.9	65.5	61.8	61.6	59.4	63.0	**62.4**	0.2
11e	63.3	59.9	62.7	60.5	64.3	65.4	61.6	61.5	61.1	62.9	**62.3**	0.2

12	59.5	59.2	62.0	60.7	61.9	64.7	61.7	63.5	59.6	63.2	**61.6**	-0.6
17a	62.1	61.5	63.6	62.8	63.8	65.8	63.4	64.2	62.3	64.5	**63.4**	1.2
19	60.9	60.8	62.6	61.7	62.8	64.3	62.3	63.4	61.2	63.3	**62.3**	0.2
82	61.0	60.6	62.5	62.0	62.9	64.7	62.6	63.6	61.5	63.4	**62.5**	0.3
84	62.9	59.6	63.4	61.1	63.8	56.7	62.1	62.0	61.4	63.0	**61.6**	-0.6

AvG	**61.9**	**60.0**	**62.6**	**61.2**	**63.3**	**64.2**	**62.1**	**62.5**	**60.8**	**63.0**	**62.2**	

Too few reference data for statistical analysis.

7.7 Hardness

Five participants reported values for the parameter “Hardness”. The methods used was SKCS (lab 10), AACC 39-70A (labs 2 and 33), MSZ EN 15585:2009 (68) and Pearler (94). In addition, two labs reported predicted values using WHHA26 (10) and WHHA36 (lab 11). Re-predictions were also made with WHHA36 (2, 33, 68 and 94).

Two clarifications should be made about hardness. First, some reference methods such as ICC 129 and EN 15585 that refers to determination of Durum vitreousness and should not be compared with hardness (note lab 68 in the table). Vitreousness depends on the structure of the starch whereas hardness is the crashworthiness. Secondly, the hardness methods SKCS, AACC 30-70A, AACC 55-30 and Pearler method reports the results in different modes which is not comparable. In fact, AACC 39-70A is a near-Infrared method and should not be classified as a standard method, but rather a rapid method. It means the listed values in the tables below can only be used for indicative purposes.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	69.2	94.2	109.2	79.7	88.2	94.5	95.7	97.6	132.7	93.9
10	69.5	68.0	80.5	70.5	60.5	68.0	63.0	72.5	80.0	73.5
33	51.5	76.5	73.5	55.0	65.0	81.5	76.5	77.5	97.0	75.0
68	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	43.9	N/A
94	3.6	3.5	5.0	4.4	3.2	3.9	4.2	4.6	3.7	4.1
Average	**48.4**	**60.5**	**67.1**	**52.4**	**54.2**	**62.0**	**59.9**	**63.0**	**71.5**	**61.6**

Predicted values

2	52.5	57.5	62.0	41.1	33.5	58.9	42.9	69.7	55.7	65.3
10	85.0	74.7	95.9	89.4	56.7	84.7	71.7	92.7	91.8	88.7
11a	64.0	53.7	82.9	68.6	35.2	59.6	51.1	63.0	58.0	66.9
11b	64.1	52.6	83.4	70.3	42.1	57.4	51.0	59.6	59.9	69.1
11d	69.9	60.5	72.1	71.1	44.5	64.7	52.9	69.1	59.8	68.2
11e	65.5	50.7	71.5	70.2	40.1	54.4	42.0	64.8	58.5	63.5
33	62.3	57.6	84.7	57.7	40.4	65.3	61.2	69.1	65.6	76.1
68	74.3	64.9	83.2	71.7	40.3	67.0	65.1	71.1	66.5	68.3
94	67.7	61.3	67.2	84.7	45.9	45.3	66.1	72.0	73.8	47.7
Average	**67.2**	**59.3**	**78.1**	**69.4**	**42.1**	**61.9**	**56.0**	**70.1**	**65.5**	**68.2**

Too few data for statistical analysis.

8 Results for other parameters in Rapeseed

On voluntary basis participants shared results of their reference methods on other parameters which are compiled in this section. The table below shows the parameters and the number of labs reporting results for the WGN2021 exercise.

Parameter	# labs reporting (ref + pred)
TWM (mass per hectolitre)	2+6
Protein	6+18
Glucosinolates	3+6
Erucic acid	4+13
Oleic acid	4+14
Linolenic acid	4+14
Linoleic acid	4+2
FFA (Acidity index)	2+1
Saturated fats	1+2
Iodine values	1+4

8.1 Mass per hectolitre

Two labs (27 and 68) reported reference results for the test weight (mass per hectolitre, kg/hL). There were, on the other hand, reported TWM results from 6 instruments.

8.1.1 Reference method

Two participants submitted reference results.

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
27	70.2	67.6	68.3	67.6	67.0	68.2	66.8	68.2	67.6	68.6	68.0	0.08
68	69.7	67.2	68.2	67.3	66.4	68.2	66.5	68.2	68.1	68.6	67.8	-0.08
Average	70.0	67.4	68.2	67.4	66.7	68.2	66.6	68.2	67.9	68.6	67.9	0.0
sd	0.4	0.2	0.0	0.2	0.4	0.0	0.2	0.0	0.3	0.0	0.1	0.1
min	69.7	67.2	68.2	67.3	66.4	68.2	66.5	68.2	67.6	68.6	67.8	-0.1
max	70.2	67.6	68.3	67.6	67.0	68.2	66.8	68.2	68.1	68.6	68.0	0.1

8.1.2 Mass per hectolitre by Infratec TWM

Infratec TWM results for mass per hectoliter is given below.

Collation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
4a	70.2	68.0	67.8	67.7	66.9	N/A	67.1	68.0	N/A	68.2	68.0	-0.78
4b	70.6	68.2	68.3	67.9	67.3	N/A	67.4	68.1	N/A	68.5	68.3	-0.47
11f	68.0	65.4	66.6	65.6	65.2	66.9	65.2	66.6	66.6	66.9	66.3	-2.46
30a	72.2	69.7	70.2	70.3	69.6	71.0	69.4	70.7	71.0	71.1	70.5	1.76
82	71.6	69.4	69.2	69.0	68.4	69.9	68.4	69.3	70.0	70.7	69.6	0.83
85	72.0	69.4	69.2	69.6	69.1	69.8	68.4	70.4	70.0	70.7	69.9	1.10
Average	70.8	68.3	68.5	68.4	67.7	69.4	67.6	68.9	69.4	69.4	68.8	0.0
sd	1.6	1.6	1.3	1.7	1.6	1.8	1.5	1.6	1.9	1.7	1.5	1.5
min	68.0	65.4	66.6	65.6	65.2	66.9	65.2	66.6	66.6	66.9	66.3	-2.5
max	72.2	69.7	70.2	70.3	69.6	71.0	69.4	70.7	71.0	71.1	70.5	1.8

8.2 Protein

Reference results for protein in rapeseed were submitted from six labs (12, 27, 31, 33, 35 and 68. One participant reported Infratec predictions with local PLS model RAPR10 (35a-35c), one with RAPR11 (31) and RAPR12 (5, 12). Re-predictions were made with RAPR12 (labs 11, 33 and 68). In addition, one results from one from a NIRS DS2500 (35e), NIRS 6500 were submitted (35f) and one from an XDS (91).

Collation of results

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
12	24.2	20.2	21.3	19.9	20.4	17.6	19.0	25.0	22.6	18.8	**20.90**	0.03
27	24.2	19.6	21.7	19.3	19.9	17.5	18.9	24.5	21.9	18.9	**20.64**	-0.23
31	23.8	20.2	21.5	20.5	20.9	18.0	19.5	24.8	22.4	18.9	**21.05**	0.18
33	24.2	20.1	21.5	20.2	20.3	18.4	19.3	24.8	23.0	19.1	**21.08**	0.21
35	24.1	20.0	21.4	20.1	20.6	18.1	19.2	24.5	22.6	18.7	**20.93**	0.06
68	23.6	19.8	21.2	19.8	19.9	17.7	19.0	24.5	22.3	18.6	**20.64**	-0.24
Average	24.0	20.0	21.4	20.0	20.3	17.9	19.1	24.7	22.5	18.8	20.9	0.0
sd	0.3	0.2	0.2	0.4	0.4	0.3	0.2	0.2	0.4	0.2	0.2	0.2
min	23.6	19.6	21.2	19.3	19.9	17.5	18.9	24.5	21.9	18.6	20.6	-0.2
max	24.2	20.2	21.7	20.5	20.9	18.4	19.5	25.0	23.0	19.1	21.1	0.2
2	24.56	20.74	21.46	20.69	20.88	18.79	19.78	24.35	22.79	19.63	**21.37**	0.32
5	24.30	20.90	20.80	20.70	20.90	19.00	19.60	26.50	22.50	19.60	**21.48**	0.43
11a	23.60	19.83	20.31	20.03	19.88	18.10	19.11	25.72	21.58	19.05	**20.72**	-0.32
11b	23.46	20.21	20.22	20.09	20.19	18.52	19.06	25.50	21.93	18.95	**20.81**	-0.23
11d	23.61	20.29	20.46	20.34	20.72	18.73	19.29	25.69	22.18	19.37	**21.07**	0.02

11e	24.09	19.99	20.49	20.51	20.83	18.84	19.39	25.77	22.28	19.22	**21.14**	0.10
12	23.90	20.50	20.80	20.60	20.00	18.80	19.10	26.00	21.90	19.10	**21.07**	0.02
27a	24.38	21.20	22.18	20.38	21.38	18.16	19.30	26.41	23.85	18.94	**21.62**	0.57
27b	21.66	18.12	21.82	17.39	18.50	15.76	17.18	23.48	20.20	16.43	**19.05**	-1.99
31	24.30	19.60	18.50	19.90	20.50	17.90	18.20	26.60	22.60	18.50	**20.66**	-0.39
33	22.32	20.41	20.43	20.56	20.25	18.52	19.14	25.97	22.32	18.79	**20.87**	-0.17
35a	23.80	21.80	20.10	20.90	23.00	18.70	20.30	25.70	23.00	19.10	**21.64**	0.59
35b	24.20	22.70	20.20	21.00	22.20	19.00	20.50	25.90	22.80	19.20	**21.77**	0.72
35c	24.20	21.90	20.40	20.90	22.30	18.70	20.90	25.80	22.50	19.60	**21.72**	0.67
35e	23.36	19.45	20.55	19.00	19.64	17.35	18.35	24.30	21.71	18.23	**20.19**	-0.85
35f	23.93	20.16	20.90	20.17	20.39	18.64	19.13	24.72	22.40	19.38	**20.98**	-0.06
68	24.03	20.60	20.68	20.81	20.66	18.31	19.48	26.53	23.17	18.80	**21.31**	0.26
91	24.70	20.30	21.80	20.50	21.00	17.90	18.90	26.60	22.70	19.00	**21.34**	0.29

AvG.	**23.80**	**20.48**	**20.67**	**20.25**	**20.73**	**18.32**	**19.26**	**25.64**	**22.36**	**18.94**	**21.05**	

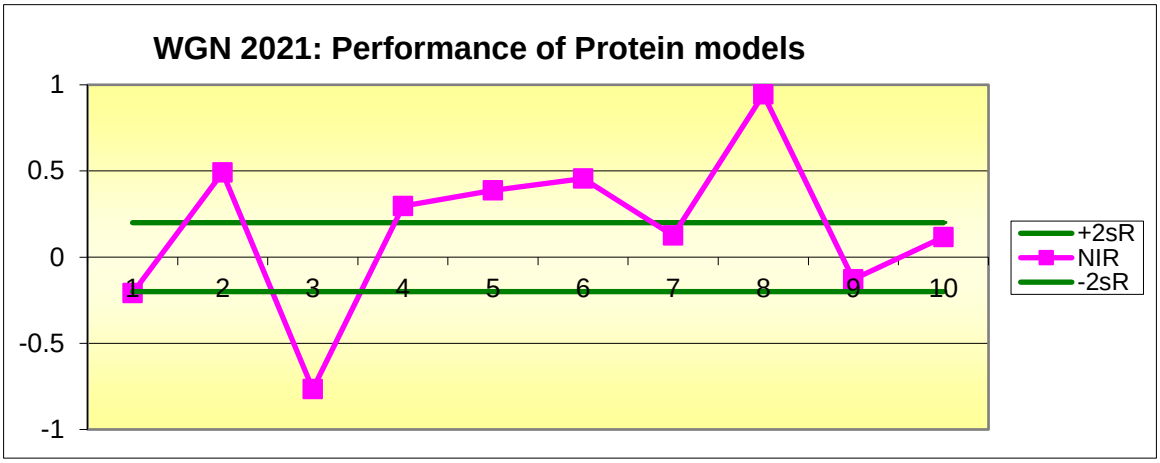


Fig. 8.2.1: Performance of average results of predictions against average reference values for protein in Rapeseed. Red lines = +/- 2 s_R.

8.3 Glucosinolates

Three participants submitted results for Glucosinolates using EN ISO 9167-1 (18 and 33) and one using a national standard method (68). Predicted results using model RAGU4 were performed for 2 instruments using extended range (11d and 11e). In addition, one result from NIRS DS2500 were submitted (35e), one from NIRS 6500 (35f) and two from XDS (2 and 91).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
18	11	14	6	14	19	18	15	9	13	15	**13**	0
33	12	16	8	16	18	18	18	11	15	18	**15**	1
68	10	12	8	13	14	16	15	11	11	15	**13**	-1
AvG.	**11**	**14**	**7**	**15**	**17**	**17**	**16**	**10**	**13**	**16**	**14**	

2	13	12	5	14	17	17	15	9	13	15	**13**	-5
11d	46	27	0	20	26	9	13	68	40	19	**27**	**9**
11e	42	17	0	18	19	6	10	70	35	11	**23**	**5**
35e	11	12	9	13	15	16	14	13	13	14	**13**	**-5**
35f	13	12	8	14	16	18	13	13	13	15	**14**	**-4**
91	15	16	13	16	21	21	18	14	17	20	**17**	**-1**

AvG.	**23**	**16**	**6**	**16**	**19**	**14**	**14**	**31**	**22**	**16**	**18**	

Glucosinolates is a difficult parameter with NIR and it is more than a bias causing the deviation.

8.4 Erucic acid

Four participants (15, 33, 35 and 68) submitted results for Erucic acid using a GC method (EN ISO-12966-2). Predicted results were reported from one participant (33) and spectra from 11 instruments were re-predicted using model RAEU7 (11, 15, 35 and 68). One predicted result from XDS (91). Erucic acid is a difficult parameter with NIR and the contents are usually very small, hence negative values have been forced to zero.

Compilation of results:

Lab	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	Mean	dev
15	0.05	0.06	0.08	0.05	0.63	0.05	0.08	0.12	0.12	0.05	**0.13**	0.01
33	0.00	0.00	0.00	0.00	0.74	0.09	0.04	0.05	0.04	0.00	**0.10**	-0.02
35	0.00	0.04	0.07	0.00	0.52	0.02	0.03	0.07	0.16	0.00	**0.09**	-0.02
68	0.05	0.05	0.08	0.05	0.80	0.05	0.11	0.10	0.12	0.05	**0.14**	0.03
AvG.	**0.03**	**0.04**	**0.06**	**0.03**	**0.67**	**0.05**	**0.06**	**0.08**	**0.11**	**0.03**	**0.12**	

11a	0.18	0.00	0.00	0.00	3.83	0.00	0.00	0.00	0.00	0.00	**0.40**	-0.29
11b	0.89	0.00	0.00	0.00	2.98	0.00	1.10	0.00	0.00	0.00	**0.50**	-0.19
11d	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	-0.69
11e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	-0.69
15a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	-0.69
15b	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	-0.69
33	5.11	11.76	0.00	6.26	13.32	0.00	2.44	0.00	0.00	0.00	**3.89**	3.20
35a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	-0.69
35b	0.00	4.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.46**	-0.23
35c	0.00	0.00	0.00	0.00	1.61	0.00	0.00	0.00	0.00	0.00	**0.16**	-0.53
35d	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	-0.69
68	0.90	4.19	0.00	5.68	9.77	0.00	4.50	0.00	0.00	0.00	**2.50**	1.82
91	1.30	0.70	0.80	1.00	1.10	1.20	0.90	0.40	1.40	1.40	**1.02**	0.33

8.5 Oleic acid

Four participants (15, 33, 35 and 68) submitted results for Oleic acid using a GC method (EN ISO-12966-2). Predicted results were reported from one participant (33) and spectra from 11 instruments were re-predicted using model RAOA3 (11, 15, 35a-35d and 68). Predicted results from NIRS DS2500 (35e) and NIRS 6500 (35f) were also received.

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
15	62.90	56.62	55.32	58.68	56.78	59.09	58.24	52.97	61.37	58.75	**58.07**	-7.15
33	66.31	60.98	58.69	62.68	60.81	63.28	62.26	56.34	65.24	62.93	**61.95**	-3.27
35	66.33	60.69	58.51	62.37	60.86	62.93	62.25	56.44	65.27	62.28	**61.79**	-3.43
68	66.96	60.97	59.20	62.85	60.77	63.36	62.49	56.82	65.91	62.85	**62.22**	-3.00
AvG.	**65.62**	**59.81**	**57.93**	**61.64**	**59.81**	**62.17**	**61.31**	**55.64**	**64.45**	**61.70**	**61.01**	

11a	67.85	65.07	46.43	65.49	66.17	67.75	65.62	51.01	67.91	66.30	**62.96**	-0.15
11b	68.05	64.92	46.18	66.00	66.67	66.79	67.52	50.38	68.07	66.42	**63.10**	-0.01
11d	67.29	64.52	46.12	65.58	65.85	66.73	67.27	51.90	67.87	66.29	**62.94**	-0.17
11e	67.96	67.13	47.08	66.25	68.37	67.38	65.94	52.78	68.31	67.68	**63.89**	0.77
15a	67.44	64.70	46.40	65.76	66.50	67.00	66.69	50.38	68.14	65.92	**62.89**	-0.22
15b	68.34	65.92	46.21	66.20	66.49	68.09	67.79	52.38	69.39	66.30	**63.71**	0.60
33	69.38	64.74	47.88	65.17	67.51	67.66	66.07	52.48	69.91	67.75	**63.85**	0.74
35a	66.91	64.39	46.14	65.75	66.47	67.03	65.96	50.66	67.08	66.83	**62.72**	-0.39
35b	67.76	64.45	47.72	66.41	67.64	67.67	67.30	51.81	68.62	66.21	**63.56**	0.44
35c	67.59	65.56	46.25	66.16	66.72	66.90	66.41	51.29	67.41	66.92	**63.12**	0.01
35d	68.17	64.56	47.06	66.40	65.99	67.45	66.65	50.94	67.88	67.01	**63.21**	0.10
35e	67.07	61.90	57.41	63.28	62.10	63.53	62.35	56.81	66.40	63.29	**62.41**	-0.70
35f	66.64	62.23	58.13	63.01	61.51	62.87	62.25	56.57	65.71	61.98	**62.09**	-1.02
68	66.83	64.99	47.12	66.93	68.15	67.36	67.24	50.64	66.16	65.86	**63.13**	0.02
AvG.	**67.66**	**64.65**	**48.29**	**65.60**	**66.15**	**66.73**	**66.08**	**52.14**	**67.78**	**66.05**	**63.11**	

8.6 Linolenic acid

Four participants (15, 33, 35 and 68) submitted results for Linolenic acid using a GC method (EN ISO-12966-2). Predicted results were reported from one participant (33) and spectra from11 instruments were re-predicted using model RALN3 (11, 15, 35 and 68). Predicted results from NIRS DS2500 (35e) and NIRS 6500 (35f) were also received.

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
15	7.08	10.68	11.19	9.24	9.90	8.33	9.84	12.50	6.84	7.66	**9.33**	-0.07
33	7.12	10.69	11.33	9.28	9.95	8.28	9.89	12.83	7.00	7.63	**9.40**	0.01
35	7.10	10.79	11.31	9.29	9.91	8.39	9.87	12.65	6.91	7.75	**9.40**	0.00
68	7.06	10.94	11.32	9.38	10.07	8.46	9.94	12.69	6.84	7.75	**9.45**	0.05
AvG.	**7.09**	**10.77**	**11.29**	**9.30**	**9.96**	**8.36**	**9.88**	**12.67**	**6.90**	**7.70**	**9.39**	
11a	5.34	7.55	17.45	7.19	7.00	6.00	7.44	14.98	5.26	6.85	**8.51**	-0.05
11b	5.11	7.57	17.33	6.85	6.58	6.41	6.18	15.31	5.10	6.74	**8.32**	-0.24
11d	5.00	6.95	16.07	6.54	6.42	5.72	6.06	13.36	4.49	6.05	**7.67**	-0.89
11e	4.73	6.28	16.54	6.69	5.43	5.84	6.56	13.44	4.79	5.62	**7.59**	-0.96
15a	4.56	6.54	16.73	6.40	6.38	5.27	5.93	13.78	4.15	6.45	**7.62**	-0.93
15b	3.83	7.49	15.75	6.84	5.64	5.73	6.61	13.71	3.81	5.54	**7.49**	-1.06
33	6.43	8.25	18.41	7.54	7.11	6.77	7.65	16.12	6.37	6.78	**9.14**	0.59
35a	5.88	8.48	17.80	7.20	6.16	6.36	6.95	15.19	5.53	7.08	**8.66**	0.11
35b	5.52	7.62	17.95	7.25	6.94	6.98	7.08	15.26	5.92	6.79	**8.73**	0.18
35c	5.51	8.38	17.61	6.95	7.21	6.37	7.14	15.56	5.66	6.48	**8.69**	0.13
35d	6.21	8.91	18.18	7.87	7.72	7.26	7.58	15.86	6.35	7.59	**9.35**	0.80
35e	6.15	11.24	11.87	8.95	9.91	7.68	9.82	12.19	6.29	7.69	**9.18**	0.62
35f	7.24	11.09	11.64	9.65	9.45	7.84	9.62	11.83	6.51	7.39	**9.22**	0.67
68	6.50	8.83	19.18	6.70	6.69	7.21	7.81	16.93	8.04	8.04	**9.59**	1.04
AvG.	**5.57**	**8.23**	**16.61**	**7.33**	**7.05**	**6.53**	**7.32**	**14.54**	**5.59**	**6.79**	**8.56**	

There is a clear bias for the Infratec prediction model relative the reference method, so at least a bias adjustment is required for RALN2 to work properly. The NIR reflectance models seems to work better (labs 33 and 35d-35f).

8.7 Linoleic acid

Four participants (15, 33, 35 and 68) submitted results for Linoleic acid using a GC method (EN ISO-12966-2). Predicted results have also been supplied from NIRS DS2500 (35e) and NIRS 6500 (35f).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
15	17.71	20.17	22.79	19.43	19.86	19.48	19.62	23.60	18.33	20.71	**19.70**	-1.95
33	17.84	20.18	22.80	19.38	19.78	19.35	19.63	23.50	18.56	20.39	**21.31**	-0.34
35	17.29	19.74	22.34	19.07	19.48	19.12	19.13	23.09	17.85	20.38	**21.13**	-0.52
68	17.53	20.15	22.63	19.36	19.97	19.52	19.52	23.55	18.22	20.62	**24.46**	2.81
AvG.	**17.59**	**20.06**	**22.64**	**19.31**	**19.77**	**19.37**	**19.48**	**23.44**	**18.24**	**20.52**	**21.65**	
35e	17.99	18.39	21.24	18.50	18.67	18.84	18.85	21.83	17.76	19.11	**19.12**	-0.12
35f	17.06	18.09	20.96	17.53	19.60	19.45	19.34	22.79	18.25	20.63	**19.37**	0.12
AvG.	**17.53**	**18.24**	**21.10**	**18.01**	**19.13**	**19.14**	**19.09**	**22.31**	**18.01**	**19.87**	**19.24**	

8.8 Free fatty acid acidity index (FFA)

Two participants (33 and 35) submitted results for Free fatty acid using titration methods ISO 660 (lab 33) and Analytica Chemica Acta 99:387–391 (lab 35). Free fatty acid is based on the Oleic acid and relates to the oil conservation, which gives an indication about the global content of fatty acids that are liberated by oxidation. This should be distinguished to the Free fatty acid compositional value that describes how much of each fatty acid that are included in the oil. One set of predicted results from XDS (91) have been received.

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
33	0.34	0.59	0.63	1.06	0.55	0.35	0.44	0.97	0.54	0.39	**0.59**	0.10
35	0.14	0.49	0.60	0.48	0.40	0.25	0.25	0.82	0.24	0.14	**0.38**	-0.10
AvG.	**0.24**	**0.54**	**0.61**	**0.77**	**0.48**	**0.30**	**0.35**	**0.90**	**0.39**	**0.26**	**0.48**	
91	1.30	1.20	1.70	1.20	1.30	1.70	1.30	1.70	1.30	1.60	**1.43**	0.00
AvG.	**1.30**	**1.20**	**1.70**	**1.20**	**1.30**	**1.70**	**1.30**	**1.70**	**1.30**	**1.60**	**1.43**	

8.9 Saturated Fats

One participant (35) submitted results for Saturated fats using a GC method (ISO-12966-1). Predicted results have also been supplied from NIRS DS2500 (35e) and NIRS 6500 (35f).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
35	7.23	6.54	5.75	7.09	6.78	7.38	6.61	5.62	7.65	7.46	**6.81**	
AvG.	**7.23**	**6.54**	**5.75**	**7.09**	**6.78**	**7.38**	**6.61**	**5.62**	**7.65**	**7.46**	**6.81**	
35e	6.85	6.37	6.73	6.55	6.69	6.68	6.58	6.67	6.94	7.05	**6.71**	0.04
35f	6.58	6.27	6.37	6.59	6.65	6.67	6.61	6.76	6.79	7.02	**6.63**	-0.04
AvG.	**6.72**	**6.32**	**6.55**	**6.57**	**6.67**	**6.67**	**6.59**	**6.72**	**6.87**	**7.03**	**6.67**	

8.10 Iodine Value

One participant (35) submitted results for Iodine Value method (AOCS Cd 1c-85). Predicted results have also been supplied from lab 27 and form NIRS DS2500 (35e) and NIRS 6500 (35f).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
35	106.8	116.0	119.8	112.3	113.9	110.5	113.8	123.0	106.5	110.5	**113.3**	
AvG.	**106.8**	**116.0**	**119.8**	**112.3**	**113.9**	**110.5**	**113.8**	**123.0**	**106.5**	**110.5**	**113.3**	
27a	107.3	112.2	125.8	110.7	108.9	109.7	112.2	131.9	107.1	108.3	**113.4**	1.0
27b	104.1	111.9	122.3	108.3	106.2	104.6	106.5	129.3	104.0	106.9	**110.4**	-2.0
35e	105.9	114.9	119.9	111.3	113.2	109.8	113.4	119.8	105.7	109.7	**112.4**	-0.1
35f	107.6	115.9	119.5	112.6	114.6	111.5	114.6	120.5	107.5	111.1	**113.5**	1.1
AvG.	**106.2**	**113.7**	**121.9**	**110.7**	**110.7**	**108.9**	**111.7**	**125.4**	**106.1**	**109.0**	**112.4**	

I. Annex: Protein and Moisture content in Wheat & Barley by local NIR prediction models

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	12.90	14.60	12.30	12.00	12.70	12.80	12.00	13.40	12.10	12.40	12.72	-0.33	0.09
2	13.27	15.11	12.57	12.48	12.99	13.28	12.33	13.71	12.58	12.78	13.11	0.06	0.03
4a	13.19	15.20	12.38	12.50	12.91	13.12	12.30	13.63	12.26	12.53	13.00	-0.05	0.13
4b	13.16	14.98	12.65	12.33	12.91	13.22	12.31	13.53	12.55	12.66	13.03	-0.02	0.09
5	13.30	15.20	12.50	12.50	13.10	13.20	12.20	13.60	12.60	12.80	13.10	0.05	0.07
8a	13.20	15.30	12.55	12.30	13.00	13.30	12.20	13.65	12.45	12.65	13.06	0.01	0.10
8b	13.25	15.05	12.50	12.40	13.00	13.15	12.00	13.60	12.55	12.70	13.02	-0.03	0.07
10	13.00	14.70	12.60	12.50	13.00	12.90	12.00	13.30	12.40	12.50	12.89	-0.16	0.17
11	13.18	15.08	12.46	12.39	12.89	13.20	12.10	13.66	12.55	12.61	13.01	-0.04	0.05
12	13.10	14.90	12.30	12.30	12.80	13.00	11.90	13.60	12.60	12.70	12.92	-0.13	0.11
15	13.10	14.89	12.57	12.47	12.91	13.00	11.85	13.62	12.39	12.57	12.94	-0.11	0.12
17a	13.15	15.00	12.60	12.45	13.05	13.10	12.10	13.65	12.40	12.65	13.02	-0.04	0.07
17b	13.10	15.00	12.60	12.50	12.85	13.05	12.10	13.65	12.55	12.60	13.00	-0.05	0.09
18	13.00	15.10	12.60	12.20	13.00	13.30	12.10	13.70	12.60	12.70	13.03	-0.02	0.11
19	13.06	14.89	12.51	12.41	12.85	13.15	12.07	13.62	12.56	12.57	12.97	-0.08	0.07
25	13.00	15.10	12.30	12.30	12.90	13.10	12.00	13.50	12.40	12.60	12.92	-0.13	0.07
27a	13.38	15.35	12.80	12.60	13.16	13.58	12.12	13.98	12.81	12.82	13.26	0.21	0.13
27b	11.98	13.59	11.32	11.24	11.68	11.81	10.92	12.46	11.34	11.51	11.79	-1.27	0.10
30a	13.41	15.23	12.73	12.73	13.07	13.30	12.16	13.75	12.73	12.84	13.19	0.14	0.10
30b	13.41	15.34	12.50	12.73	13.18	13.18	12.39	13.86	12.73	13.07	13.24	0.19	0.12
30c	13.15	15.16	12.39	12.40	13.00	13.20	12.18	13.65	12.34	12.75	13.02	-0.03	0.08
30d	13.19	15.16	12.45	12.58	13.01	13.22	12.28	13.82	12.55	12.76	13.10	0.05	0.07
30e	13.32	15.22	12.69	12.40	13.10	13.22	12.27	13.86	12.78	12.80	13.17	0.11	0.08
30f	13.32	14.94	12.09	12.45	14.35	15.51	14.94	14.07	13.03	14.08	13.88	0.83	1.07
30h	13.51	15.42	12.70	12.42	13.16	13.51	12.43	14.08	12.85	12.92	13.30	0.25	0.12
30i	13.36	15.31	12.70	12.48	13.08	13.24	12.42	13.77	12.43	12.78	13.16	0.11	0.10
33	13.20	15.10	12.50	12.50	13.10	13.10	12.20	13.60	12.30	12.80	13.04	-0.01	0.10
35a	13.40	15.30	12.70	12.70	13.40	13.40	12.50	14.00	12.70	12.90	13.30	0.25	0.08

35b	13.40	15.30	12.80	12.70	13.20	13.40	12.40	14.00	12.90	12.90	13.30	0.25	0.06
35c	13.40	15.30	12.90	12.70	13.40	13.50	12.50	14.00	12.80	13.10	13.36	0.31	0.06
35d	13.20	15.10	12.60	12.50	13.10	13.30	12.10	13.80	12.50	12.70	13.09	0.04	0.07
64	13.00	15.00	12.40	12.30	12.90	13.00	12.00	13.60	12.40	12.60	12.92	-0.13	0.05
66	13.10	15.20	12.60	12.30	13.00	13.20	12.20	13.80	12.50	12.70	13.06	0.01	0.08
68	12.90	14.60	12.30	12.20	12.69	12.90	11.80	13.50	12.00	12.50	12.74	-0.31	0.12
73	13.12	15.15	12.52	12.42	12.93	13.17	12.13	13.60	12.59	12.80	13.04	-0.01	0.06
75	13.13	15.04	12.48	12.39	12.95	13.12	12.17	13.62	12.51	12.65	13.01	-0.04	0.02
77a	13.14	14.67	12.53	12.42	12.97	13.24	12.37	13.43	12.49	12.76	13.00	-0.05	0.16
80	13.09	15.19	12.58	12.42	13.02	13.14	12.06	13.81	12.46	12.65	13.04	-0.01	0.10
81	13.10	15.10	12.50	12.30	13.00	13.20	12.20	13.70	12.50	12.60	13.02	-0.03	0.06
82	13.20	15.00	12.60	12.50	12.80	13.20	12.20	13.70	12.60	12.70	13.05	0.00	0.08
85	12.80	14.80	12.30	12.10	12.60	12.80	11.90	13.20	12.40	12.40	12.73	-0.32	0.10
88	13.10	14.90	12.20	12.20	12.80	12.90	11.90	13.40	12.60	12.40	12.84	-0.21	0.13
91	13.00	14.90	12.50	12.40	12.60	13.00	12.00	13.50	12.40	12.60	12.89	-0.16	0.11
94a	13.30	15.00	12.40	12.30	12.70	13.10	12.20	13.60	12.60	12.60	12.98	-0.07	0.12
94b	13.20	15.10	12.50	12.40	13.00	12.90	12.00	13.60	12.70	12.60	13.00	-0.05	0.13
97	14.69	16.66	13.70	13.59	14.25	14.47	13.40	14.91	13.70	14.10	14.35	1.30	0.15
98	12.90	14.90	12.30	12.30	12.70	13.00	11.90	13.40	12.20	12.60	12.82	-0.23	0.08
Average	13.18	15.07	12.52	12.42	13.00	13.21	12.21	13.67	12.53	12.72	13.05	0.00	0.11
Std	0.32	0.37	0.30	0.29	0.38	0.47	0.51	0.32	0.31	0.37	0.33	0.33	0.15
Min	12.0	13.6	11.3	11.2	11.7	11.8	10.9	12.5	11.3	11.5	11.8	-1.3	0.0
Max	14.7	16.7	13.7	13.6	14.4	15.5	14.9	14.9	13.7	14.1	14.3	1.3	1.1

Table I.1 Protein content in wheat samples by local NIR prediction models

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	10.60	12.50	10.60	12.10	10.00	9.50	11.70	12.20	12.40	11.50	11.31	0.12	0.18
2	10.48	11.97	10.57	12.24	9.86	9.20	11.33	12.05	12.45	11.47	11.16	-0.04	0.09
4a	10.55	11.89	10.43	11.98	9.93	9.20	11.13	12.08	12.24	11.48	11.09	-0.10	0.09
4b	10.23	11.64	10.54	12.07	9.91	9.02	11.47	12.08	12.43	11.38	11.08	-0.12	0.14
5	10.60	11.80	10.60	12.00	10.10	9.40	11.30	12.30	12.40	11.60	11.21	0.02	0.11
6	10.37	11.94	10.41	11.66	9.88	9.10	11.19	12.20	12.20	11.39	11.03	-0.16	0.13
8a	10.50	11.75	10.45	12.10	10.00	9.10	11.25	12.10	12.50	11.30	11.11	-0.09	0.11
8b	10.40	11.55	10.35	11.90	9.90	9.15	11.30	12.15	12.55	11.55	11.08	-0.11	0.16
11	10.94	11.78	10.67	12.23	10.14	9.04	11.37	12.28	12.39	11.45	11.23	0.03	0.21
12	10.00	11.90	10.40	12.00	9.70	9.20	11.10	12.20	12.60	11.40	11.05	-0.14	0.19
15	10.56	12.19	10.56	12.06	10.13	9.44	11.25	12.25	12.38	11.69	11.25	0.06	0.11
17a	10.35	11.70	10.45	11.95	9.80	9.15	11.20	12.05	12.20	11.20	11.01	-0.19	0.07
18	10.50	12.00	10.30	12.10	9.90	9.10	11.20	12.20	12.40	11.40	11.11	-0.08	0.11
19	10.39	11.96	10.45	12.06	10.00	9.14	11.37	12.00	12.47	11.20	11.10	-0.09	0.10
25	10.40	11.80	10.50	12.00	10.00	9.20	11.10	12.10	12.20	11.40	11.07	-0.12	0.08
27a	10.53	12.48	10.72	12.09	10.47	9.78	11.69	12.49	12.62	11.62	11.45	0.25	0.17
27b	10.91	12.13	10.80	12.40	10.39	9.76	11.64	12.41	12.41	11.74	11.46	0.26	0.13
30a	10.63	11.88	10.63	12.50	10.00	9.38	11.25	12.50	12.50	11.88	11.31	0.12	0.19
30b	10.63	11.69	10.50	12.19	9.88	9.19	11.25	12.19	12.31	11.00	11.08	-0.11	0.19
30c	10.56	11.88	10.56	12.25	10.31	9.25	11.75	12.31	12.38	11.75	11.30	0.11	0.16
30d	10.75	12.25	10.50	12.13	10.13	9.38	11.63	12.13	12.31	11.75	11.29	0.10	0.15
30e	10.06	12.25	10.44	12.25	10.50	9.75	11.50	12.13	12.94	12.00	11.38	0.19	0.30
30f	10.56	12.06	10.63	12.56	10.44	9.38	11.63	11.94	12.31	11.75	11.33	0.13	0.21
30h	10.38	12.19	10.44	12.31	10.00	9.25	11.38	12.19	12.13	11.44	11.17	-0.03	0.15
30i	11.04	12.22	10.83	12.54	10.42	9.83	11.63	11.91	12.31	11.84	11.46	0.26	0.26
30j	10.56	11.63	10.75	12.25	10.06	9.38	11.56	12.19	12.56	11.63	11.26	0.06	0.16
32	10.43	11.83	10.37	12.17	9.97	9.20	11.40	12.27	12.30	11.37	11.13	-0.06	0.10
33	10.60	11.90	10.80	12.10	9.90	9.40	11.40	12.50	12.50	11.30	11.24	0.05	0.17
35a	10.60	12.20	10.80	12.10	10.30	9.60	11.40	12.50	13.20	11.70	11.44	0.25	0.22
35b	10.60	12.80	10.90	12.50	10.70	9.60	11.80	12.30	12.80	12.00	11.60	0.41	0.21

35c	10.80	12.60	10.80	12.40	10.50	9.80	11.70	12.50	12.50	11.90	11.55	0.36	0.15
35d	10.50	12.20	10.60	12.30	10.20	9.50	11.60	12.10	12.60	11.70	11.33	0.14	0.09
64	10.40	11.90	10.40	12.10	9.90	9.10	11.10	12.30	12.40	11.40	11.10	-0.09	0.12
68	10.60	11.60	10.60	11.70	10.00	9.10	11.50	12.00	12.40	11.50	11.10	-0.09	0.19
75	10.49	11.93	10.57	12.08	10.09	9.35	11.33	12.06	12.43	11.49	11.18	-0.01	0.05
77a	10.69	11.73	10.94	12.02	10.35	9.90	11.42	11.68	12.11	11.52	11.24	0.04	0.33
80	10.03	11.79	10.32	11.88	9.74	8.96	11.29	12.03	11.99	11.37	10.94	-0.25	0.13
82	10.30	11.90	10.40	11.90	10.00	9.10	11.20	12.00	12.30	11.50	11.06	-0.13	0.07
84	10.20	11.70	10.40	11.70	9.70	9.20	11.40	11.80	12.20	11.30	10.96	-0.23	0.13
85	10.10	11.90	10.40	11.80	10.00	9.20	11.10	12.20	12.60	11.20	11.05	-0.14	0.17
88	10.10	11.90	10.20	12.20	10.10	9.30	11.30	12.10	12.30	11.30	11.08	-0.11	0.15
91	10.30	12.10	10.40	12.00	9.70	9.00	11.10	12.00	12.30	11.00	10.99	-0.20	0.17
94a	10.10	12.00	10.30	11.70	9.80	9.40	11.00	11.90	12.10	11.40	10.97	-0.22	0.17
94b	10.20	11.90	10.40	12.20	9.60	9.40	11.30	12.20	12.30	11.10	11.06	-0.13	0.19
97	10.00	12.00	10.80	12.30	10.30	9.40	11.60	12.20	13.30	11.60	11.35	0.16	0.33
98	10.80	12.00	10.60	12.10	10.00	9.20	11.50	12.20	12.30	11.60	11.23	0.04	0.14
Average	10.46	11.98	10.55	12.11	10.06	9.33	11.38	12.16	12.42	11.50	11.19	0.00	0.16
Std	0.25	0.27	0.18	0.22	0.25	0.24	0.20	0.18	0.25	0.24	0.16	0.16	0.06
Min	10.0	11.6	10.2	11.7	9.6	9.0	11.0	11.7	12.0	11.0	10.9	-0.3	0.0
Max	11.0	12.8	10.9	12.6	10.7	9.9	11.8	12.5	13.3	12.0	11.6	0.4	0.3

Table I.2 Protein content in barley samples by local NIR prediction models.

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	12.81	13.80	11.09	11.50	13.21	14.15	13.66	12.91	12.00	12.86	12.8	0.12	0.03
2	12.87	13.79	11.25	11.58	13.24	14.25	13.68	12.97	12.17	12.95	12.9	0.20	0.03
4a	12.90	14.02	11.10	11.54	13.43	14.48	13.92	13.02	12.11	13.03	13.0	0.28	0.12
4b	12.82	13.83	11.13	11.52	13.23	14.28	13.70	12.96	12.08	12.90	12.8	0.17	0.04
5	12.70	13.70	11.10	11.50	13.20	14.20	13.60	12.90	12.00	12.80	12.8	0.09	0.04
8a	12.70	13.70	11.10	11.50	13.20	14.05	13.60	12.80	12.00	12.80	12.7	0.07	0.04
8b	12.70	13.70	11.10	11.50	13.15	14.15	13.60	12.90	12.00	12.80	12.8	0.08	0.03
10	11.80	12.70	10.10	10.50	12.10	13.10	12.60	11.90	11.00	11.90	11.8	-0.91	0.04

11a	12.65	13.62	10.93	11.31	13.07	14.01	13.51	12.73	11.88	12.70	12.6	-0.04	0.03
11f	12.52	13.26	10.82	11.12	12.79	13.78	13.34	12.51	11.94	12.48	12.5	-0.22	0.10
12	12.70	13.70	11.00	11.40	13.20	14.10	13.60	12.80	12.00	12.80	12.7	0.05	0.04
15	12.80	13.70	11.20	11.50	13.20	14.20	13.60	12.90	12.10	12.90	12.8	0.13	0.04
17a	12.95	13.90	11.30	11.60	13.30	14.30	13.75	13.05	12.15	13.00	12.9	0.25	0.03
17b	12.70	13.60	11.00	11.30	13.10	14.00	13.50	12.75	11.90	12.70	12.7	-0.02	0.03
18	12.60	13.50	10.90	11.30	12.10	14.00	13.40	12.70	11.80	12.60	12.5	-0.19	0.28
19	12.93	13.89	11.26	11.60	13.36	14.31	13.83	13.03	12.08	13.00	12.9	0.25	0.04
25	12.60	13.50	10.90	11.30	13.00	13.90	13.40	12.70	11.80	12.60	12.6	-0.11	0.03
27a	12.61	13.56	10.97	11.28	13.01	13.92	13.42	12.69	11.80	12.64	12.6	-0.09	0.03
27b	12.59	13.53	11.01	11.31	12.93	13.91	13.35	12.66	11.86	12.63	12.6	-0.10	0.05
30a	12.40	13.30	10.60	11.10	12.80	13.70	13.20	12.50	11.60	12.40	12.4	-0.32	0.05
30b	12.30	13.30	10.60	11.00	12.80	13.80	13.30	12.50	11.60	12.50	12.4	-0.31	0.06
30c	12.49	13.52	10.94	11.30	12.97	13.92	13.45	12.70	11.84	12.67	12.6	-0.10	0.03
30d	12.45	13.39	10.93	11.27	12.92	13.85	13.34	12.66	11.77	12.61	12.5	-0.16	0.04
30e	12.09	13.11	10.60	10.96	12.60	13.58	13.14	12.33	11.44	12.32	12.2	-0.46	0.05
30f	12.15	13.15	10.64	10.96	12.63	13.65	13.15	12.38	11.47	12.39	12.3	-0.42	0.05
30h	12.26	13.26	10.72	11.03	12.72	13.70	13.18	12.45	11.59	12.44	12.3	-0.34	0.03
30i	12.09	13.05	10.61	10.94	12.57	13.56	13.03	12.36	11.50	12.30	12.2	-0.48	0.06
33	13.10	14.00	11.40	11.90	13.40	14.40	13.90	13.20	12.30	13.10	13.1	0.39	0.06
35a	12.80	13.70	11.10	11.40	13.10	14.10	13.60	12.90	12.00	12.90	12.8	0.08	0.04
35b	12.90	13.80	11.20	11.50	13.20	14.10	13.60	12.90	12.00	12.90	12.8	0.13	0.06
35c	12.80	13.70	11.10	11.50	13.10	14.10	13.60	12.90	12.00	12.90	12.8	0.09	0.04
35d	12.80	13.70	11.20	11.50	13.10	14.10	13.70	12.90	12.00	12.90	12.8	0.11	0.05
64	12.87	13.85	11.21	11.55	13.30	14.24	13.73	12.97	12.13	12.98	12.9	0.21	0.02
66	12.70	13.60	11.00	11.50	13.10	14.10	13.50	12.80	12.00	12.80	12.7	0.03	0.05
68	12.40	13.40	10.80	11.20	12.80	13.50	13.30	12.50	11.40	12.50	12.4	-0.30	0.13
73	12.85	13.80	11.20	11.50	13.20	14.20	13.70	13.00	12.10	12.95	12.9	0.17	0.03
75	12.67	13.61	11.03	11.37	14.28	14.04	13.52	12.76	11.87	12.78	12.8	0.12	0.38
77a	12.79	13.76	11.14	11.48	13.19	14.20	13.61	12.92	12.06	12.88	12.8	0.13	0.02
80	12.95	13.88	11.32	11.71	13.38	14.37	13.80	13.07	12.23	13.04	13.0	0.30	0.02

81	12.90	13.90	11.30	11.60	13.30	14.30	13.70	13.00	12.20	13.00	12.9	0.24	0.04
82	13.00	13.90	11.30	11.70	13.40	14.30	13.80	13.00	12.10	13.00	13.0	0.27	0.05
85	12.50	13.50	10.90	11.30	12.90	13.90	13.40	12.70	11.80	12.70	12.6	-0.12	0.04
88	12.70	13.70	11.10	11.50	13.10	14.10	13.70	12.90	12.10	12.80	12.8	0.09	0.05
91	13.00	13.90	11.30	11.60	13.40	14.30	13.80	13.00	12.20	13.00	13.0	0.27	0.04
94a	13.00	14.00	11.40	11.70	13.40	14.40	13.90	13.10	12.30	13.10	13.0	0.35	0.03
94b	12.60	13.60	10.90	11.30	13.10	14.10	13.50	12.70	11.90	12.70	12.6	-0.04	0.05
97	13.00	13.90	11.40	11.70	13.40	14.50	13.80	13.10	12.30	13.10	13.0	0.34	0.05
98	12.30	13.30	10.70	11.00	12.70	13.60	13.20	12.50	11.60	12.40	12.3	-0.35	0.04
Average	12.66	13.62	11.02	11.38	13.08	14.04	13.53	12.78	11.92	12.75	12.68	0.00	0.06
Std	0.28	0.28	0.26	0.26	0.35	0.29	0.26	0.25	0.27	0.25	0.26	0.26	0.06
Min	11.8	12.7	10.1	10.5	12.1	13.1	12.6	11.9	11.0	11.9	11.8	-0.9	0.0
Max	13.1	14.0	11.4	11.9	14.3	14.5	13.9	13.2	12.3	13.1	13.1	0.4	0.4

Table I.3 Moisture content in wheat samples by NIR prediction models

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	13.67	13.40	12.20	13.65	14.91	13.13	13.23	12.95	13.51	13.28	13.4	0.15	0.14
2	14.08	13.63	12.44	13.79	14.83	13.46	13.50	13.14	14.04	13.59	13.6	0.41	0.13
4a	13.81	13.07	12.36	13.72	14.79	13.26	13.33	13.00	13.71	13.32	13.4	0.20	0.07
4b	13.77	13.18	12.21	13.57	14.67	13.20	13.21	12.89	13.51	13.40	13.4	0.12	0.06
5	13.70	13.00	12.20	13.50	14.60	13.10	13.20	12.90	13.40	13.30	13.3	0.05	0.03
6	13.75	13.03	12.32	13.62	14.76	13.28	13.25	13.02	13.62	13.38	13.4	0.17	0.06
8a	13.65	13.05	12.10	13.50	14.60	13.20	13.20	12.90	13.30	13.25	13.3	0.04	0.07
8b	13.80	13.10	12.15	13.50	14.55	13.10	13.25	12.90	13.20	13.20	13.3	0.04	0.10
11a	13.64	12.96	12.15	13.54	14.63	13.15	13.15	12.85	13.29	13.21	13.3	0.02	0.07
11f	13.60	13.03	12.17	13.57	14.34	12.95	13.01	12.67	13.07	13.04	13.1	-0.09	0.14
12	13.70	12.90	12.20	13.50	14.60	13.10	13.20	12.90	13.50	13.20	13.3	0.04	0.05
15	13.70	13.00	12.10	13.40	14.50	13.00	13.10	12.80	13.40	13.20	13.2	-0.02	0.04
17a	13.85	13.05	12.35	13.50	14.55	13.20	13.25	13.00	13.70	13.35	13.4	0.14	0.08
18	13.60	13.00	12.10	13.50	14.50	13.10	13.10	12.80	13.30	13.40	13.2	0.00	0.08

19	13.76	13.32	12.31	13.72	14.70	13.36	13.28	13.00	13.74	13.33	13.5	0.21	0.09
25	13.60	12.90	12.10	13.40	14.40	13.00	13.10	12.70	13.30	13.10	13.2	-0.08	0.05
27a	13.49	12.86	12.04	13.39	14.52	13.02	13.10	12.80	13.29	13.10	13.2	-0.08	0.05
27b	13.70	12.87	12.07	13.37	14.43	13.05	13.12	12.83	13.62	13.13	13.2	-0.02	0.09
30a	13.70	13.00	12.20	13.60	14.50	13.10	13.10	12.90	13.40	13.20	13.3	0.03	0.05
30b	13.30	12.80	12.10	13.50	14.50	12.90	13.10	12.90	13.40	13.30	13.2	-0.06	0.13
30c	13.02	12.52	11.75	13.05	14.10	12.52	12.71	12.44	12.89	12.91	12.8	-0.45	0.09
30d	13.11	12.62	11.70	12.96	14.10	12.45	12.67	12.63	12.89	12.70	12.8	-0.46	0.10
30e	12.78	12.43	11.72	12.98	14.07	12.49	12.67	12.55	13.16	12.97	12.8	-0.46	0.18
30f	12.96	12.48	11.82	13.16	14.04	12.52	12.98	12.57	12.84	12.78	12.8	-0.42	0.16
30h	13.46	12.99	12.10	13.35	14.49	12.91	13.11	12.76	13.25	13.11	13.2	-0.09	0.07
30i	13.23	12.54	11.73	12.97	14.22	12.47	12.69	12.66	13.39	12.79	12.9	-0.37	0.16
30j	13.33	13.01	12.04	13.30	14.43	12.78	13.04	12.86	13.53	13.31	13.2	-0.08	0.14
32	13.60	12.90	12.00	13.40	14.40	12.90	13.00	12.70	13.20	13.10	13.1	-0.12	0.05
33	14.30	13.50	12.60	14.10	15.00	13.60	13.60	13.30	14.10	13.90	13.8	0.56	0.10
35a	13.70	12.90	12.00	13.40	14.40	12.90	13.00	12.90	13.50	13.10	13.2	-0.06	0.09
35b	14.00	13.40	12.40	13.50	14.70	13.30	13.40	13.10	13.70	13.40	13.5	0.25	0.11
35c	13.80	13.10	12.40	13.60	14.60	13.20	13.20	13.30	13.40	13.60	13.4	0.18	0.14
35d	13.90	13.20	12.50	13.70	14.70	13.30	13.40	13.20	13.70	13.40	13.5	0.26	0.06
64	13.72	13.00	12.17	13.51	14.58	13.08	13.21	12.89	13.32	13.31	13.3	0.04	0.05
68	12.70	12.40	11.50	12.70	13.70	12.50	12.60	12.30	12.90	12.60	12.6	-0.65	0.14
75	13.34	12.70	11.91	13.16	14.19	12.79	12.88	12.55	13.13	12.89	13.0	-0.28	0.03
77a	13.49	12.90	12.08	13.52	14.50	13.02	13.08	12.81	13.45	13.15	13.2	-0.04	0.06
80	13.99	13.19	12.38	13.67	14.79	13.36	13.37	13.12	13.77	13.46	13.5	0.27	0.05
82	13.90	13.10	12.30	13.70	14.80	13.30	13.30	13.00	13.60	13.40	13.4	0.20	0.05
84	13.70	12.90	12.10	13.30	14.40	13.00	13.00	12.80	13.40	13.10	13.2	-0.07	0.07
85	13.60	12.80	12.00	13.50	14.50	12.90	13.00	12.70	13.30	13.10	13.1	-0.10	0.07
88	13.60	12.70	12.00	13.40	14.40	13.20	13.10	13.00	13.10	13.00	13.2	-0.09	0.15
91	13.90	13.20	12.40	14.00	14.90	13.60	13.50	13.20	13.70	13.70	13.6	0.37	0.12
94a	13.90	13.20	12.30	13.70	14.70	13.30	13.30	13.20	13.50	13.40	13.5	0.21	0.07
94b	13.90	13.10	12.00	13.60	14.60	13.10	13.20	12.80	13.80	13.10	13.3	0.08	0.16

97	14.10	13.30	12.30	13.60	14.80	13.30	13.40	13.10	13.70	13.50	13.5	0.27	0.09
98	13.90	12.50	11.80	13.20	14.30	12.80	12.80	12.50	13.00	12.80	13.0	-0.28	0.21
Average	13.63	12.97	12.12	13.47	14.52	13.05	13.13	12.87	13.42	13.21	13.24	0.00	0.09
Std	0.33	0.28	0.23	0.26	0.26	0.28	0.23	0.22	0.29	0.26	0.25	0.25	0.04
Min	12.7	12.4	11.5	12.7	13.7	12.5	12.6	12.3	12.8	12.6	12.6	-0.6	0.0
Max	14.3	13.6	12.6	14.1	15.0	13.6	13.6	13.3	14.1	13.9	13.8	0.6	0.2

Table I.4 Moisture content in barley samples by local NIR prediction models.

II. Annex: Protein and Moisture content in Wheat & Barley by NIR prediction model WB003034

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	13.19	14.90	12.57	12.32	12.99	13.10	12.27	13.64	12.42	12.69	13.01	0.04	0.08
2	13.19	14.98	12.52	12.41	12.95	13.14	12.20	13.62	12.48	12.66	13.02	0.04	0.05
4a	13.08	14.84	12.34	12.53	12.90	13.06	12.22	13.56	12.19	12.47	12.92	-0.06	0.14
4b	13.11	14.90	12.53	12.27	12.89	13.14	12.18	13.52	12.44	12.58	12.96	-0.02	0.08
5	13.18	15.11	12.40	12.36	13.00	13.07	12.07	13.57	12.43	12.69	12.99	0.01	0.06
8a	13.18	15.23	12.57	12.35	13.02	13.39	12.30	13.68	12.42	12.65	13.08	0.10	0.10
8b	13.14	14.98	12.45	12.32	12.90	13.04	11.92	13.54	12.44	12.59	12.93	-0.04	0.05
10	13.25	14.97	12.64	12.54	12.99	13.04	11.99	13.65	12.51	12.60	13.02	0.04	0.10
11a	13.18	15.08	12.46	12.39	12.89	13.20	12.10	13.66	12.55	12.61	13.01	0.04	0.05
11b	13.16	15.03	12.44	12.29	12.87	13.19	12.15	13.57	12.40	12.66	12.98	0.00	0.06
11d	13.13	14.99	12.50	12.28	12.93	13.14	12.03	13.56	12.47	12.62	12.97	-0.01	0.04
11e	13.09	15.08	12.47	12.21	12.87	13.00	12.04	13.59	12.36	12.62	12.93	-0.04	0.05
12	13.13	14.92	12.31	12.35	12.94	13.09	11.97	13.73	12.53	12.69	12.97	-0.01	0.09
15	13.25	14.95	12.69	12.52	12.95	13.09	11.97	13.67	12.39	12.67	13.01	0.04	0.10
17	13.12	14.96	12.52	12.36	12.99	13.04	11.99	13.64	12.31	12.60	12.95	-0.02	0.05
18	12.96	15.02	12.56	12.15	12.93	13.20	11.97	13.66	12.55	12.64	12.96	-0.01	0.11
19	13.10	15.00	12.56	12.44	12.99	13.19	12.15	13.70	12.55	12.65	13.03	0.06	0.05
25	13.02	15.06	12.30	12.28	12.85	13.15	12.03	13.50	12.38	12.64	12.92	-0.06	0.08
27a	13.22	15.20	12.63	12.44	12.95	13.44	11.94	13.83	12.63	12.66	13.09	0.12	0.13
27b	13.29	15.10	12.54	12.45	12.93	13.09	12.07	13.84	12.53	12.75	13.06	0.08	0.07
30a	13.27	15.11	12.46	12.41	12.91	13.20	12.05	13.64	12.41	12.71	13.02	0.04	0.06
30b	13.16	15.10	12.43	12.33	12.98	12.88	12.07	13.56	12.40	12.72	12.96	-0.01	0.09
30c	13.06	15.04	12.34	12.33	12.92	13.04	12.02	13.56	12.28	12.63	12.92	-0.05	0.05
30d	13.05	14.97	12.33	12.43	12.87	12.96	12.05	13.65	12.36	12.59	12.93	-0.05	0.07
30e	13.17	15.05	12.55	12.27	12.98	13.05	12.10	13.67	12.56	12.64	13.00	0.03	0.06
30f	13.18	14.86	12.43	12.42	12.91	13.16	12.01	13.66	12.42	12.64	12.97	-0.01	0.07
30h	13.24	15.08	12.43	12.16	12.88	13.13	12.07	13.75	12.55	12.60	12.99	0.01	0.10
30i	13.19	15.10	12.54	12.32	12.98	13.01	12.20	13.56	12.29	12.63	12.98	0.01	0.08

33	13.11	14.99	12.47	12.42	12.98	13.08	12.08	13.54	12.23	12.68	12.96	-0.02	0.08
35a	13.03	14.96	12.32	12.22	13.02	12.98	12.08	13.63	12.38	12.61	12.92	-0.05	0.07
35b	13.09	15.02	12.45	12.31	12.88	13.05	12.06	13.61	12.55	12.66	12.97	-0.01	0.05
35c	13.10	15.03	12.57	12.29	13.10	13.19	12.15	13.69	12.47	12.64	13.02	0.05	0.07
35d	13.58	15.08	12.50	12.34	13.07	13.20	12.10	13.65	12.40	12.63	13.06	0.08	0.14
64	13.05	15.04	12.49	12.35	12.94	13.09	12.04	13.65	12.43	12.65	12.97	0.00	0.03
66	13.13	15.05	12.47	12.24	12.97	13.09	12.09	13.67	12.36	12.61	12.97	-0.01	0.04
68	13.07	14.74	12.43	12.34	12.83	12.97	11.99	13.71	12.15	12.65	12.89	-0.09	0.11
75	13.11	14.99	12.46	12.36	12.91	13.02	12.08	13.64	12.44	12.55	12.95	-0.02	0.04
77a	13.12	14.91	12.48	12.28	13.01	13.01	12.10	13.69	12.26	12.72	12.96	-0.02	0.08
80	13.04	15.12	12.43	12.27	12.98	12.98	11.95	13.69	12.22	12.51	12.92	-0.06	0.09
81	13.09	14.97	12.41	12.28	12.92	13.07	12.05	13.61	12.40	12.49	12.93	-0.05	0.04
82	13.09	14.97	12.46	12.40	12.84	13.15	12.04	13.58	12.38	12.64	12.96	-0.02	0.05
88	13.06	15.15	12.42	12.37	12.91	13.10	12.05	13.68	12.47	12.77	13.00	0.02	0.07
91	13.07	14.96	12.46	12.39	12.77	13.00	12.03	13.54	12.33	12.62	12.92	-0.06	0.06
94a	13.24	15.03	12.41	12.17	12.70	12.99	12.12	13.62	12.47	12.60	12.94	-0.04	0.10
94b	13.17	15.08	12.51	12.38	13.07	13.05	11.98	13.66	12.59	12.60	13.01	0.03	0.08
98	13.06	15.09	12.50	12.35	12.84	13.07	12.01	13.60	12.31	12.72	12.96	-0.02	0.07
Average	13.14	15.02	12.47	12.34	12.93	13.09	12.07	13.64	12.41	12.64	12.98	0.00	0.07
Std	0.10	0.09	0.09	0.09	0.08	0.10	0.08	0.07	0.11	0.06	0.05	0.05	0.03
Min	13.0	14.7	12.3	12.1	12.7	12.9	11.9	13.5	12.2	12.5	12.9	-0.1	0.0
Max	13.6	15.2	12.7	12.5	13.1	13.4	12.3	13.8	12.6	12.8	13.1	0.1	0.1

Table II.1 Protein content in **Wheat** samples by using the ANN model WB003034.

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	10.49	12.43	10.48	12.02	9.82	9.35	11.40	12.13	12.35	11.45	11.2	0.09	0.19
2	10.71	12.03	10.62	12.12	9.91	9.29	11.32	12.09	12.43	11.53	11.2	0.10	0.09
4a	10.65	11.86	10.47	11.96	9.85	9.18	11.06	12.06	12.23	11.47	11.1	-0.03	0.09
4b	10.48	11.68	10.52	12.03	9.89	9.08	11.46	12.12	12.48	11.36	11.1	0.01	0.13
5	10.60	11.64	10.42	11.90	9.91	9.18	11.21	12.12	12.27	11.43	11.1	-0.04	0.08
6	10.46	12.01	10.50	11.73	9.92	9.12	11.28	12.31	12.26	11.50	11.1	0.00	0.13
8a	10.55	11.86	10.55	12.08	9.92	9.06	11.22	12.19	12.11	11.33	11.1	-0.02	0.10
8b	10.52	11.71	10.39	11.91	9.73	9.22	11.26	12.09	12.06	11.58	11.0	-0.06	0.11
11a	10.94	11.78	10.67	12.23	10.14	9.04	11.37	12.28	12.39	11.45	11.2	0.12	0.17
11b	10.51	11.82	10.50	11.95	9.92	9.29	11.32	12.11	12.40	11.40	11.1	0.02	0.06
11d	10.53	11.93	10.51	12.05	9.92	9.34	11.36	12.08	12.41	11.50	11.2	0.06	0.06
11e	10.27	11.85	10.47	11.98	10.02	9.22	11.23	12.11	12.47	11.36	11.1	-0.01	0.11
12	10.18	11.84	10.41	11.86	9.83	9.13	11.30	12.09	12.28	11.30	11.0	-0.08	0.10
15	10.60	12.14	10.57	11.93	9.98	9.34	11.18	12.09	12.10	11.50	11.1	0.04	0.13
17	10.30	11.78	10.45	11.96	9.84	9.18	11.14	12.17	12.27	11.30	11.0	-0.07	0.07
18	10.68	11.93	10.31	12.01	9.96	9.09	11.17	12.20	12.29	11.45	11.1	0.00	0.10
19	10.55	12.05	10.52	12.15	10.05	9.20	11.42	12.16	12.53	11.37	11.2	0.09	0.10
25	10.40	11.79	10.48	11.93	9.95	9.19	11.10	12.09	12.20	11.41	11.1	-0.05	0.05
27a	10.36	12.27	10.55	11.99	10.29	9.59	11.51	12.35	12.38	11.48	11.3	0.17	0.18
27b	10.76	11.98	10.62	12.23	10.20	9.58	11.47	12.26	12.29	11.56	11.3	0.19	0.10
30a	10.37	10.93	10.95	12.05	10.03	9.10	11.29	12.16	12.30	11.52	11.1	-0.04	0.35
30b	10.59	11.73	10.34	12.20	9.83	9.05	11.18	12.18	12.30	10.95	11.0	-0.07	0.19
30c	10.50	11.72	10.44	12.01	10.12	9.12	11.45	12.10	12.07	11.53	11.1	0.00	0.12
30d	10.54	12.05	10.33	11.91	10.00	9.17	11.38	12.10	12.18	11.64	11.1	0.03	0.11
30e	10.10	11.68	10.25	12.01	10.31	9.47	11.29	11.95	12.66	11.83	11.2	0.05	0.29
30f	10.40	11.72	10.33	12.09	10.05	9.06	11.25	11.68	12.01	11.52	11.0	-0.09	0.17
30h	10.51	12.21	10.45	12.19	10.00	9.26	11.35	12.16	12.01	11.40	11.2	0.05	0.16

30i	10.79	11.82	10.64	12.16	9.96	9.43	11.32	11.87	12.19	11.51	11.2	0.06	0.16
30j	10.44	11.96	10.39	12.20	10.03	9.24	11.11	11.92	12.37	11.41	11.1	0.00	0.13
32	10.58	11.99	10.40	12.19	9.95	9.25	11.44	12.26	12.30	11.36	11.2	0.07	0.10
33	10.93	11.72	10.59	11.96	9.85	9.28	11.18	12.25	12.26	11.24	11.1	0.02	0.18
35a	10.15	11.65	10.42	11.70	9.94	9.11	10.94	12.22	12.09	11.46	11.0	-0.14	0.15
35b	10.44	12.13	10.45	12.05	10.21	9.01	11.34	11.97	12.32	11.66	11.2	0.05	0.16
35c	10.56	12.03	10.38	11.90	10.09	9.27	11.17	12.10	12.03	11.49	11.1	0.00	0.13
35d	10.49	11.86	10.42	12.02	9.98	9.30	11.32	12.04	12.35	11.55	11.1	0.03	0.06
64	10.55	11.91	10.37	11.94	9.95	9.10	11.14	12.37	12.40	11.53	11.1	0.02	0.12
68	10.66	11.55	10.50	11.60	9.87	8.91	11.24	11.97	12.36	11.33	11.0	-0.11	0.18
75	10.51	11.81	10.50	11.96	9.99	9.24	11.22	12.02	12.27	11.43	11.1	-0.01	0.04
77a	9.90	11.97	10.33	11.90	10.02	9.19	11.14	12.09	11.90	11.32	11.0	-0.13	0.21
80	10.36	11.85	10.44	11.86	9.87	9.10	11.35	12.17	12.10	11.48	11.1	-0.05	0.09
82	10.36	11.80	10.41	11.82	9.98	9.07	11.15	12.07	12.34	11.40	11.0	-0.06	0.08
84	10.42	11.72	10.43	11.75	9.67	9.23	11.39	11.88	12.26	11.38	11.0	-0.09	0.13
85	10.27	11.85	10.47	11.77	10.01	9.23	11.03	12.18	12.60	11.29	11.1	-0.04	0.18
88	10.30	11.95	10.41	12.10	9.84	9.13	11.13	12.15	12.34	11.20	11.1	-0.05	0.13
91	10.52	12.07	10.48	12.00	9.80	9.05	11.14	12.06	12.32	11.14	11.1	-0.05	0.14
94a	10.50	12.11	10.56	11.89	9.90	9.44	11.12	12.12	12.26	11.53	11.1	0.04	0.13
94b	10.54	10.99	10.44	12.26	9.76	9.33	11.40	12.19	12.38	11.24	11.1	-0.05	0.32
98	10.67	11.84	10.48	11.97	9.79	9.07	11.36	12.24	11.50	12.11	11.1	0.00	0.35
Average	10.49	11.85	10.47	11.99	9.95	9.21	11.26	12.12	12.26	11.44	11.10	0.00	0.14
Std	0.19	0.26	0.11	0.15	0.13	0.14	0.13	0.13	0.19	0.17	0.07	0.07	0.07
Min	9.9	10.9	10.2	11.6	9.7	8.9	10.9	11.7	11.5	11.0	11.0	-0.1	0.0
Max	10.9	12.4	10.9	12.3	10.3	9.6	11.5	12.4	12.7	12.1	11.3	0.2	0.4

Table II.2 Protein content in **Barley** samples by using the ANN model WB003034.

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	12.60	13.59	10.88	11.30	13.01	13.95	13.46	12.69	11.82	12.65	12.6	-0.03	0.02
2	12.74	13.64	11.05	11.42	13.10	14.07	13.54	12.82	12.00	12.78	12.7	0.09	0.02
4a	12.61	13.63	10.93	11.31	13.10	14.02	13.53	12.72	11.85	12.71	12.6	0.02	0.04
4b	12.62	13.59	10.96	11.37	13.03	14.00	13.48	12.74	11.89	12.68	12.6	0.01	0.01
5	12.58	13.57	10.93	11.29	13.01	13.96	13.42	12.69	11.85	12.65	12.6	-0.03	0.02
8a	12.63	13.62	10.94	11.33	13.05	13.97	13.48	12.72	11.86	12.69	12.6	0.01	0.02
8b	12.67	13.63	11.00	11.41	13.07	14.05	13.51	12.78	11.92	12.75	12.7	0.06	0.02
10	12.75	13.67	11.04	11.44	13.18	14.10	13.60	12.85	12.01	12.82	12.7	0.12	0.02
11a	12.65	13.62	10.93	11.31	13.07	14.01	13.51	12.73	11.88	12.70	12.6	0.02	0.02
11b	12.61	13.60	10.89	11.29	13.04	13.98	13.49	12.71	11.85	12.67	12.6	-0.01	0.03
11d	12.54	13.47	10.91	11.28	12.97	13.90	13.39	12.66	11.79	12.59	12.6	-0.07	0.02
11e	12.54	13.46	10.89	11.25	12.94	13.87	13.35	12.65	11.75	12.57	12.5	-0.10	0.02
12	12.73	13.71	11.03	11.40	13.12	14.09	13.63	12.77	11.95	12.76	12.7	0.09	0.04
15	12.70	13.62	11.05	11.41	13.11	14.04	13.52	12.81	11.96	12.76	12.7	0.08	0.02
17	12.72	13.66	11.02	11.39	13.12	14.08	13.54	12.81	11.94	12.77	12.7	0.08	0.02
18	12.59	13.55	10.94	11.32	12.67	13.97	13.44	12.71	11.87	12.66	12.6	-0.05	0.11
19	12.63	13.59	10.93	11.30	13.06	14.00	13.52	12.72	11.76	12.69	12.6	0.00	0.04
25	12.60	13.57	10.91	11.30	13.05	13.96	13.48	12.71	11.87	12.64	12.6	-0.02	0.02
27a	12.63	13.60	10.97	11.29	12.99	13.93	13.42	12.70	11.83	12.64	12.6	-0.02	0.03
27b	12.63	13.54	11.01	11.33	12.95	13.91	13.35	12.68	11.89	12.63	12.6	-0.03	0.05
30a	12.68	13.62	10.97	11.36	13.07	14.04	13.55	12.78	11.86	12.74	12.7	0.04	0.02
30b	12.61	13.64	11.01	11.36	13.11	14.08	13.58	12.80	11.92	12.79	12.7	0.06	0.04
30c	12.52	13.54	10.96	11.33	13.02	13.94	13.47	12.74	11.87	12.70	12.6	-0.02	0.04
30d	12.59	13.52	11.04	11.38	13.04	13.96	13.47	12.79	11.90	12.73	12.6	0.02	0.04
30e	12.48	13.46	10.92	11.27	13.00	13.91	13.49	12.68	11.78	12.65	12.6	-0.06	0.04
30f	12.50	13.48	10.93	11.28	12.98	13.92	13.47	12.71	11.79	12.68	12.6	-0.05	0.04
30h	12.49	13.48	10.90	11.25	12.94	13.90	13.40	12.68	11.80	12.65	12.5	-0.08	0.03
30i	12.53	13.48	11.00	11.35	13.03	13.94	13.47	12.76	11.91	12.70	12.6	-0.01	0.05
33	12.71	13.64	10.99	11.45	13.05	14.04	13.55	12.77	11.92	12.74	12.7	0.06	0.03

35a	12.58	13.49	10.88	11.20	12.93	13.86	13.40	12.65	11.78	12.65	12.5	-0.08	0.03
35b	12.60	13.54	10.93	11.28	12.98	13.90	13.43	12.70	11.83	12.67	12.6	-0.04	0.02
35c	12.54	13.45	10.88	11.24	12.90	13.86	13.35	12.63	11.76	12.62	12.5	-0.10	0.02
35d	12.81	13.48	10.89	11.25	12.95	13.92	13.42	12.67	11.82	12.62	12.6	-0.04	0.08
64	12.66	13.64	10.97	11.33	13.09	13.99	13.49	12.75	11.89	12.74	12.7	0.03	0.02
66	12.70	13.64	11.04	11.44	13.12	14.07	13.51	12.81	11.95	12.77	12.7	0.08	0.02
68	12.44	13.41	10.80	11.18	12.83	13.56	13.33	12.53	11.50	12.49	12.4	-0.22	0.09
75	12.63	13.51	10.98	11.35	13.04	14.01	13.45	12.69	11.77	12.75	12.6	-0.01	0.05
77a	12.64	13.60	10.95	11.31	13.02	14.02	13.46	12.76	11.91	12.72	12.6	0.02	0.02
80	12.66	13.58	10.98	11.39	13.08	14.04	13.49	12.75	11.91	12.71	12.7	0.03	0.02
81	12.63	13.58	10.95	11.35	13.05	14.00	13.47	12.73	11.87	12.69	12.6	0.01	0.01
82	12.73	13.64	11.01	11.43	13.09	14.05	13.55	12.77	11.89	12.73	12.7	0.07	0.03
88	12.54	13.47	10.86	11.27	12.97	13.89	13.37	12.65	11.79	12.62	12.5	-0.08	0.01
91	12.70	13.63	10.98	11.35	13.11	14.03	13.48	12.76	11.90	12.75	12.7	0.04	0.03
94a	12.64	13.61	10.97	11.34	13.08	14.05	13.51	12.77	11.93	12.72	12.7	0.04	0.02
94b	12.70	13.69	10.95	11.34	13.05	14.10	13.55	12.76	11.91	12.73	12.7	0.05	0.04
98	12.61	13.57	10.97	11.35	13.04	13.91	13.50	12.74	11.88	12.69	12.6	0.00	0.03
Average	12.62	13.57	10.96	11.33	13.03	13.98	13.48	12.73	11.86	12.69	12.62	0.00	0.03
Std	0.08	0.07	0.06	0.06	0.09	0.09	0.07	0.06	0.08	0.06	0.06	0.06	0.02
Min	12.4	13.4	10.8	11.2	12.7	13.6	13.3	12.5	11.5	12.5	12.4	-0.2	0.0
Max	12.8	13.7	11.1	11.5	13.2	14.1	13.6	12.9	12.0	12.8	12.7	0.1	0.1

Table II.3 Moisture content in **Wheat** samples by using the ANN model WB003034.

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	13.58	13.04	12.08	13.55	14.60	13.02	13.13	12.80	13.24	13.18	13.2	0.03	0.06
2	13.76	13.08	12.17	13.57	14.58	13.19	13.21	12.88	13.58	13.25	13.3	0.14	0.08
4a	13.59	12.85	12.13	13.54	14.58	13.09	13.13	12.77	13.38	13.12	13.2	0.03	0.05
4b	13.66	12.92	12.13	13.52	14.57	13.11	13.14	12.80	13.35	13.22	13.2	0.05	0.04
5	13.59	12.87	12.11	13.49	14.52	13.04	13.11	12.83	13.23	13.14	13.2	0.00	0.03
6	13.56	12.86	12.15	13.47	14.56	13.14	13.14	12.84	13.37	13.22	13.2	0.04	0.04
8a	13.61	12.94	12.11	13.52	14.57	13.13	13.19	12.84	13.26	13.20	13.2	0.05	0.04
8b	13.75	13.06	12.19	13.53	14.61	13.12	13.28	12.88	13.40	13.24	13.3	0.11	0.05
11a	13.64	12.96	12.15	13.54	14.63	13.15	13.15	12.85	13.29	13.21	13.3	0.06	0.04
11b	13.61	12.93	12.08	13.48	14.58	13.10	13.15	12.82	13.28	13.18	13.2	0.03	0.04
11d	13.55	12.86	12.04	13.40	14.43	12.97	13.03	12.79	13.14	13.02	13.1	-0.07	0.04
11e	13.51	12.86	12.05	13.35	14.42	12.91	13.03	12.68	13.12	13.00	13.1	-0.10	0.05
12	13.63	12.92	12.18	13.52	14.63	13.12	13.21	12.94	13.43	13.16	13.3	0.08	0.04
15	13.74	13.04	12.22	13.52	14.58	13.14	13.20	12.90	13.45	13.24	13.3	0.11	0.04
17	13.64	12.90	12.19	13.48	14.55	13.14	13.20	12.83	13.35	13.26	13.3	0.06	0.04
18	13.67	13.00	12.12	13.51	14.53	13.08	13.15	12.82	13.26	13.17	13.2	0.04	0.05
19	13.57	12.98	12.11	13.54	14.54	13.08	13.12	12.81	13.40	13.11	13.2	0.03	0.04
25	13.62	12.89	12.08	13.51	14.54	13.08	13.10	12.78	13.29	13.13	13.2	0.01	0.04
27a	13.45	12.86	12.07	13.38	14.55	13.05	13.12	12.79	13.31	13.09	13.2	-0.03	0.04
27b	13.61	12.82	12.09	13.35	14.44	13.07	13.09	12.81	13.41	13.12	13.2	-0.01	0.07
30a	13.64	12.43	12.43	13.58	14.51	13.10	13.11	12.85	13.31	13.16	13.2	0.02	0.20
30b	13.39	12.94	12.16	13.55	14.63	12.94	13.14	12.82	13.32	13.31	13.2	0.03	0.09
30c	13.38	12.94	12.17	13.49	14.56	12.87	13.13	12.82	13.31	13.23	13.2	0.00	0.09
30d	13.45	12.96	12.13	13.41	14.51	12.87	13.09	12.97	13.24	13.13	13.2	-0.02	0.08
30e	13.13	12.76	12.07	13.35	14.48	12.81	13.01	12.80	13.13	13.22	13.1	-0.12	0.13
30f	13.21	12.76	12.08	13.45	14.40	12.87	13.02	12.74	13.15	13.07	13.1	-0.12	0.09
30h	13.37	12.97	12.10	13.40	14.53	12.91	13.13	12.78	13.25	13.12	13.2	-0.04	0.07
30i	13.53	12.95	12.15	13.41	14.54	12.86	13.08	12.88	13.47	13.11	13.2	0.00	0.09

30j	13.31	13.02	12.11	13.38	14.51	12.83	13.12	12.90	13.28	13.05	13.2	-0.04	0.11
32	13.60	12.96	12.10	13.47	14.48	13.03	13.09	12.79	13.30	13.16	13.2	0.01	0.03
33	13.43	12.98	12.17	13.64	14.58	13.14	13.18	12.82	13.38	13.18	13.2	0.06	0.08
35a	13.51	12.71	11.91	13.32	14.35	12.81	12.98	12.73	13.15	13.02	13.0	-0.14	0.06
35b	13.52	12.84	12.00	13.27	14.44	12.87	13.04	12.76	13.18	13.01	13.1	-0.10	0.05
35c	13.43	12.73	11.98	13.20	14.38	12.85	12.94	12.71	13.20	13.00	13.0	-0.15	0.05
35d	13.51	12.86	12.04	13.34	14.46	12.98	13.05	12.78	13.23	13.08	13.1	-0.06	0.02
64	13.67	13.02	12.14	13.56	14.61	13.11	13.19	12.88	13.29	13.18	13.3	0.07	0.04
68	12.98	12.61	11.82	13.02	14.05	12.77	12.88	12.58	13.05	12.89	12.9	-0.33	0.12
75	13.53	12.89	12.14	13.43	14.49	13.04	13.13	12.77	13.28	13.09	13.2	-0.01	0.03
77a	13.53	12.98	12.15	13.60	14.60	13.08	13.15	12.86	13.43	13.21	13.3	0.07	0.05
80	13.68	12.96	12.14	13.48	14.57	13.14	13.15	12.87	13.41	13.19	13.3	0.07	0.04
82	13.55	12.88	12.11	13.48	14.57	13.09	13.12	12.79	13.30	13.15	13.2	0.01	0.03
84	13.55	12.86	12.13	13.37	14.41	13.04	13.08	12.84	13.32	13.13	13.2	-0.02	0.05
85	13.46	12.78	12.00	13.40	14.43	12.97	12.97	12.67	13.25	13.07	13.1	-0.09	0.04
88	13.46	12.78	12.06	13.38	14.34	12.98	13.04	12.69	13.06	13.05	13.1	-0.11	0.06
91	13.67	12.96	12.15	13.64	14.62	13.15	13.17	12.86	13.36	13.28	13.3	0.10	0.05
94a	13.69	13.03	12.13	13.58	14.57	13.14	13.15	12.88	13.27	13.22	13.3	0.07	0.06
94b	13.84	13.09	12.18	13.67	14.66	13.17	13.24	12.87	13.47	13.17	13.3	0.14	0.08
98	13.73	12.90	12.12	13.53	14.55	13.11	13.08	13.30	13.15	12.80	13.2	0.03	0.21
Average	13.54	12.90	12.11	13.46	14.52	13.03	13.11	12.82	13.29	13.14	13.19	0.00	0.06
Std	0.16	0.12	0.09	0.12	0.10	0.12	0.08	0.10	0.11	0.10	0.09	0.09	0.04
Min	13.0	12.4	11.8	13.0	14.1	12.8	12.9	12.6	13.1	12.8	12.9	-0.3	0.0
Max	13.8	13.1	12.4	13.7	14.7	13.2	13.3	13.3	13.6	13.3	13.3	0.1	0.2

Table II.4 Moisture content in **Barley** samples by using the ANN model WB003034.

III. Annex: Oil and Moisture content in Rapeseed by local NIR prediction models

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	46.60	48.80	49.70	48.30	47.90	48.90	49.00	42.40	47.30	47.20	47.6	0.45	0.75
2	45.64	49.15	47.05	48.02	48.14	48.76	49.91	41.90	46.15	46.56	47.1	-0.03	0.32
4a	47.06	49.24	48.82	49.08	48.82	49.02	49.80	45.50	47.75	47.54	48.3	1.11	0.97
4b	47.40	49.50	47.80	48.80	48.80	49.20	50.20	45.30	47.50	47.30	48.2	1.02	0.94
5	47.60	50.90	50.00	50.00	50.10	50.20	50.90	43.00	47.80	48.00	48.9	1.69	0.32
6	44.94	49.76	48.20	48.74	48.63	48.92	49.69	41.40	45.81	46.60	47.3	0.11	0.50
8a	45.80	49.30	47.70	48.60	48.65	49.30	50.20	42.10	46.30	46.85	47.5	0.32	0.28
8b	46.60	49.00	48.60	48.40	48.70	48.90	49.55	42.85	46.70	46.95	47.6	0.47	0.33
11	46.54	49.30	48.11	48.71	48.89	48.58	50.03	42.34	46.73	46.92	47.6	0.46	0.23
12	46.40	50.00	47.60	49.10	49.40	49.40	50.50	42.20	46.60	47.10	47.8	0.67	0.40
15a	46.83	50.43	49.31	49.38	49.04	49.20	50.35	42.37	47.13	47.53	48.2	1.00	0.35
15b	46.93	50.11	49.30	49.25	49.03	49.41	50.59	42.22	47.10	47.74	48.2	1.01	0.36
17a	45.95	49.85	46.90	48.40	48.50	48.35	50.15	42.20	46.65	46.20	47.3	0.16	0.51
17b	46.25	49.40	48.60	48.45	48.55	48.90	50.10	43.00	46.30	46.70	47.6	0.47	0.33
18	45.50	48.60	47.10	48.00	48.00	48.50	48.90	41.70	45.70	45.80	46.8	-0.38	0.19
19	46.40	49.60	47.80	48.65	48.70	49.40	50.10	42.70	47.25	47.30	47.8	0.63	0.28
25	46.40	49.10	49.30	48.50	48.10	48.00	49.60	41.80	47.20	46.70	47.5	0.31	0.63
27a	45.32	49.44	47.75	49.14	48.73	49.02	49.91	41.50	46.33	47.27	47.4	0.28	0.45
27b	41.85	45.36	44.22	44.74	44.72	44.71	45.41	38.19	42.07	42.17	43.3	-3.81	0.27
30a	43.80	47.60	44.20	46.30	46.30	46.60	47.90	39.60	44.40	44.40	45.1	-2.05	0.59
30e	43.70	46.70	45.60	45.70	46.30	45.30	47.70	39.10	43.90	43.50	44.8	-2.41	0.51
30f	43.66	47.40	45.34	45.66	46.83	46.52	46.80	39.15	44.05	44.31	45.0	-2.18	0.42
31	44.80	50.10	49.00	48.70	48.80	49.70	50.90	39.80	45.80	47.60	47.5	0.36	1.17
33	44.30	49.60	49.40	48.70	49.40	49.50	50.10	39.30	45.50	47.50	47.3	0.17	1.34
35a	45.90	48.30	49.30	47.90	47.10	48.20	49.30	42.50	46.10	47.00	47.2	0.00	0.78
35b	46.60	48.20	49.50	48.30	47.60	49.00	49.10	42.70	46.70	47.00	47.5	0.31	0.78

35c	46.00	48.60	49.40	48.40	47.70	48.70	48.90	42.60	46.50	46.80	47.4	0.20	0.66
35d	45.80	48.70	49.20	48.00	47.40	48.30	39.30	42.70	46.20	46.60	46.2	-0.94	3.26
35e	45.22	49.23	47.02	48.60	49.02	49.32	50.65	41.75	45.62	46.65	47.3	0.15	0.65
35f	44.46	48.35	46.75	47.30	48.44	47.94	49.77	41.02	45.04	45.18	46.4	-0.73	0.58
64	46.00	49.00	48.40	48.30	48.80	48.80	50.30	42.30	46.40	46.70	47.5	0.34	0.30
68	45.91	49.52	47.70	48.07	48.71	48.98	49.73	41.78	45.86	46.45	47.3	0.11	0.30
80	45.90	45.49	41.08	49.91	48.73	48.09	48.14	46.87	48.97	44.89	46.8	-0.35	3.24
82	46.40	49.80	47.60	48.70	48.70	49.20	50.50	43.20	46.70	47.20	47.8	0.64	0.39
85	44.67	48.48	46.41	46.96	47.39	47.83	49.02	40.22	45.11	45.65	46.2	-0.98	0.41
88	45.20	49.10	47.30	48.00	48.60	48.70	49.90	39.00	46.10	46.40	46.8	-0.33	0.97
91	45.40	50.00	47.10	48.80	48.50	49.40	50.40	42.10	46.00	47.00	47.5	0.31	0.57
94a	46.20	49.30	48.20	48.70	48.40	48.80	50.00	41.80	46.00	47.00	47.4	0.28	0.29
94b	47.00	50.30	48.60	49.10	49.80	50.00	50.30	42.50	46.90	47.00	48.2	0.99	0.35
98	45.32	49.52	47.60	48.50	48.50	48.54	49.84	42.61	46.18	45.85	47.2	0.09	0.42
Average	45.7	49.0	47.7	48.3	48.3	48.6	49.3	41.9	46.2	46.5	47.2	0.0	0.7
Std	1.16	1.17	1.76	1.08	1.01	1.12	1.97	1.73	1.20	1.20	1.05	1.05	0.66
Min	41.9	45.4	41.1	44.7	44.7	44.7	39.3	38.2	42.1	42.2	43.3	-3.8	0.2
Max	47.6	50.9	50.0	50.0	50.1	50.2	50.9	46.9	49.0	48.0	48.9	1.7	3.3

Table 6.1.3.1 Oil content in rapeseed samples by local NIR prediction models

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	7.05	5.96	7.38	6.87	6.50	6.80	6.29	7.73	6.90	7.24	6.9	-0.20	0.25
2	7.38	6.46	6.77	7.19	7.08	7.41	6.69	7.73	7.37	7.63	7.2	0.10	0.19
4a	7.50	6.30	6.50	6.90	6.80	7.20	6.60	7.20	7.30	7.20	7.0	-0.12	0.24
4b	7.44	6.63	6.63	7.09	6.95	7.25	6.49	8.13	7.24	7.41	7.1	0.06	0.25
5	7.20	6.60	6.60	6.80	6.80	6.90	6.50	7.50	6.90	7.00	6.9	-0.19	0.17
6	7.28	6.46	7.90	7.15	6.71	7.09	6.63	7.54	7.24	7.15	7.1	0.04	0.29
8a	7.70	6.75	7.85	7.45	7.05	7.65	6.90	8.90	7.50	7.75	7.6	0.48	0.33
8b	7.75	7.05	7.50	7.45	7.40	7.65	6.85	8.00	7.40	7.90	7.5	0.42	0.10
11a	7.31	6.59	7.03	7.03	6.93	7.10	6.61	7.42	7.30	7.26	7.1	-0.01	0.11
11f	6.95	6.25	6.46	6.70	6.79	6.82	6.49	6.48	6.55	6.93	6.6	-0.43	0.30
12	7.50	6.40	7.10	6.80	6.60	6.90	6.30	7.00	7.30	7.30	6.9	-0.15	0.23
15a	7.00	6.50	6.40	6.65	6.70	6.70	6.35	7.25	6.95	6.80	6.7	-0.34	0.21
15b	7.30	6.40	6.70	6.80	7.00	6.90	6.30	7.40	7.00	7.00	6.9	-0.19	0.14
17a	7.75	6.35	7.00	6.90	6.85	7.25	6.40	8.10	7.25	7.55	7.1	0.07	0.23
17b	7.20	6.25	6.45	6.95	6.70	7.25	6.35	7.35	7.25	7.30	6.9	-0.17	0.22
18	7.30	6.60	6.60	6.90	7.00	7.20	6.50	7.40	7.40	7.60	7.1	-0.02	0.24
19	7.25	6.54	6.56	7.05	7.10	7.31	6.49	8.15	7.02	7.47	7.1	0.02	0.28
25	7.20	6.30	7.90	6.80	6.60	7.10	6.50	8.20	7.10	7.30	7.1	0.03	0.36
27a	7.63	6.73	6.58	7.38	7.22	7.22	6.53	7.32	7.11	7.40	7.1	0.04	0.28
27b	7.81	6.83	7.07	7.39	7.76	7.54	6.93	7.70	7.70	7.89	7.5	0.39	0.25
30a	7.90	6.30	7.80	6.90	6.90	7.30	6.80	8.40	7.60	7.60	7.4	0.28	0.33
30e	7.20	6.50	6.70	7.30	7.20	7.20	6.50	7.80	6.90	7.10	7.0	-0.03	0.24
30f	7.47	6.75	7.31	7.19	7.18	7.14	6.76	7.50	7.23	7.47	7.2	0.13	0.12
31	7.40	6.60	7.00	7.10	7.00	7.30	6.60	7.50	7.20	7.40	7.1	0.04	0.09
33	7.50	6.50	7.80	7.00	6.90	7.20	6.80	7.80	7.10	7.20	7.2	0.11	0.23
35a	7.90	6.90	9.20	7.40	7.10	7.70	6.70	8.30	7.50	7.80	7.7	0.58	0.55

35b	7.80	6.70	9.00	7.60	7.20	7.60	6.90	8.10	7.70	7.70	7.6	0.56	0.48
35c	7.70	6.70	8.90	7.30	7.10	7.80	6.90	8.00	4.20	7.80	7.2	0.17	1.18
35d	8.30	6.90	9.30	7.30	7.20	7.40	7.40	8.20	7.90	7.90	7.8	0.71	0.57
35e	6.55	5.45	6.55	5.95	5.93	6.02	5.65	6.56	6.10	6.14	6.1	-0.98	0.18
35f	6.90	5.90	6.60	6.40	6.50	6.50	6.10	7.20	6.50	6.60	6.5	-0.55	0.11
64	7.39	6.54	6.94	6.98	6.91	7.10	6.53	7.39	7.18	7.44	7.0	-0.03	0.10
68	7.20	6.50	6.70	6.80	7.00	7.10	6.30	6.90	7.10	7.00	6.9	-0.21	0.23
80	7.46	6.41	6.63	7.08	7.06	7.18	6.28	7.73	7.25	7.53	7.1	-0.01	0.21
82	7.60	6.70	6.40	7.20	7.10	7.40	6.60	7.80	7.30	7.50	7.2	0.09	0.29
85	7.20	6.40	6.30	7.00	6.80	7.10	6.30	6.80	7.00	7.30	6.8	-0.25	0.30
88	7.30	6.50	6.90	7.00	6.90	7.20	6.60	7.50	7.20	7.30	7.0	-0.03	0.09
91	7.50	6.40	7.00	6.90	7.00	7.10	6.50	7.30	7.30	7.40	7.0	-0.03	0.14
94a	7.40	6.80	7.00	7.10	7.00	7.10	6.60	7.80	7.20	7.20	7.1	0.05	0.14
94b	7.30	6.50	6.60	7.00	6.70	7.00	6.50	7.90	7.10	7.30	7.0	-0.08	0.21
98	7.10	6.10	6.30	6.60	6.60	7.30	6.30	6.60	7.10	7.30	6.7	-0.34	0.35
Average	7.4	6.5	7.1	7.0	6.9	7.2	6.5	7.6	7.1	7.3	7.1	0.0	0.3
Std	0.32	0.29	0.80	0.31	0.29	0.33	0.28	0.52	0.57	0.35	0.31	0.31	0.18
Min	6.6	5.4	6.3	5.9	5.9	6.0	5.7	6.5	4.2	6.1	6.1	-1.0	0.1
Max	8.3	7.1	9.3	7.6	7.8	7.8	7.4	8.9	7.9	7.9	7.8	0.7	1.2

Table 6.1.4.1 Moisture content in rapeseed samples by NIR prediction models

IV. Annex: Oil and Moisture content in Rapeseed by NIR prediction model RA002635

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	46.63	49.82	48.79	48.85	48.63	49.39	49.57	42.78	46.89	47.65	47.9	0.28	0.33
2	46.53	50.04	49.09	48.88	48.48	49.34	50.03	42.08	46.82	47.31	47.9	0.24	0.29
4a	45.87	49.19	48.04	48.36	48.71	48.58	49.96	42.13	46.44	46.41	47.4	-0.25	0.23
4b	46.44	49.43	48.49	48.79	48.13	49.50	50.48	42.47	46.55	46.54	47.7	0.06	0.37
5	46.60	49.76	48.98	48.92	49.07	49.16	49.81	42.11	46.65	47.01	47.8	0.19	0.24
6	46.37	50.00	48.17	48.84	48.70	48.97	49.95	42.39	46.63	47.22	47.7	0.10	0.16
8a	46.39	49.36	47.98	48.50	48.79	48.84	49.96	42.28	46.77	47.19	47.6	-0.01	0.19
8b	46.68	49.51	48.56	48.97	48.26	48.91	50.13	42.27	46.81	46.75	47.7	0.07	0.26
11a	46.54	49.30	48.11	48.71	48.89	48.58	50.03	42.34	46.73	46.92	47.6	-0.01	0.22
11b	46.67	49.40	48.27	48.87	48.76	48.76	49.86	42.52	46.65	47.09	47.7	0.07	0.21
11d	46.75	49.59	49.01	48.93	48.66	49.34	49.66	42.00	46.38	47.06	47.7	0.12	0.32
11e	46.37	49.65	48.76	48.76	48.41	49.06	50.24	42.16	46.67	46.93	47.7	0.08	0.21
12	45.69	49.38	47.10	48.56	48.91	48.71	49.72	41.70	45.97	46.52	47.2	-0.39	0.37
15a	46.30	49.82	48.73	48.27	48.53	48.70	49.73	41.78	46.55	46.94	47.5	-0.08	0.27
15b	46.50	49.71	48.92	49.09	48.74	48.94	50.02	42.05	46.75	47.46	47.8	0.20	0.25
17	46.74	49.76	48.39	48.48	48.81	48.61	50.01	42.20	46.34	46.94	47.6	0.01	0.21
18	46.51	49.59	48.58	48.38	48.71	49.00	50.41	41.65	46.59	46.95	47.6	0.01	0.26
19	46.43	49.66	47.94	48.55	48.46	49.13	49.73	42.24	46.66	47.08	47.6	-0.03	0.17
25	46.66	49.93	48.37	49.03	48.51	48.99	50.25	42.37	46.99	47.03	47.8	0.19	0.19
27a	45.90	49.57	47.72	48.60	48.93	48.35	49.72	42.12	45.95	46.78	47.4	-0.26	0.30
27b	46.64	49.52	48.88	49.32	47.51	49.33	49.82	42.64	46.74	47.98	47.8	0.22	0.60
30a	46.31	49.80	48.04	48.85	48.80	49.28	50.05	42.21	46.58	47.04	47.7	0.08	0.14
30e	46.55	49.54	48.56	48.50	49.25	48.40	50.39	42.10	46.84	46.35	47.6	0.03	0.41
30f	46.29	49.93	47.98	48.48	49.47	49.63	49.34	41.60	46.57	46.74	47.6	-0.02	0.46
31	46.63	49.46	48.41	48.31	48.99	50.17	48.26	42.18	46.57	47.22	47.6	0.00	0.72
33	47.12	49.56	47.42	48.82	49.28	49.17	49.90	42.22	46.58	47.61	47.8	0.15	0.45
35a	46.13	49.27	47.89	48.48	48.45	48.03	50.20	41.87	46.31	46.77	47.3	-0.28	0.30

35b	46.42	49.39	48.02	48.63	48.36	49.15	49.97	42.13	46.67	46.91	47.6	-0.06	0.15
35c	46.27	49.45	47.83	48.45	48.33	48.90	49.81	42.04	46.54	46.64	47.4	-0.19	0.13
35d	46.51	49.28	47.80	48.46	48.42	48.70	49.95	41.96	46.65	46.76	47.5	-0.17	0.18
64	46.12	49.41	48.35	48.43	48.97	48.81	50.18	42.06	46.42	46.92	47.6	-0.05	0.20
68	46.21	49.74	47.35	48.38	48.84	49.11	49.87	42.01	46.19	47.13	47.5	-0.14	0.33
80	46.79	49.45	48.74	48.55	48.71	49.50	50.24	42.13	46.91	47.12	47.8	0.19	0.24
82	46.31	49.84	47.88	48.51	48.03	48.44	50.28	41.84	46.39	46.85	47.4	-0.18	0.31
85	45.83	49.68	47.37	48.02	48.65	48.58	50.13	41.61	46.36	46.73	47.3	-0.32	0.34
88	46.18	49.59	48.71	48.44	48.92	49.49	50.47	42.31	46.75	47.20	47.8	0.19	0.27
94a	46.64	49.48	48.45	48.92	48.18	48.94	50.28	42.05	46.22	47.22	47.6	0.02	0.28
94b	46.48	49.89	48.23	48.63	49.31	49.67	49.79	42.12	46.32	46.56	47.7	0.08	0.35
98	45.75	50.35	47.74	48.82	48.93	48.89	49.94	41.87	46.49	46.37	47.5	-0.10	0.43
Average	46.4	49.6	48.2	48.6	48.7	49.0	50.0	42.1	46.6	47.0	47.6	0.0	0.3
Std	0.31	0.25	0.50	0.26	0.38	0.42	0.38	0.26	0.24	0.35	0.17	0.17	0.12
Min	45.7	49.2	47.1	48.0	47.5	48.0	48.3	41.6	45.9	46.4	47.2	-0.4	0.1
Max	47.1	50.4	49.1	49.3	49.5	50.2	50.5	42.8	47.0	48.0	47.9	0.3	0.7

Table 6.1.5.1 Oil content in **Rapeseed** samples by using the ANN model RA002635 (RAOI0035).

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	7.14	6.52	6.92	7.07	6.80	6.68	6.58	7.38	6.97	7.22	6.9	-0.06	0.15
2	7.23	6.51	6.74	7.01	6.99	7.10	6.40	7.53	7.16	7.17	7.0	0.00	0.10
4a	7.49	6.47	6.78	6.93	6.84	7.12	6.57	7.16	7.26	7.07	7.0	-0.02	0.11
4b	7.46	6.67	7.10	7.01	6.90	7.04	6.46	7.54	7.22	7.05	7.0	0.06	0.10
5	7.25	6.58	6.67	6.92	6.93	6.97	6.54	7.46	7.01	7.02	6.9	-0.05	0.09
6	7.31	6.46	6.74	7.08	6.50	6.98	6.34	7.11	7.26	7.06	6.9	-0.10	0.16
8a	7.47	6.65	7.37	7.31	6.98	7.44	6.79	8.37	7.33	7.63	7.3	0.35	0.28
8b	7.26	6.62	6.82	6.80	7.02	7.04	6.39	7.50	7.06	7.10	7.0	-0.02	0.10
11a	7.31	6.59	7.03	7.03	6.93	7.10	6.61	7.42	7.30	7.26	7.1	0.07	0.07
11b	7.46	6.55	7.05	7.08	7.18	7.25	6.58	7.64	7.21	7.26	7.1	0.14	0.09
11d	6.93	6.51	6.48	6.64	6.84	6.65	6.24	7.34	6.79	6.98	6.7	-0.25	0.16
11e	7.00	6.30	6.38	6.62	6.51	6.63	6.18	7.25	6.91	6.81	6.7	-0.33	0.10
12	7.68	6.49	7.11	6.96	6.69	6.98	6.58	7.00	7.32	7.20	7.0	0.01	0.21
15a	7.23	6.49	6.54	6.81	6.93	6.79	6.49	7.30	7.05	6.91	6.9	-0.13	0.11
15b	7.42	6.54	6.79	6.95	7.04	7.01	6.38	7.45	7.23	7.09	7.0	0.00	0.08
17	7.18	6.39	6.65	6.97	6.81	7.21	6.47	7.40	7.23	7.14	6.9	-0.04	0.12
18	7.34	6.62	6.66	6.79	7.14	6.81	6.37	7.29	7.16	7.03	6.9	-0.07	0.14
19	7.24	6.56	6.86	7.02	6.98	7.21	6.57	7.69	7.06	7.33	7.1	0.06	0.13
25	7.43	6.69	7.22	7.04	6.76	7.18	6.69	8.05	7.11	7.35	7.2	0.16	0.22
27a	8.34	6.88	7.38	7.60	7.36	7.58	6.85	7.43	7.71	7.76	7.5	0.50	0.24
27b	8.13	6.95	7.19	7.34	7.59	7.44	6.95	7.77	7.98	7.80	7.5	0.53	0.18
30a	7.39	6.49	6.81	6.81	6.87	6.91	6.64	7.23	7.07	7.12	6.9	-0.05	0.08
30e	7.04	6.42	6.39	7.06	7.03	7.05	6.41	7.57	6.73	7.01	6.9	-0.12	0.23
30f	7.33	6.49	7.02	6.91	6.85	6.99	6.57	7.04	7.01	7.22	6.9	-0.04	0.14
31	7.40	6.58	6.83	6.90	6.97	6.56	7.00	7.62	7.14	7.07	7.0	0.02	0.24
33	7.34	6.73	7.48	7.10	7.10	7.38	6.88	7.70	7.32	7.47	7.3	0.26	0.18
35a	7.18	6.10	6.29	6.47	6.47	6.73	6.12	6.58	6.68	6.48	6.5	-0.48	0.17

35b	7.18	6.21	6.63	6.93	6.67	6.87	6.44	7.32	6.90	6.96	6.8	-0.18	0.09
35c	7.16	6.33	6.62	6.87	6.47	6.95	6.52	7.04	6.93	7.12	6.8	-0.19	0.14
35d	7.42	6.57	6.98	6.94	7.04	6.95	6.56	7.14	7.30	7.22	7.0	0.03	0.12
64	7.39	6.53	6.77	6.89	6.96	7.08	6.65	7.60	7.15	7.34	7.0	0.05	0.10
68	7.67	6.79	7.31	7.16	7.23	7.15	6.59	7.08	7.24	6.96	7.1	0.13	0.23
80	7.42	6.62	6.80	6.89	7.12	7.05	6.46	7.41	7.09	7.11	7.0	0.01	0.09
82	7.38	6.50	7.00	6.94	6.87	7.15	6.34	7.13	7.17	7.12	7.0	-0.03	0.12
85	7.67	6.47	6.89	6.98	6.80	6.96	6.33	6.91	7.06	7.06	6.9	-0.07	0.19
88	7.32	6.36	6.50	6.62	6.62	7.01	6.37	7.31	6.83	6.85	6.8	-0.21	0.12
94a	7.34	6.69	6.99	6.96	6.89	7.04	6.53	7.59	7.18	7.02	7.0	0.04	0.10
94b	7.42	6.65	6.65	7.15	6.79	7.12	6.59	7.96	7.17	7.41	7.1	0.10	0.21
98	7.61	6.41	6.81	6.75	6.82	7.13	6.40	6.65	7.29	7.07	6.9	-0.09	0.26
Average	7.4	6.5	6.9	7.0	6.9	7.0	6.5	7.4	7.1	7.2	7.0	0.0	0.1
Std	0.26	0.16	0.29	0.20	0.23	0.22	0.19	0.35	0.24	0.25	0.19	0.19	0.06
Min	6.9	6.1	6.3	6.5	6.5	6.6	6.1	6.6	6.7	6.5	6.5	-0.5	0.1
Max	8.3	7.0	7.5	7.6	7.6	7.6	7.0	8.4	8.0	7.8	7.5	0.5	0.3

6.1.6.1 Moisture content in **Rapeseed** samples by using the ANN model RA002635 (RAMO0026).