

World Grain Network Ring Test

**Results of the worldwide inter-laboratory study
conducted in February/March 2022**

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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 2021 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 2022 all samples (2021 harvest)	Ref. methods	Local models	FOSS ANN
Protein, range	8.4 % - 13.7 %		
Mean (%)	11.67	11.72	11.70
deviation from mean		0.11	0.03
SD reproducibility	0.17	0.19	0.12
RSD reproducibility	1.4	1.7	1.0
Moisture, range	11.6 % - 16.0 %		
Mean (%)	13.30	13.34	13.25
deviation from mean		0.04	-0.05
SD reproducibility	0.17	0.18	0.07
RSD reproducibility	1.3	1.4	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 2022 all samples (2021 harvest)	Ref. methods	Local models	FOSS ANN
Oil, range	45.2 % - 50.6 %		
Mean (%)	47.69	47.89	48.01
deviation from mean		0.20	0.32
SD reproducibility	0.71	0.68	0.28
RSD reproducibility	1.5	1.4	0.6
Moisture, range	6.1 % - 7.9 %		
Mean (%)	6.95	6.93	6.89
deviation from mean		-0.02	-0.06
SD reproducibility	0.15	0.30	0.16
RSD reproducibility	2.1	4.4	2.4

Forty-one laboratories from twenty-one different countries world-wide (six continents) participated in this test, which is similar as last couple of years. 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 proficiency testing scheme used is compliant with ISO 17043. 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
- Investigate whether there are differences between the master labs and 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 couple of years: forty-one participants as compared to forty-five last year; and twenty-one as compared to twenty-two countries last year.

This multi sample and multi parameter inter-laboratory study was organized by FOSS Analytical (Denmark) in February/March 2022 with Dr. T. Nilsson as project leader. The preliminary results of the study were presented on the FOSS Grain Network Webinar 28 March 2022.

2 Participants

Forty-one participants from twenty-one countries submitted results:

Argentina	BCR
Australia	GrainCorp
Austria	RWA
Belgium	CRA-W
Canada	Canadian Grain Commission
Canada	SGS
China	FOSS Suzhou
Czech Republic	Agro 2000
Czech Republic	Agrovykup
Czech Republic	Plzensky Prazdroj (Pilsner Urquel)
Denmark	DAKOFO
Denmark	Eurofins Steins
Denmark	FOSS Analytical
Denmark	Viking Malt
Estonia	Agricultural Research Centre
Estonia	Avena Nordic Grain
Estonia	Scanola Baltic
Finland	Finnish Food Authority
France	Agroreso (Arvalis)
France	Laborargo - InVivo
France	Ulice (Limagrain)
Germany	Cargill
Germany	Max Rubner Institute, Detmold
Hungary	SGS
Italy	CREA-QCE, Rome

Latvia	Eira Lab
Latvia	Institute of Agricultural Resources and Economics
Lithuania	Plant Products Quality Testing Laboratory
The Netherlands	Agrifirm Plant
Poland	Cargill
Poland	Gdanskie Mlyny
Poland	Hamilton
Poland	Inspectis, Gdansk
South Africa	GWK
South Africa	OVK
South Africa	SAGL
South Africa	Senwes
Sweden	Eurofins
Sweden	Lantmännen
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

4.1 Test samples

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

Wheat samples		
Marking	Specification	Country
W1	"Porthus" Winter Wheat	Germany
W2	Winter Wheat	Latvia
W3	"Kapitol" Spring Wheat	Denmark
W4	Starch Wheat	Sweden
W5	"Opoka" Winter Wheat	Poland
W6	"Extase" Winter Wheat	UK
W7	"Mortimer" Winter Wheat	Germany
W8	"Messino" Winter Wheat	Germany
W9	"Chevignon" Winter Wheat	France
W10	"Porthus" Winter Wheat	Germany

Table 4.1.1: 2021 harvest wheat samples selected for the study (W7 and W8 from 2020).
All samples belong to "Triticum Aestivum".

Barley samples		
Marking	Specification	Country
B1	Spring Barley	Finland
B2	Winter Barley	Latvia
B3	" Wish" Spring Barley	Denmark
B4	Barley	Sweden
B5	"Adwokat" Spring Barley	Poland
B6	"Salamandre" Winter Barley	France
B7	"Tungsten" Spring Barley	UK
B8	"Planet" Spring Barley	UK
B9	" Medusa" Spring Barley	Germany
B10	"Orbit Zs" Winter Barley	Germany

Table 4.1.2: 2021 harvest barley samples selected for the study.
All samples belong to "Hordeum Vulgare".

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

Table 4.1.3: 2021 harvest rapeseed samples selected for the study (R8-R10 from 2020). Samples R1 and R2 belong to “Brassica Rapa” and R3-R10 belong to “Brassica Napus”.

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 48 laboratories from 21 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.

4.2 Statistical design and evaluation methods

The statistical design for the WGN Ring test is compliant with ISO 5725-2, which applies an outlier removal procedure and determines repeatability and inter-laboratory reproducibility. Besides these statistical measures, also the mean values are determined which are used as the assigned values. Before the repeatability, reproducibility and mean values can be correctly determined, the original data needs to be evaluated for outlying results. Redundant, non-

compliant or missing data must be handled before checking for outliers. The outlier removal process is described in detail in ISO 5725-2.

The evaluation of the results is conducted both on an individual participant level as well as on average behavior. For the individual performance assessment, a Z-score is calculated for each type of measurement. It is calculated by dividing the difference between the laboratory mean and the best estimate of the true value (i.e. mean value of the statistical analysis, after the elimination of outlying results) by the standard deviation of the method.

The fixed values used in the evaluation of reference methods, local NIR methods and global ANN methods is listed in Table 4.2.1. Absolute z-scores below 2 correspond to good laboratory performance. The performance is questionable for absolute scores between 2 – 3 (marked yellow in Z-score tables) and unsatisfactory for absolute values above 3 (marked red in Z-score tables).

Parameter	Commodity	s _R (%)	Standards
Protein	Wheat and Barley	0.20	EN ISO 20483 (Kjeldahl) and EN ISO 16634 (Dumas)
Moisture	Wheat	0.14	EN ISO 712
Moisture	Barley	0.17	EN ISO 712
Oil	Rapeseed	0.55	ISO 659:1998
Moisture	Rapeseed	0.16	ISO 665:2000

Table 4.2.1: Reproducibility values s_R according to specific standards used in the evaluation of Z-scores for each parameter and commodity.

5 Results for protein and moisture in Wheat & Barley

5.1 Collation of results

5.1.1 Protein content by reference methods

Twenty-five 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)
6	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)
30	P06	AACCI 46-30.01 (Dumas)
32	P06	Analytica EBC 3.3.1 Total Nitrogen of barley (Kjeldahl)
33	P02	EN ISO 16634 (Dumas combustion)
35	P06	AACCI 46-30.01 (Dumas)
64	P01	ISO 20483 (Kjeldahl, Cu/Ti)
68	P01	ISO 20483 (Kjeldahl, Cu/Ti)
77a	P06	AOAC 2001.11:2005 (Kjeldahl)
80	P01	ISO 20483 (Kjeldahl, Cu/Ti)
81	P04	ICC 105/2 (Kjeldahl)
84	P06	Analytica EBC 3.3.1 Total Nitrogen of barley (Kjeldahl)
85	P03	ISO 5986-2 (Kjeldahl, Cu)
93	P01	ISO 20483 (Kjeldahl, Cu/Ti)
94	P02	EN ISO 16634 (Dumas combustion)

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-seven 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	M01	ISO 712:2009	130° C, 2 h
5	M01	ISO 712:2009	130° C, 2 h
8	M02	ICC 110/1	130° C, 2 h
10	M03	ICC 110/1 modified	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
26	M01	ISO 712:2009	130° C, 2 h
30a	M01	ICC 110/1	130° C, 2 h
30b	M03	National	103° C, 72 h (whole wheat)
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
77a	M01	ISO 712:2009	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
91	M01	ISO 712:2009	130° C, 2 h
93	M01	ISO 712:2009	130° C, 2 h
94	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

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Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	12.48	13.48	12.79	10.96	13.61	10.23	9.73	13.34	11.10	12.91	12.06	-0.03	0.15
2	12.53	13.72	12.76	11.02	13.67	10.04	9.88	13.32	11.29	12.80	12.10	0.01	0.16
4	12.55	13.53	13.19	11.07	13.84	10.39	9.72	13.32	11.54	12.64	12.18	0.09	0.11
5	12.50	13.50	12.90	10.90	13.70	10.50	9.80	13.50	11.50	12.60	12.14	0.05	0.09
8	12.50	13.60	12.90	10.90	13.70	10.30	9.70	13.30	11.30	12.40	12.06	-0.03	0.07
10	12.48	13.36	12.90	10.81	13.72	10.32	9.99	13.17	11.34	12.42	12.05	-0.04	0.11
12	12.20	13.30	12.70	10.70	13.40	10.10	9.60	13.30	11.30	12.50	11.91	-0.18	0.11
15	12.98	13.91	13.33	11.19	14.06	10.46	10.11	12.90	11.04	12.79	12.28	0.19	0.30
17	12.50	13.50	13.00	10.90	13.70	10.50	9.90	13.30	11.40	12.50	12.12	0.03	0.07
18	12.54	13.31	12.62	10.80	13.52	10.31	9.76	13.36	11.46	12.69	12.04	-0.05	0.14
19	12.47	13.41	12.89	10.94	13.59	10.42	9.70	13.14	11.25	12.59	12.04	-0.05	0.06
30	12.68	13.74	13.00	11.18	13.98	10.62	9.85	13.45	11.42	12.66	12.26	0.17	0.08
33	12.43	13.76	12.71	10.87	13.63	10.42	9.66	13.37	11.39	12.55	12.08	-0.01	0.13
35	12.70	13.80	13.20	11.10	13.90	10.60	10.00	13.60	11.50	12.70	12.31	0.22	0.06
64	12.65	13.41	12.92	10.89	13.72	10.27	9.85	13.26	11.21	12.44	12.06	-0.03	0.09
68	12.33	13.24	12.72	10.77	13.51	10.20	9.73	13.10	11.35	12.35	11.93	-0.16	0.08
77a	12.50	13.30	12.70	10.90	13.50	10.40	9.70	13.10	11.30	12.40	11.98	-0.11	0.09
80	12.46	13.59	12.82	10.77	13.68	10.54	9.65	13.32	11.44	12.45	12.07	-0.02	0.11
81	12.60	13.60	13.10	11.00	13.70	10.70	9.80	13.20	11.40	12.70	12.18	0.09	0.11
85	12.20	13.20	13.10	10.80	13.40	10.20	9.80	13.10	11.10	12.20	11.91	-0.18	0.17
94	12.49	13.60	12.70	10.90	13.90	10.28	9.76	13.41	11.26	12.60	12.09	0.00	0.12
Average	12.5	13.5	12.9	10.9	13.7	10.4	9.8	13.3	11.3	12.6	12.1	0.0	0.1
Std	0.17	0.20	0.20	0.13	0.18	0.17	0.13	0.16	0.14	0.17	0.11	0.11	0.05
Min	12.2	13.2	12.6	10.7	13.4	10.0	9.6	12.9	11.0	12.2	11.9	-0.2	0.1
Max	13.0	13.9	13.3	11.2	14.1	10.7	10.1	13.6	11.5	12.9	12.3	0.2	0.3

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

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	12.77	13.35	8.15	13.15	12.43	12.99	9.35	9.87	9.23	10.46	11.18	-0.06	0.13
2	12.40	12.69	8.16	13.06	11.99	12.59	8.94	9.57	8.90	10.03	10.83	-0.40	0.15
4	13.11	13.71	8.66	13.55	12.39	12.91	9.63	9.98	9.73	10.65	11.43	0.20	0.18
5	13.00	13.60	8.70	13.50	12.30	13.00	9.60	10.00	9.50	10.60	11.38	0.14	0.13
6	12.62	13.44	8.50	13.21	12.37	12.96	9.66	9.90	9.44	10.61	11.27	0.03	0.07
8	12.60	13.60	8.40	13.00	12.50	12.90	9.60	9.90	9.30	10.40	11.22	-0.02	0.15
10	12.51	13.37	8.35	13.05	12.13	12.83	9.49	9.89	9.03	10.38	11.10	-0.13	0.09
12	12.40	13.00	8.30	13.10	12.40	12.80	9.50	10.20	9.30	10.50	11.15	-0.09	0.17
15	12.50	13.42	8.40	13.38	12.44	12.74	9.77	10.38	9.58	11.15	11.38	0.14	0.25
17	12.60	13.50	8.60	13.20	12.30	12.90	9.60	10.20	9.40	10.50	11.28	0.04	0.11
18	12.68	13.28	8.46	13.22	12.58	13.17	9.66	10.22	9.18	10.65	11.31	0.07	0.14
19	12.67	13.39	8.51	13.27	12.41	13.02	9.54	9.97	9.28	10.52	11.26	0.02	0.05
30	12.96	13.66	8.62	13.50	12.56	13.30	9.86	10.11	9.53	10.65	11.47	0.24	0.07
32	12.80	13.70	8.40	13.40	12.20	13.30	9.60	10.10	9.30	10.60	11.34	0.10	0.15
33	12.71	13.83	8.23	13.25	12.13	12.96	9.54	9.93	9.41	10.35	11.23	0.00	0.20
64	12.54	13.42	8.42	13.23	12.16	12.89	9.60	10.04	9.59	10.59	11.25	0.01	0.12
68	12.81	13.30	8.25	13.53	12.41	13.14	9.82	10.03	8.98	10.52	11.28	0.04	0.19
80	12.35	13.00	8.39	13.54	12.30	12.91	9.54	9.83	9.24	10.55	11.17	-0.07	0.17
84	11.90	12.20	8.30	13.00	11.70	12.40	9.00	9.20	8.90	10.10	10.67	-0.57	0.29
93	12.70	13.60	8.30	13.60	12.70	13.30	9.70	10.00	9.40	10.60	11.39	0.15	0.15
94	12.77	13.44	8.53	13.40	12.59	13.30	9.70	9.89	9.48	10.65	11.38	0.14	0.11
Average	12.6	13.4	8.4	13.3	12.3	13.0	9.6	10.0	9.3	10.5	11.2	0.0	0.1
Std	0.26	0.38	0.16	0.20	0.23	0.23	0.23	0.24	0.23	0.22	0.19	0.19	0.06
Min	11.9	12.2	8.2	13.0	11.7	12.4	8.9	9.2	8.9	10.0	10.7	-0.6	0.0
Max	13.1	13.8	8.7	13.6	12.7	13.3	9.9	10.4	9.7	11.2	11.5	0.2	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

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	13.65	12.07	13.50	12.22	12.98	16.03	13.78	14.01	14.11	11.70	13.4	0.18	0.06
2	13.79	12.27	13.60	12.40	13.03	16.04	13.84	14.06	14.08	11.85	13.5	0.27	0.04
4	13.67	12.08	13.52	12.27	12.98	16.01	13.78	14.04	13.98	11.66	13.4	0.18	0.06
5	13.30	12.00	13.20	12.30	12.90	15.80	13.70	13.90	13.90	11.70	13.3	0.05	0.11
8	13.50	11.90	13.30	12.10	12.80	15.90	13.60	13.90	13.90	11.50	13.2	0.02	0.07
10	13.30	11.40	12.99	11.82	12.32	15.48	13.28	13.84	13.65	10.88	12.9	-0.33	0.22
12	13.60	12.10	13.50	12.20	12.90	16.00	13.70	14.00	14.10	11.70	13.4	0.16	0.07
15	13.46	12.00	13.37	12.29	13.00	16.45	13.50	13.88	13.96	11.54	13.3	0.12	0.21
17	13.64	11.99	13.44	12.11	12.93	15.78	13.66	13.90	13.88	11.63	13.3	0.07	0.07
18	13.47	11.70	13.42	12.04	12.82	15.98	13.70	13.99	13.97	11.41	13.3	0.03	0.15
19	13.72	12.16	13.58	12.34	13.06	16.13	13.84	14.15	14.15	11.80	13.5	0.27	0.06
25	13.30	11.80	13.20	12.10	12.80	15.90	13.70	13.90	13.80	11.30	13.2	-0.04	0.14
26	12.92	11.61	12.58	11.72	12.15	13.93	12.90	10.94	13.20	12.99	12.5	-0.73	1.08
30a	12.93	11.52	12.50	11.46	12.13	14.38	12.66	12.70	12.27	10.81	12.3	-0.89	0.38
30b	13.01	11.31	12.67	11.52	12.28	15.39	12.93	13.41	13.29	10.88	12.7	-0.56	0.12
33	13.43	12.06	13.20	12.25	12.74	15.95	13.65	13.87	13.90	11.77	13.3	0.06	0.10
35	13.37	11.77	13.33	12.11	12.80	16.02	13.64	13.88	13.94	11.33	13.2	0.00	0.14
64	13.70	12.20	13.46	12.29	12.95	16.08	13.75	13.92	13.91	11.83	13.4	0.19	0.06
68	13.34	11.61	13.22	11.99	12.72	15.85	13.61	13.76	13.78	11.30	13.1	-0.10	0.12
77a	14.06	12.27	14.03	12.60	13.11	16.30	14.20	14.20	14.23	11.99	13.7	0.48	0.13
80	13.68	12.12	13.54	12.28	12.97	15.93	13.76	14.02	14.03	11.60	13.4	0.17	0.07
81	13.40	12.10	13.30	12.10	12.80	16.10	13.50	13.80	13.90	11.80	13.3	0.06	0.13
82	13.68	12.13	13.48	12.28	13.01	15.98	13.88	14.13	14.14	11.75	13.4	0.22	0.07
91	13.37	11.75	13.32	11.95	12.64	15.87	13.75	13.65	13.72	11.55	13.2	-0.07	0.11
94	13.60	12.00	13.50	12.30	13.00	16.00	13.80	14.10	14.10	11.70	13.4	0.19	0.08
Average	13.5	11.9	13.3	12.1	12.8	15.8	13.6	13.8	13.8	11.6	13.2	0.0	0.2

Std	0.27	0.27	0.34	0.27	0.28	0.55	0.34	0.66	0.41	0.43	0.32	0.32	0.21
Min	12.9	11.3	12.5	11.5	12.1	13.9	12.7	10.9	12.3	10.8	12.3	-0.9	0.0
Max	14.1	12.3	14.0	12.6	13.1	16.5	14.2	14.2	14.2	13.0	13.7	0.5	1.1

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

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	12.09	12.80	13.35	12.56	12.98	11.68	15.77	14.41	14.06	14.12	13.4	0.10	0.05
2	12.19	12.92	13.41	12.59	13.16	11.76	15.53	14.30	14.02	14.14	13.4	0.12	0.08
4	12.17	12.90	13.35	12.53	13.09	11.74	15.67	14.42	14.01	14.18	13.4	0.12	0.04
5	12.10	12.80	13.40	12.50	12.80	11.60	15.60	14.40	13.80	14.00	13.3	0.02	0.09
8	11.90	12.60	13.20	12.30	12.80	11.40	15.60	14.20	13.90	13.80	13.2	-0.11	0.08
10	11.53	12.59	13.33	12.22	12.48	11.28	15.24	14.43	13.66	13.92	13.1	-0.21	0.20
12	11.90	12.80	13.30	12.50	13.00	11.70	15.70	14.40	14.10	14.30	13.4	0.09	0.10
15	11.94	12.78	13.42	12.38	12.97	11.79	16.01	14.27	14.03	13.95	13.4	0.07	0.15
17	11.98	12.73	13.31	12.45	13.00	11.65	15.79	14.22	13.82	13.94	13.3	0.01	0.09
18	11.92	12.73	13.25	12.40	12.94	11.62	15.32	14.27	13.84	13.99	13.2	-0.05	0.07
19	12.15	12.98	13.43	12.59	13.14	11.80	15.82	14.54	14.17	14.30	13.5	0.21	0.05
25	12.10	12.90	13.40	12.40	13.00	11.80	15.70	14.30	14.00	14.10	13.4	0.09	0.06
30a	11.66	12.30	12.94	12.13	12.56	11.41	14.92	13.79	13.35	13.53	12.9	-0.43	0.13
32	12.00	12.80	13.20	12.40	12.90	11.60	15.50	14.20	13.80	13.90	13.2	-0.05	0.05
33	12.03	12.82	13.07	12.39	12.98	11.72	15.02	14.26	13.89	14.11	13.2	-0.05	0.20
64	12.14	12.86	13.32	12.53	12.91	11.72	15.46	14.36	13.98	14.05	13.3	0.05	0.07
68	11.99	12.73	13.24	12.47	12.90	11.62	15.69	14.38	14.00	14.11	13.3	0.03	0.06
80	12.10	12.88	13.23	12.52	13.01	11.71	15.71	14.38	13.99	14.02	13.4	0.07	0.06
82	12.07	12.88	13.32	12.54	13.05	11.69	15.46	14.29	13.96	14.06	13.3	0.05	0.07
91	12.01	12.61	13.35	12.38	13.00	11.78	15.78	14.23	14.04	14.01	13.3	0.04	0.11
93	11.50	12.50	13.30	12.30	12.50	11.20	15.50	13.80	13.80	13.40	13.0	-0.30	0.21
94	12.10	12.95	13.43	12.59	13.11	11.75	15.75	14.42	14.11	14.24	13.4	0.16	0.04
Average	12.0	12.8	13.3	12.4	12.9	11.6	15.6	14.3	13.9	14.0	13.3	0.0	0.1
Std	0.19	0.16	0.12	0.12	0.19	0.17	0.26	0.18	0.18	0.22	0.15	0.15	0.05
Min	11.5	12.3	12.9	12.1	12.5	11.2	14.9	13.8	13.3	13.4	12.9	-0.4	0.0
Max	12.2	13.0	13.4	12.6	13.2	11.8	16.0	14.5	14.2	14.3	13.5	0.2	0.2

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 WGN2022.

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-six 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 WGN2022.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.52	13.52	12.90	10.92	13.69	10.37	9.79	13.28	11.33	12.57
3	0.09	0.20	0.20	0.13	0.18	0.17	0.13	0.16	0.14	0.17
4	0.72	1.45	1.52	1.21	1.29	1.65	1.30	1.19	1.21	1.36

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	12.64	13.51	8.41	13.29	12.33	12.92	9.62	10.00	9.32	10.54
3	0.26	0.16	0.16	0.20	0.23	0.14	0.12	0.17	0.23	0.10
4	2.05	1.18	1.86	1.47	1.84	1.10	1.25	1.74	2.44	0.91

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:

For description of Z-score calculations, see section 4.2. The wheat results show that the reference analyses for protein are well under control. Only lab 15 show three yellow marked results just above the limit for W1-W3.

For barley, Labs 2 and 84 show evidence of a systematic negative bias with each having 2 and 5 red marked, respectively, and 3 yellow marked samples each. They do have some results that are fine, so it might not be entirely a systematic problem here. Lab 15 have one red marked sample B10. Labs 4, 12 and 80 has one yellow marked each. This seems to be more random problems.

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-0.2	-0.2	-0.6	0.2	-0.4	-0.7	-0.3	0.3	-1.1	1.7
2	0.0	1.0	-0.7	0.5	-0.1	-1.7	0.4	0.2	-0.2	1.2
4	0.1	0.1	1.4	0.7	0.8	0.1	-0.4	0.2	1.1	0.4
5	-0.1	-0.1	0.0	-0.1	0.1	0.6	0.0	1.1	0.9	0.2
8	-0.1	0.4	0.0	-0.1	0.1	-0.4	-0.5	0.1	-0.1	-0.8
10	-0.2	-0.8	0.0	-0.6	0.2	-0.3	1.0	-0.5	0.1	-0.7
12	-1.6	-1.1	-1.0	-1.1	-1.4	-1.4	-1.0	0.1	-0.1	-0.3
15	2.3	2.0	2.1	1.3	1.9	0.4	1.6	-1.9	-1.4	1.1
17	-0.1	-0.1	0.5	-0.1	0.1	0.6	0.5	0.1	0.4	-0.3
18	0.1	-1.0	-1.4	-0.6	-0.8	-0.3	-0.2	0.4	0.7	0.6
19	-0.3	-0.5	-0.1	0.1	-0.5	0.2	-0.5	-0.7	-0.4	0.1
30	0.8	1.1	0.5	1.3	1.5	1.2	0.3	0.9	0.5	0.5
33	-0.5	1.2	-1.0	-0.3	-0.3	0.2	-0.7	0.5	0.3	-0.1
35	0.9	1.4	1.5	0.9	1.1	1.1	1.0	1.6	0.9	0.7
64	0.6	-0.5	0.1	-0.2	0.2	-0.5	0.3	-0.1	-0.6	-0.6
68	-1.0	-1.4	-0.9	-0.8	-0.9	-0.9	-0.3	-0.9	0.1	-1.1
77a	-0.1	-1.1	-1.0	-0.1	-0.9	0.1	-0.5	-0.9	-0.1	-0.8
80	-0.3	0.4	-0.4	-0.8	0.0	0.8	-0.7	0.2	0.6	-0.6
81	0.4	0.4	1.0	0.4	0.1	1.6	0.0	-0.4	0.4	0.7
85	-1.6	-1.6	1.0	-0.6	-1.4	-0.9	0.0	-0.9	-1.1	-1.8
94	-0.2	0.4	-1.0	-0.1	1.1	-0.5	-0.2	0.7	-0.3	0.2

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	0.7	-0.8	-1.3	-0.7	0.5	0.4	-1.3	-0.7	-0.4	-0.4
2	-1.2	-4.1	-1.2	-1.2	-1.7	-1.6	-3.4	-2.1	-2.1	-2.6
4	2.4	1.0	1.2	1.3	0.3	0.0	0.1	-0.1	2.1	0.5
5	1.8	0.5	1.4	1.0	-0.2	0.4	-0.1	0.0	0.9	0.3
6	-0.1	-0.3	0.4	-0.4	0.2	0.2	0.2	-0.5	0.6	0.3
8	-0.2	0.5	-0.1	-1.5	0.8	-0.1	-0.1	-0.5	-0.1	-0.7
10	-0.6	-0.7	-0.3	-1.2	-1.0	-0.4	-0.6	-0.6	-1.4	-0.8
12	-1.2	-2.5	-0.6	-1.0	0.3	-0.6	-0.6	1.0	-0.1	-0.2
15	-0.7	-0.4	-0.1	0.4	0.5	-0.9	0.8	1.9	1.3	3.0
17	-0.2	0.0	0.9	-0.5	-0.2	-0.1	-0.1	1.0	0.4	-0.2
18	0.2	-1.1	0.2	-0.4	1.2	1.3	0.2	1.1	-0.7	0.5
19	0.2	-0.6	0.5	-0.1	0.4	0.5	-0.4	-0.2	-0.2	-0.1
30	1.6	0.8	1.0	1.0	1.1	1.9	1.2	0.5	1.1	0.5
32	0.8	1.0	-0.1	0.5	-0.7	1.9	-0.1	0.5	-0.1	0.3
33	0.4	1.6	-0.9	-0.2	-1.0	0.2	-0.4	-0.4	0.5	-1.0
64	-0.5	-0.4	0.0	-0.3	-0.9	-0.1	-0.1	0.2	1.4	0.2
68	0.9	-1.0	-0.8	1.2	0.4	1.1	1.0	0.1	-1.7	-0.1
80	-1.4	-2.5	-0.1	1.2	-0.2	0.0	-0.4	-0.9	-0.4	0.0
84	-3.7	-6.5	-0.6	-1.5	-3.2	-2.6	-3.1	-4.0	-2.1	-2.2
93	0.3	0.5	-0.6	1.5	1.8	1.9	0.4	0.0	0.4	0.3
94	0.7	-0.3	0.6	0.5	1.3	1.9	0.4	-0.6	0.8	0.5

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-eight 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 WGN2022.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	13.48	11.92	13.31	12.12	12.79	16.00	13.71	13.95	13.96	11.64
3	0.27	0.27	0.34	0.27	0.28	0.16	0.10	0.13	0.15	0.19
4	1.99	2.26	2.53	2.19	2.20	0.97	0.76	0.96	1.06	1.63

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	12.05	12.80	13.31	12.44	12.92	11.71	15.57	14.33	13.94	14.06
3	0.09	0.11	0.09	0.12	0.19	0.07	0.26	0.09	0.13	0.13
4	0.76	0.88	0.69	1.00	1.48	0.58	1.68	0.65	0.90	0.94

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:

For description of Z-score calculations, see section 4.2. The results show that the determination of moisture in wheat deviates with a significant negative bias for three labs (10, 26 and 30). Lab 30 has both methods (30a and 30b) deviating. Moisture loss during milling is the most likely reason. One lab has a significant positive bias (77a), which could mean that their procedure is more optimized to withstand milling issues than for the other labs. There are a few more labs with yellow marked samples (labs 2, 25, 35, 68 and 91). Lab 2 has all results with positive sign and lab 68 has all results with negative sign. It means there is a tendency for a systematic shift that should be monitored.

The moisture determination for barley looks in general very good, but three labs (10, 30a and 93) have red and yellow marked Z-scores where all results are with negative sign. This indicates a systematic bias that may originate from moisture loss during milling. Only one more lab (15) display a yellow marked result (B7), so not much to worry about.

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	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	1.2	1.1	1.4	0.7	1.3	0.2	0.5	0.4	1.1	0.4
2	2.2	2.5	2.1	2.0	1.7	0.3	1.0	0.8	0.9	1.5
4	1.4	1.2	1.5	1.1	1.3	0.0	0.5	0.6	0.1	0.2
5	-1.3	0.6	-0.8	1.3	0.8	-1.5	0.0	-0.4	-0.4	0.4
8	0.2	-0.1	-0.1	-0.2	0.1	-0.7	-0.8	-0.4	-0.4	-1.0
10	-1.3	-3.7	-2.3	-2.2	-3.4	-3.7	-3.0	-0.8	-2.2	-5.4
12	0.9	1.3	1.4	0.6	0.8	0.0	0.0	0.4	1.0	0.4
15	-0.1	0.6	0.4	1.2	1.5	3.2	-1.5	-0.5	0.0	-0.7
17	1.2	0.5	0.9	-0.1	1.0	-1.6	-0.3	-0.4	-0.6	-0.1
18	0.0	-1.5	0.8	-0.6	0.2	-0.2	0.0	0.3	0.1	-1.6
19	1.7	1.7	1.9	1.6	1.9	0.9	1.0	1.4	1.4	1.2
25	-1.3	-0.8	-0.8	-0.2	0.1	-0.7	0.0	-0.4	-1.1	-2.4
26	-4.0	-2.2	-5.2	-2.9	-4.6	-14.8	-5.8	-21.5	-5.4	9.7
30a	-3.9	-2.8	-5.8	-4.7	-4.8	-11.6	-7.5	-9.0	-12.1	-5.9
30b	-3.4	-4.4	-4.6	-4.3	-3.7	-4.4	-5.6	-3.9	-4.8	-5.4
33	-0.3	1.0	-0.8	0.9	-0.4	-0.4	-0.4	-0.6	-0.4	0.9
35	-0.8	-1.0	0.1	-0.1	0.1	0.1	-0.5	-0.5	-0.1	-2.2
64	1.6	2.0	1.1	1.2	1.1	0.5	0.3	-0.2	-0.4	1.4
68	-1.0	-2.2	-0.6	-0.9	-0.5	-1.1	-0.7	-1.4	-1.3	-2.4
77a	4.2	2.5	5.1	3.4	2.3	2.1	3.5	1.8	1.9	2.5
80	1.5	1.5	1.6	1.1	1.3	-0.5	0.4	0.5	0.5	-0.3
81	-0.5	1.3	-0.1	-0.2	0.1	0.7	-1.5	-1.1	-0.4	1.2
82	1.5	1.5	1.2	1.1	1.6	-0.2	1.2	1.3	1.3	0.8
91	-0.8	-1.2	0.1	-1.2	-1.1	-1.0	0.3	-2.1	-1.7	-0.6
94	0.9	0.6	1.4	1.3	1.5	0.0	0.7	1.1	1.0	0.4

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

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	0.3	0.0	0.2	0.7	0.3	-0.2	1.2	0.4	0.7	0.3
2	0.8	0.7	0.6	0.9	1.4	0.3	-0.2	-0.2	0.5	0.5
4	0.7	0.6	0.2	0.5	1.0	0.2	0.6	0.5	0.4	0.7
5	0.3	0.0	0.5	0.4	-0.7	-0.6	0.2	0.4	-0.8	-0.4
8	-0.9	-1.2	-0.7	-0.8	-0.7	-1.8	0.2	-0.8	-0.3	-1.5
10	-3.0	-1.3	0.1	-1.3	-2.6	-2.5	-1.9	0.6	-1.7	-0.8
12	-0.9	0.0	-0.1	0.4	0.5	0.0	0.8	0.4	0.9	1.4
15	-0.6	-0.1	0.6	-0.3	0.3	0.5	2.6	-0.4	0.5	-0.7
17	-0.4	-0.4	0.0	0.1	0.5	-0.3	1.3	-0.7	-0.7	-0.7
18	-0.7	-0.4	-0.4	-0.2	0.1	-0.5	-1.5	-0.4	-0.6	-0.4
19	0.6	1.0	0.7	0.9	1.3	0.5	1.5	1.2	1.3	1.4
25	0.3	0.6	0.5	-0.2	0.5	0.5	0.8	-0.2	0.3	0.2
30a	-2.3	-3.0	-2.2	-1.8	-2.2	-1.7	-3.8	-3.2	-3.5	-3.2
32	-0.3	0.0	-0.7	-0.2	-0.1	-0.6	-0.4	-0.8	-0.8	-1.0
33	-0.1	0.1	-1.4	-0.3	0.3	0.1	-3.2	-0.4	-0.3	0.3
64	0.6	0.3	0.0	0.5	-0.1	0.1	-0.6	0.2	0.2	-0.1
68	-0.3	-0.4	-0.4	0.2	-0.1	-0.5	0.7	0.3	0.3	0.3
80	0.3	0.5	-0.5	0.5	0.5	0.0	0.8	0.3	0.3	-0.2
82	0.1	0.5	0.0	0.6	0.8	-0.1	-0.6	-0.3	0.1	0.0
91	-0.2	-1.1	0.2	-0.3	0.5	0.4	1.2	-0.6	0.6	-0.3
93	-3.2	-1.8	-0.1	-0.8	-2.5	-3.0	-0.4	-3.1	-0.8	-3.9
94	0.3	0.9	0.7	0.9	1.1	0.3	1.1	0.5	1.0	1.0

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 WGN2022.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.59	13.48	13.04	10.97	13.73	10.57	9.81	13.28	11.32	12.54
3	0.17	0.20	0.20	0.14	0.18	0.18	0.11	0.17	0.19	0.16
4	0.19	0.19	0.16	0.20	0.16	0.16	0.15	0.14	0.16	0.14
5	1.48	1.43	1.25	1.78	1.20	1.52	1.48	1.04	1.40	1.10

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	12.59	13.26	8.99	13.22	12.03	12.82	9.77	10.05	9.75	10.60
3	-0.05	-0.25	0.58	-0.07	-0.30	-0.10	0.15	0.05	0.43	0.06
4	0.25	0.25	0.34	0.22	0.17	0.27	0.17	0.14	0.26	0.15
5	1.99	1.92	3.74	1.63	1.39	2.08	1.73	1.44	2.62	1.39

Table 5.2.3.2 - Results of statistical analysis for the determination of the protein content in barley 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:

For description of Z-score calculations, see section 4.2. 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 (labs 30h, 68, 85, 94a and 94b). However, there is one instrument (lab 79b) that deviate significantly with both red and yellow marked Z-scores of negative sign. This is most likely an instrument that requires adjustment since the other two instruments from the same lab (79a and 79c) are fine. For lab 10, one result is red marked (W3) and one is yellow marked (W5). This could be measurement issue causing outlier warning and it is recommended check that and if needed, repeat the measurement.

For barley, there are more red marked results compared to wheat, which is normal due to the nature of inhomogeneity in barley. Labs showing only one red marked result are 6, 11a, 12, 19, and 68. Lab 79c has two red-marked and one yellow marked result, but it does not seem to be a systematic problem. Lab 10 show several red marked and one yellow marked, but not all with the same sign. It is not clear what the main issue is here, but maybe check if there were any outlier warnings that can shed some light. 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	-1.0	-0.9	-0.9	-1.3	-0.9	-0.4	-0.5	-0.7	-1.3	-1.2
2	0.6	0.9	0.7	-0.2	0.1	0.0	0.7	0.6	-0.4	-0.1
4a	-0.3	0.1	0.8	0.5	-0.8	-0.2	0.2	0.6	0.2	0.7
4b	0.7	0.5	0.0	0.4	0.3	-0.3	0.1	0.0	-0.3	-0.2
5	-0.5	0.1	0.3	-0.3	-0.6	-0.9	0.0	-0.4	-0.1	-0.2
8a	0.5	0.1	0.8	0.2	-0.1	0.1	0.5	0.6	0.9	-0.2
8b	0.0	0.6	0.3	0.7	0.9	0.1	1.0	0.6	0.9	0.3
10	-0.5	-0.4	-3.7	1.7	2.4	0.6	1.5	-0.4	0.9	0.3
11a	0.1	-0.1	0.0	-0.2	0.0	-0.6	0.1	-0.2	-0.5	-0.4
11b	-0.1	-0.3	0.2	0.0	0.0	-0.1	-0.1	-0.4	0.3	-0.6
12	-1.0	-0.9	-1.2	-1.3	-2.1	-1.4	-1.0	-0.9	-1.1	-1.2
15	-0.2	0.8	0.4	0.2	0.6	1.7	0.2	-0.6	-0.6	0.1
17a	-0.2	-0.2	-0.4	-0.3	0.1	0.1	-0.3	0.1	-0.3	-0.5
18	0.5	-0.4	0.3	0.2	0.9	0.1	0.5	1.1	0.4	-0.2
19	-0.8	-0.9	-0.4	-1.1	-1.0	-0.8	-0.4	-0.3	-1.2	-0.9
24	0.0	-0.4	-0.7	-0.8	-0.6	0.6	0.0	0.6	-0.1	-0.7
25	-1.0	-0.4	-0.7	-0.3	0.4	-0.4	-0.5	-0.4	-0.1	-0.7
26	1.8	1.4	1.3	1.2	1.3	0.9	1.3	1.2	0.6	0.9
27	0.9	0.9	1.3	0.3	1.0	1.6	1.1	0.7	0.8	1.5
30a	1.2	0.8	0.5	1.2	0.4	0.4	0.5	0.2	1.6	0.8
30b	1.0	1.1	1.2	1.8	0.8	0.6	0.4	1.1	-0.6	0.5
30c	0.3	0.4	0.4	0.2	0.6	-0.2	0.4	0.1	-0.6	0.1
30h	2.4	1.8	1.0	1.4	1.3	1.8	0.5	2.4	1.2	1.1
33	0.5	0.1	0.3	-0.3	-0.6	-0.4	-0.5	0.1	0.4	-0.2
35a	1.0	1.6	0.8	1.7	0.4	0.1	1.0	1.1	1.4	1.3
35b	1.5	1.1	0.8	1.2	0.4	0.6	0.5	0.6	1.4	0.8
35c	1.0	1.6	1.3	1.7	0.4	1.1	0.5	1.1	0.9	1.3
35d	1.0	1.1	0.8	1.2	-0.1	1.1	0.0	0.6	0.4	0.3
56	-1.0	-0.9	-1.2	-1.3	-1.1	-0.4	-1.0	-0.9	-1.6	-0.7
64	0.0	-0.4	-0.7	-0.3	-0.1	-0.9	0.0	-0.4	-0.1	-0.7
66	1.0	0.1	0.8	0.7	0.4	1.1	1.0	0.6	0.4	0.3
68	-1.5	-1.4	-1.2	-1.3	-1.6	-1.9	-1.5	-1.9	-2.1	-2.2
75a	0.0	0.4	0.0	-0.4	0.1	-0.7	-0.1	-0.7	-0.7	-0.3
75b	-0.4	0.1	0.0	0.0	-0.3	-0.8	-0.1	-0.8	-0.1	0.0
77a	-0.4	-0.1	-0.1	1.1	-0.1	-0.7	-0.8	0.3	0.1	-0.5
79a	-0.5	1.1	-0.7	0.2	-0.1	-0.4	0.5	0.6	-0.1	0.3
79b	-3.0	-2.9	-3.2	-2.3	-3.1	-3.4	-2.0	-2.9	-2.1	-2.2
79c	-0.5	0.1	-1.2	-0.3	-0.1	-0.4	-0.5	-0.4	-0.6	0.3
80	-0.8	-0.5	-0.5	-0.2	-0.9	-0.1	0.2	-0.4	-0.5	-0.4
81	0.0	-0.4	-0.2	-0.3	0.4	-1.9	0.0	-0.9	-0.1	0.8
82	-1.5	-0.4	-0.7	-0.5	-1.4	-1.4	-1.3	-0.9	-1.1	-0.5
85	-1.5	-0.9	-1.2	-0.3	-2.1	-1.9	-2.0	-0.9	-2.6	-2.2

91	-1.0	-0.4	-0.7	-0.3	-1.1	-0.9	-0.5	-0.9	-0.6	-0.7
94a	-1.0	-1.4	-1.7	-0.8	-1.1	-0.9	-1.0	-0.9	-2.1	-0.7
94b	-1.5	-1.9	-2.7	-1.8	-2.1	-1.9	-1.5	-1.9	-2.1	-2.2

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	0.6	-1.3	2.5	-0.6	-0.4	1.4	0.7	0.3	-0.8	0.0
2	-0.5	-1.3	-2.1	-0.1	-0.4	-2.3	-0.4	0.6	-0.3	-0.1
4a	-1.0	0.6	0.8	-0.7	0.4	0.7	-0.3	-0.6	-2.1	0.5
4b	-1.2	-0.1	0.0	-0.7	-0.7	0.3	-1.8	0.7	0.4	0.4
5	0.6	0.7	0.0	0.4	0.3	-0.6	1.7	1.3	1.7	0.5
6	-0.4	-1.3	-0.5	0.9	0.8	-3.6	-0.8	0.8	2.7	-1.0
8a	1.6	0.7	0.5	0.4	0.3	1.4	1.2	0.3	0.2	-0.5
8b	0.6	0.2	0.0	0.4	0.3	-0.1	0.2	-1.2	0.7	-0.5
10	-2.9	-3.3	4.0	-3.1	-1.7	-4.6	1.2	-0.2	1.2	-1.5
11a	-0.2	0.3	0.4	1.6	-0.6	-4.8	1.9	-0.5	-1.2	-0.7
11b	1.6	1.6	1.8	1.6	1.0	-0.7	0.3	-1.0	0.1	-1.0
12	0.1	-1.8	-1.5	-1.6	1.3	-0.6	-4.8	-1.2	-0.3	-1.0
15	2.4	0.6	1.0	-0.5	1.1	0.3	0.2	0.4	2.5	1.4
17a	0.6	0.9	0.3	-0.4	-1.4	-0.4	-0.8	-0.2	-0.8	0.5
18	0.1	0.7	-1.5	0.9	-0.2	-0.1	-0.3	-1.2	-0.8	1.0
19	-1.4	-0.2	-4.0	-0.6	-0.6	-1.4	0.4	-0.8	-0.6	-0.5
24	-0.9	-1.3	-1.0	0.4	-1.2	1.9	-0.8	-0.2	-0.3	0.0
25	-0.4	-2.3	0.0	0.4	-0.7	-0.1	1.2	0.3	0.2	0.0
27	3.0	3.4	1.8	2.6	2.0	0.6	3.4	3.2	0.8	1.3
30a	-1.2	0.1	2.8	1.4	0.6	-1.8	0.2	1.7	0.8	-0.3
30b	0.2	0.9	-2.2	-1.1	0.1	0.9	0.2	0.1	0.6	0.8
30c	2.1	0.9	1.6	-0.5	0.5	2.1	-0.1	1.3	0.3	1.4
30h	0.2	2.1	2.2	0.8	1.4	0.9	-0.1	2.6	2.5	0.5
32	0.1	-0.3	0.0	-0.1	-0.7	-2.1	-0.3	0.3	-0.3	-1.5
33	-0.4	0.2	1.5	0.9	1.3	0.4	-0.3	0.8	1.2	0.0
56	0.1	0.7	0.5	-1.1	-0.7	-1.1	-0.3	-0.2	-0.3	-0.5
64	0.1	0.7	-2.0	-0.1	-0.2	0.4	-0.3	0.3	-0.3	0.0
68	1.9	-0.3	-0.5	4.1	0.0	-0.6	1.5	-0.6	0.7	-0.1
79a	-1.9	-1.8	-2.5	-0.6	-0.7	-0.1	-1.3	0.3	0.2	0.0
79c	0.1	0.2	-1.5	1.4	-1.2	-4.6	-0.3	-2.7	-3.3	-0.5
80	-0.4	-0.1	-1.1	0.9	0.4	0.1	-0.2	-0.3	-1.1	0.4
82	-2.2	-1.3	-1.7	-0.1	-0.4	0.9	-0.3	-0.5	-1.0	-0.2
84	-0.4	1.2	-1.5	0.4	-0.2	1.9	-0.3	-0.7	-2.8	0.5
85	0.1	-0.8	1.5	-1.1	-0.2	1.4	-0.3	0.3	-0.3	0.5
91	-0.9	0.2	0.0	-1.1	0.3	1.9	-0.3	0.3	-0.8	1.0
94a	1.1	0.2	-0.5	-0.1	-0.2	-0.6	0.7	0.3	0.2	0.0
94b	-0.4	0.2	0.0	-0.6	-0.2	-1.6	-1.3	-0.2	-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 WGN2022.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	13.61	11.94	13.28	12.13	12.75	15.98	13.48	13.60	13.77	11.66
3	0.14	0.03	-0.03	0.01	-0.04	-0.03	-0.22	-0.35	-0.19	0.02
4	0.17	0.13	0.17	0.14	0.19	0.22	0.18	0.17	0.15	0.18
5	1.23	1.12	1.28	1.14	1.49	1.36	1.34	1.26	1.12	1.58

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	12.14	12.91	13.48	12.50	12.93	12.26	15.78	14.45	14.11	14.11
3	0.09	0.10	0.16	0.06	0.01	0.55	0.21	0.12	0.16	0.05
4	0.15	0.22	0.24	0.16	0.13	0.39	0.14	0.14	0.17	0.16
5	1.22	1.68	1.81	1.27	0.98	3.22	0.86	0.96	1.18	1.17

Table 5.2.4.2 - Results of statistical analysis for the determination of the moisture content in barley 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:

For description of Z-score calculations, see section 4.2. The wheat results show a negative systematic shift for lab 10 with 8 results red marked and two with yellow marks. This originates from adjustment to a deviating reference method that have negative bias. For the same reason, labs 30a and 30b have a negative systematic shift based on adjustment to a deviating reference method. Lab 77a also show a systematic shift (two red marked and 6 yellow marked), but a positive one. The reason is also here an adjustment against a deviating reference method, here with positive sign. Lab 4a has one red marked and five yellow marked results and all with positive sign indicating a systematic shift. It may not be necessary to adjust at this time, but keep monitoring. There are three more labs (30h, 33 and 82) with 1-3 yellow marked z-scores, but they are just above the limit so no need to take action.

For barley, the performance is overall good, but one lab (30c) has a three red and six yellow marked with negative sign hence a systematic shift. Besides this lab, only few red marked results (labs 2, 6, 10, 27 and 79c). Labs 79c seems to be a random issue possibly due to outlier warning for samples B6, but the labs 2 and 6 could have a tendency for a positive systematic bias. For lab 10 there are two red marked with positive sign and one yellow marked with negative sign. It means it cannot be explained by a systematic shift, so possibly an outlier issue. Beside this, only sample inhomogeneity seems to be causing some yellow marked results (labs 4b, 19, 24, 64, 68 and 91).

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.8	0.9	0.6	0.3	0.4	1.0	0.6	1.2	0.6	0.7
2	0.4	0.9	0.2	0.4	0.3	0.9	0.2	0.4	0.7	0.3
4a	2.3	0.8	2.2	1.0	1.9	4.4	2.8	2.8	2.6	0.5
4b	0.7	0.7	0.5	0.4	0.4	1.6	0.8	1.2	0.8	0.2
5	0.6	1.1	0.9	0.5	1.1	0.9	0.8	0.7	0.2	0.3
8a	-0.1	0.4	0.2	-0.2	0.4	0.9	0.1	0.0	0.2	-0.4
8b	-0.1	0.4	0.2	-0.2	0.4	0.9	0.1	0.0	-0.5	0.3
10	-2.9	-2.5	-3.4	-3.8	-3.9	-4.1	-3.4	-3.6	-4.1	-3.3
11a	-0.6	-0.3	-0.5	-0.9	-0.6	-0.2	-0.2	-0.5	-0.4	-0.9
11b	-0.4	-0.4	-0.7	-0.7	-0.3	-0.4	-0.7	-0.4	-0.4	-1.1
12	-0.1	0.4	0.2	-0.2	-0.3	0.1	0.8	0.7	0.2	-0.4
15	-0.1	0.4	0.2	0.5	-0.3	0.1	-0.6	0.0	0.2	0.3
17a	1.3	1.1	0.9	0.5	1.1	0.5	0.8	1.4	0.6	1.0
18	-1.5	-0.3	-1.3	-0.9	-1.1	-1.3	-1.3	-0.7	-1.2	-1.1
19	1.2	1.3	1.0	0.9	0.9	1.5	1.4	1.5	1.3	1.1
24	-0.1	-0.3	-0.6	-0.2	-1.1	-0.6	-0.6	-0.7	-0.5	-1.1
25	-1.5	-1.0	-0.6	-0.9	-1.1	-0.6	-1.3	-0.7	-1.2	-1.1
26	0.6	1.1	0.9	0.5	0.4	0.9	0.1	0.7	0.9	0.3
27	-1.1	-0.6	-1.1	-1.0	-0.5	-1.0	-0.7	-1.0	-0.9	-0.8
30a	-2.1	-2.0	-2.3	-2.3	-2.6	-3.0	-2.7	-2.4	-2.7	-2.3
30b	-2.2	-1.5	-2.8	-2.2	-2.7	-3.4	-2.4	-2.5	-1.9	-2.3
30c	-0.6	0.3	-0.5	-0.6	-0.7	-1.4	-1.0	-0.7	-1.1	-0.5
30h	-1.6	-1.0	-1.6	-1.3	-1.6	-2.7	-1.7	-1.7	-2.0	-1.0
33	2.1	1.8	1.6	1.9	1.8	1.6	1.6	1.4	1.6	2.4
35a	1.3	1.8	1.6	1.2	1.1	0.1	0.8	1.4	0.9	1.0
35b	0.6	1.8	0.9	1.2	1.1	0.1	0.8	0.7	0.9	1.7
35c	0.6	1.8	0.9	1.2	1.1	-0.6	0.8	0.7	0.2	1.7
35d	0.6	1.1	0.9	1.2	1.1	-0.6	0.8	0.7	0.2	1.0
56	-0.1	0.4	0.2	-0.2	0.4	0.9	-0.6	0.0	-0.5	0.3
64	0.6	0.8	0.2	0.6	0.7	0.7	0.8	1.3	0.5	0.7
66	-0.8	-0.3	-0.6	-0.9	-1.1	-0.6	-1.3	-0.7	-1.2	-1.1
68	0.6	0.4	0.2	0.5	1.1	0.9	1.6	1.4	0.9	0.3
75a	-0.6	-0.2	-0.7	-0.6	-0.7	-0.7	-0.5	-0.6	-0.7	-0.8
75b	-0.6	-0.4	-0.8	-0.8	-0.9	-0.5	-0.6	-0.7	-0.7	-0.8
77a	2.8	3.3	2.3	3.4	3.2	2.3	2.3	2.8	1.6	3.9
79a	-0.1	0.4	0.2	-0.2	-0.3	-1.3	-0.6	-0.7	-0.5	0.3
79b	-0.8	-0.3	-0.6	-0.2	-0.3	-1.3	-0.6	-0.7	-0.5	-0.4
79c	-0.8	-0.3	-0.6	-0.2	-1.1	-0.6	-0.6	-0.7	-0.5	-0.4
80	1.2	1.8	1.3	1.2	1.3	1.7	1.5	1.4	1.1	1.3
81	1.3	1.8	1.6	1.2	1.8	1.6	1.6	1.4	1.6	1.7
82	1.0	1.1	0.9	1.4	1.4	1.3	1.6	2.1	1.3	1.0
85	-1.5	-1.7	-1.3	-1.6	-1.8	-1.3	-1.3	-1.5	-1.2	-1.8
91	0.6	1.8	0.9	0.5	1.1	1.6	0.8	0.7	0.2	1.0
94a	-0.1	0.4	0.2	-0.2	-0.3	0.1	-0.6	0.0	-0.5	-0.4
94b	-0.8	-1.0	-1.3	-0.9	-1.1	-0.6	-0.6	0.0	-0.5	-1.1

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	-0.1	-0.2	0.5	-0.2	0.6	-1.1	0.4	0.5	0.8	0.8
2	1.5	3.3	2.6	2.5	1.4	1.5	1.8	1.5	1.9	1.9
4a	0.9	0.4	-0.5	1.0	0.8	1.6	0.0	0.5	1.6	0.7
4b	-1.0	-1.6	-1.4	-0.6	-0.1	-2.7	-0.3	0.1	0.2	0.0
5	0.4	0.0	0.7	1.2	0.4	0.8	0.7	1.5	0.6	0.5
6	0.4	2.3	0.1	0.6	0.4	6.1	1.3	0.9	0.6	1.1
8a	-0.2	-0.6	-0.5	-0.6	-0.2	-1.5	-0.5	-0.3	-0.6	0.0
8b	-0.8	0.0	-0.5	-0.6	0.4	-0.9	0.1	0.3	0.0	0.5
10	3.3	1.7	0.1	1.2	1.6	3.8	-2.8	-1.5	-0.6	1.7
11a	-0.5	-1.3	-1.2	-0.5	-0.3	-1.5	-0.4	-0.1	-0.4	0.4
11b	-0.8	-1.2	-0.7	-0.9	-0.2	-1.8	-0.3	-0.2	0.1	0.7
12	-0.2	-0.6	-1.6	0.6	-0.8	0.2	-0.5	-0.9	-1.2	-0.6
15	-0.2	0.5	0.7	-0.6	-0.8	-0.4	-0.5	-0.9	-0.6	-0.6
17a	-0.5	-0.3	0.1	0.6	0.4	1.4	-0.2	0.3	0.3	0.2
18	0.4	-0.6	-0.5	-0.6	-0.2	-0.4	0.1	-0.3	0.6	-0.6
19	0.8	1.7	2.5	1.1	0.7	1.4	0.4	0.8	0.3	0.3
24	0.4	2.3	0.7	-0.6	0.4	0.8	0.1	0.3	0.0	1.1
25	-0.8	0.0	-1.6	-0.6	-0.2	-1.5	-0.5	-0.9	-0.6	0.0
27	-1.0	-1.9	-1.5	-1.0	-0.1	-5.2	-1.5	-1.2	-1.0	-0.9
30a	0.7	-1.2	0.3	-0.4	-0.6	1.1	1.3	0.4	-0.7	0.0
30b	1.6	0.5	1.5	1.8	1.1	-0.4	1.1	0.9	1.0	0.7
30c	0.1	-2.0	-2.5	-2.2	-2.7	-4.1	-3.1	-3.1	-2.9	-2.9
30h	0.1	0.2	4.3	0.0	0.1	3.7	-0.7	0.8	1.5	-0.8
32	-0.8	-0.6	-0.5	0.0	-0.8	-0.4	0.7	-0.3	-0.6	-0.6
33	-0.2	0.5	1.3	0.6	0.4	1.4	0.1	0.9	1.1	1.1
56	-0.8	-1.2	-0.5	0.0	-0.8	-0.4	-1.0	-0.9	-0.6	-0.6
64	-0.6	-1.3	-1.6	-0.3	-1.0	-2.2	-1.3	-1.1	-1.2	-1.0
68	-0.2	0.0	-0.5	-0.6	-0.8	-2.7	-1.0	-0.9	0.0	-0.6
79a	1.5	0.0	0.1	0.0	0.4	-0.9	0.1	0.3	0.0	-0.6
79c	-0.8	-1.2	-0.5	-0.6	-0.8	5.5	-1.0	-0.3	0.6	-0.6
80	1.2	1.3	1.2	0.5	1.0	0.1	1.3	0.9	1.5	1.0
82	1.2	0.5	0.3	0.6	1.0	-0.8	0.7	1.2	1.1	0.8
84	-1.4	0.5	-0.5	-1.2	-0.8	0.2	0.1	-0.3	-0.6	-0.6
85	-0.8	-1.2	-1.6	-0.6	-1.4	0.2	-1.0	-0.9	-1.2	-1.2
91	1.8	1.7	2.8	1.2	0.4	-0.4	0.4	0.9	0.6	0.8
94a	-0.8	-1.2	-0.5	-1.2	-0.8	-2.1	0.1	-0.9	-0.6	-1.2
94b	-0.2	1.1	-1.6	0.0	-0.8	1.4	-0.5	-0.9	-0.6	-0.6

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 51 different set of scans submitted by 41 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 WGN2022.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.60	13.45	12.99	10.92	13.71	10.45	9.78	13.19	11.27	12.48
3	0.08	-0.07	0.09	0.00	0.02	0.07	-0.01	-0.09	-0.06	-0.08
4	0.06	0.07	0.08	0.06	0.08	0.13	0.08	0.07	0.07	0.08
5	0.51	0.10	0.64	0.59	0.60	1.20	0.86	0.52	0.66	0.62

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	12.74	13.28	9.09	13.28	11.99	12.88	9.74	9.97	9.74	10.43
3	0.10	-0.23	0.68	-0.02	-0.34	-0.04	0.12	-0.03	0.43	-0.11
4	0.17	0.19	0.20	0.15	0.10	0.19	0.18	0.11	0.19	0.10
5	1.32	1.46	2.21	1.10	0.81	1.48	1.89	1.11	1.92	0.98

Table 5.2.5.2 - Results of statistical analysis for the determination of the protein content in barley 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:

For description of Z-score calculations, see section 4.2. Results for wheat shows extremely good agreement among all Infratec instruments. There are no red or yellow marked results at all.

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 79b 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 four red marked and nine yellow marked. This means that the larger number of red and 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
1a	0.3	0.1	0.6	-0.3	0.5	0.8	0.6	0.6	0.3	0.1
1b	0.1	0.0	-0.5	-0.3	-0.2	0.5	0.1	-0.4	0.4	0.5
2	0.2	0.6	0.4	-0.3	0.2	-0.5	0.5	0.0	0.1	-0.1
4a	-0.3	0.0	1.0	0.2	-0.7	-0.4	0.0	0.5	0.4	0.9
4b	0.4	0.2	0.1	0.4	0.7	-0.1	0.4	-0.3	0.1	-0.2
5	-0.2	-0.3	0.5	-0.3	-0.2	-0.5	-0.1	-0.1	0.4	0.1
8a	0.5	0.1	1.0	0.5	0.1	1.5	0.6	0.7	0.8	0.1
8b	0.3	0.1	-0.1	0.2	0.0	-0.1	0.1	0.3	0.3	0.2
10	-0.2	0.6	-0.4	0.3	1.3	0.9	0.0	-0.5	-0.3	0.1
11a	0.0	0.0	0.2	0.1	0.1	0.0	0.3	0.3	-0.2	-0.1
11b	-0.1	-0.1	0.4	0.3	0.1	0.5	0.0	0.1	0.5	-0.3
11e	-0.3	0.0	0.1	0.2	0.2	0.3	0.7	0.4	-0.1	-0.3
12	0.0	-0.1	-0.2	-0.4	-0.8	0.1	-0.7	0.0	-0.1	-0.4
15	-0.3	0.3	0.3	0.2	0.6	1.0	0.3	-0.6	-0.4	0.1
17	-0.2	-0.3	-0.5	-0.5	0.1	0.3	-0.4	0.1	-0.3	-0.3
18	0.1	-0.6	0.1	-0.1	0.2	-0.1	0.2	0.6	0.3	-0.3
19	-0.4	-0.9	-0.1	-0.5	0.0	-1.4	-0.9	0.4	-0.3	-0.1
24	-0.1	-0.3	-0.6	-0.6	-0.6	0.2	-0.1	0.2	-0.1	-0.3
26	0.3	-0.1	0.0	0.1	0.0	-0.6	-0.4	-0.4	-0.1	-0.2
30b	-0.1	0.1	0.1	0.7	0.0	-0.5	-0.6	-0.3	-0.4	-0.3
30c	-0.1	0.2	0.2	0.0	0.5	-0.5	0.2	-0.4	-0.4	0.3
30h	0.6	0.2	-0.6	-0.2	-0.1	0.1	-0.9	0.4	0.0	-0.2
33	0.4	0.0	0.5	-0.1	-0.5	0.1	-0.4	0.2	0.4	0.1
35a	-0.4	0.3	-0.5	0.6	-0.1	-0.3	0.2	-0.1	0.8	0.0
35b	0.0	0.0	-0.2	-0.2	0.1	0.1	0.2	-0.1	0.2	-0.3
35c	-0.2	0.2	0.1	0.5	0.2	0.3	0.1	0.3	0.2	0.0
35d	-0.2	-0.4	-0.2	-0.1	-0.3	0.7	-0.5	-0.2	-0.2	-0.9
56	0.1	-0.1	0.1	-0.2	0.0	0.3	0.1	0.2	-0.3	0.0
64	0.8	0.2	-0.3	0.4	0.1	0.0	0.3	0.0	0.4	-0.1
66	0.5	-0.3	0.2	0.3	0.1	0.4	0.3	0.1	0.2	0.2
68	-0.3	-0.3	0.0	-0.2	-0.2	0.3	-0.1	-0.5	-0.7	-0.9
75a	-0.1	0.5	0.2	-0.1	0.2	0.0	0.0	-0.2	-0.5	0.0
75b	-0.5	0.2	0.3	0.3	-0.2	-0.1	0.0	-0.3	0.2	0.3
77a	0.5	0.9	0.5	-0.2	-0.5	1.3	0.8	0.3	-0.2	0.6
79a	-0.4	0.8	-0.6	-0.1	-0.1	-0.4	0.7	0.1	0.4	0.6
79b	0.2	-0.7	-0.3	-0.2	-1.0	-0.4	-0.1	-0.4	0.0	-0.1
79c	-0.3	0.0	-0.9	-0.2	-0.2	-0.2	-0.2	-0.5	-0.4	0.5
80	-0.2	-0.3	-0.1	0.3	0.1	0.1	0.4	0.0	0.2	0.2
81	0.0	-0.1	-0.1	-0.3	0.4	-1.8	-0.2	-0.3	-0.2	1.1
82	-0.7	-0.1	-0.2	-0.1	0.1	-0.5	-0.7	-0.3	-0.1	0.0
85	-0.2	0.4	0.4	1.3	-0.6	-0.9	-0.7	0.4	-0.9	-0.5
91	-0.2	-0.5	-0.1	-0.1	0.1	-0.8	0.0	-0.4	0.2	0.0
94a	0.1	-0.1	-0.1	0.4	0.1	0.1	0.2	0.1	-0.4	0.3
94b	0.3	-0.3	-0.7	-0.1	0.2	0.1	-0.1	-0.2	0.0	-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
1a	0.1	-0.1	0.9	0.4	0.4	0.6	1.4	0.7	0.4	1.0
1b	1.1	-0.2	1.3	-0.3	-0.7	-0.5	0.0	0.5	0.3	0.2
2	0.2	-0.3	-1.7	0.3	0.0	-2.0	0.4	0.7	0.7	-0.1
4a	-0.6	0.1	1.1	-0.3	0.5	0.1	0.1	-0.7	-1.7	0.3
4b	-0.7	0.2	0.7	0.3	-0.2	1.8	-1.3	0.4	0.9	0.3
5	0.5	0.4	-0.9	-0.5	0.2	-0.1	0.4	0.5	0.6	0.4
6	-1.1	-1.9	-1.5	0.2	0.0	-4.5	-2.0	0.0	1.7	-1.4
8a	1.3	0.8	0.1	0.0	0.4	0.3	1.1	0.7	1.1	0.5
8b	-0.7	-0.1	0.4	0.4	0.4	0.5	0.2	-0.7	0.6	-0.2
10	0.3	1.3	0.7	0.4	0.3	0.0	0.0	0.2	-0.2	-0.2
11a	-1.0	0.2	0.0	1.3	-0.4	-5.1	2.0	-0.1	-1.2	0.1
11b	0.9	1.5	1.4	1.4	1.3	-1.0	0.5	-0.6	0.2	-0.2
11e	1.7	1.0	0.1	-0.6	0.1	-0.6	0.8	0.1	0.1	0.6
12	-0.3	-1.2	-0.5	-0.5	0.7	0.3	-2.4	-1.5	-0.5	-0.6
15	0.6	-2.7	0.9	-0.7	0.0	-1.9	-0.9	-0.2	1.5	0.1
17	0.7	1.4	-0.4	-0.1	-1.2	-0.1	-1.2	0.0	-0.7	0.5
18	0.8	-0.5	-2.3	0.8	-0.1	-1.2	-0.4	-0.8	0.0	0.8
19	-1.4	-0.5	0.2	1.2	-1.2	-0.2	1.3	0.1	-2.1	-0.7
24	-0.4	-0.3	0.9	0.6	-0.3	0.2	0.1	-0.1	0.6	0.4
25	0.1	-0.2	-0.9	0.0	-0.8	-0.1	-0.5	-0.1	0.1	-0.2
30b	0.4	0.5	-1.9	-1.1	0.0	0.8	0.7	-0.4	0.7	-0.3
30c	1.4	-0.1	1.5	-1.2	0.0	1.8	0.1	0.1	-0.3	0.2
30h	-0.5	1.4	0.3	-0.3	0.1	-0.2	-0.6	1.2	0.5	-1.1
32	0.4	0.1	0.0	-0.3	-0.1	-1.1	0.1	0.3	-0.6	-0.7
33	-1.4	-1.2	0.9	0.1	0.4	1.8	-0.7	-0.3	0.7	-0.6
56	-0.2	1.0	-0.1	-0.6	0.3	-1.4	-0.5	-0.2	0.1	0.1
64	0.0	1.0	-0.5	-0.1	0.1	0.4	0.4	0.2	0.5	0.0
79a	-1.5	-1.0	-1.4	-0.3	0.2	0.5	0.1	1.1	1.1	0.1
79c	0.8	-0.2	-0.9	1.6	-0.6	-3.9	0.0	-2.0	-2.2	-0.4
80	-0.9	-0.3	0.7	0.5	0.3	0.5	0.5	-0.1	-0.2	0.2
82	-0.4	-1.5	-0.5	0.1	-0.2	0.8	0.0	-0.1	-0.4	-0.5
84	0.1	1.1	-1.0	0.6	0.1	-1.1	0.1	-0.9	-2.0	0.2
85	0.1	-0.9	1.0	-1.2	-0.3	0.4	0.0	0.1	0.2	0.6
91	-1.2	-0.4	0.0	-1.2	0.3	-0.1	-0.1	-0.2	-0.7	0.5
94a	0.8	0.8	1.3	-0.3	0.1	1.1	0.8	0.1	0.2	0.3
94b	-0.3	0.7	0.3	-0.8	0.0	-0.2	-0.8	-0.1	0.0	0.1

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 51 sets of scans from 41 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 WGN2022.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	13.53	11.91	13.18	12.03	12.63	15.85	13.37	13.51	13.66	11.57
3	0.06	-0.01	-0.13	-0.09	-0.16	-0.16	-0.34	-0.44	-0.30	-0.07
4	0.06	0.06	0.05	0.05	0.04	0.08	0.06	0.04	0.06	0.05
5	0.41	0.50	0.39	0.39	0.29	0.50	0.43	0.32	0.41	0.46

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	12.06	12.75	13.34	12.39	12.87	12.12	15.66	14.39	14.04	14.11
3	0.02	-0.05	0.03	-0.05	-0.05	0.42	0.09	0.06	0.09	0.05
4	0.09	0.11	0.10	0.06	0.05	0.23	0.08	0.05	0.07	0.06
5	0.73	0.84	0.76	0.51	0.40	1.86	0.52	0.33	0.51	0.42

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

For description of Z-score calculations, see section 4.2. The results for wheat show the same good alignment as for protein with no red or yellow marked result.

For barley, one red marked sample (B6 for lab 6) and five yellow marked samples (one for B2 and the rest for B6). This suggests that B6 has a slightly higher inhomogeneity than the other samples. Overall it looks fine.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1a	-0.1	-0.3	-0.2	-0.4	-0.2	0.4	0.0	0.4	-0.1	-0.3
1b	0.1	0.1	0.1	-0.1	0.2	0.0	0.1	-0.1	0.4	0.1
2	0.1	0.1	0.0	0.0	-0.1	0.3	-0.2	-0.1	0.2	0.1
4a	0.1	-0.6	0.3	-0.1	0.3	0.4	0.5	0.3	0.4	-0.3
4b	-0.2	-0.3	-0.3	0.0	-0.1	-0.3	-0.1	0.0	0.0	-0.2
5	0.1	0.1	0.2	0.1	0.1	0.3	0.0	-0.1	-0.1	0.1
8a	-0.1	-0.2	0.0	-0.2	0.1	1.6	0.1	0.3	-0.2	-0.4
8b	0.1	0.1	0.2	-0.1	0.2	0.5	-0.1	0.0	-0.1	-0.1
10	0.9	0.7	0.5	0.5	0.6	0.9	0.9	0.6	1.1	0.3
11a	0.0	-0.1	0.1	-0.1	0.3	0.8	0.7	0.1	0.4	-0.2
11b	0.1	-0.2	0.0	0.0	0.6	0.5	0.1	0.3	0.4	-0.5
11e	-0.7	-0.4	-0.7	-0.5	-0.6	-0.9	-0.6	-0.6	-0.7	-0.3
12	0.0	-0.2	0.1	-0.2	-0.2	0.3	0.3	0.3	0.2	-0.1
15	-0.1	0.2	0.1	0.3	-0.2	-0.3	-0.4	-0.3	0.0	0.4
17	0.2	-0.2	0.1	-0.4	0.2	0.4	0.4	0.4	0.1	-0.2
18	-0.4	-0.1	-0.5	-0.1	-0.4	-1.0	-0.3	0.0	-0.7	-0.3
19	-0.3	-0.2	-0.2	-0.2	-0.3	-0.4	-0.1	0.1	-0.2	-0.4
24	0.5	0.4	0.4	0.6	0.1	0.3	0.1	0.2	0.2	0.0
26	0.2	0.3	0.0	0.0	0.1	0.1	-0.4	-0.1	0.1	0.1
30b	0.8	1.0	0.2	0.7	0.3	-0.7	0.4	0.3	0.4	0.8
30c	0.3	0.7	0.3	0.6	0.2	-0.6	-0.1	-0.2	-0.3	0.4
30h	0.3	0.6	0.4	0.6	0.3	-0.9	0.1	0.0	0.1	0.9
33	0.2	0.1	0.2	0.3	0.0	0.6	0.5	0.4	0.6	0.2
35a	0.5	0.5	0.6	0.2	-0.1	-0.6	0.0	0.0	0.3	0.3
35b	-0.1	0.2	0.1	0.1	-0.1	-0.3	-0.3	-0.3	0.2	0.2
35a	-0.4	-0.1	-0.1	-0.1	-0.5	-0.6	-0.7	-0.5	-0.4	0.1
35d	-0.6	-0.4	-0.4	-0.3	-0.2	-0.6	-0.6	-0.5	-0.5	-0.5
56	-0.7	-0.5	-0.6	-0.5	-0.5	-0.5	-0.9	-0.8	-0.7	-0.3
64	-0.3	-0.5	-0.6	-0.2	-0.2	-0.4	-0.3	0.1	-0.2	-0.1
66	-0.2	0.1	-0.1	0.0	-0.2	-0.3	-0.4	-0.2	-0.5	-0.1
68	-0.2	-0.6	-0.4	-0.5	-0.1	0.4	0.5	0.2	-0.2	-0.3
75a	0.0	0.1	-0.1	0.1	0.1	0.2	0.3	0.1	0.1	-0.1
75b	0.0	-0.1	-0.1	0.0	-0.1	0.5	0.2	0.0	0.1	-0.2
77a	-0.7	-0.3	-0.8	-0.2	0.0	-1.1	-0.6	-0.4	-1.0	0.3
79a	0.9	1.0	0.9	0.5	0.4	-0.3	0.4	0.3	0.4	1.1
79b	0.4	0.4	0.4	0.4	0.3	0.3	0.5	0.0	0.5	0.5
79c	0.4	0.1	0.3	0.2	0.0	0.0	0.1	0.1	0.1	0.4
80	-0.3	-0.1	-0.2	-0.3	-0.2	0.0	-0.2	-0.4	-0.4	-0.3
81	0.3	0.4	0.3	0.2	0.1	0.0	0.0	0.1	0.0	0.2
82	-0.1	-0.5	-0.1	0.1	0.3	0.6	0.5	0.5	0.2	-0.2
85	-0.9	-1.1	-0.8	-0.9	-1.1	-0.4	-0.6	-0.7	-0.3	-0.8
91	0.0	0.2	0.1	-0.1	-0.1	0.3	-0.2	-0.2	-0.3	-0.1
94a	0.0	0.0	0.0	0.1	-0.1	-0.1	-0.2	-0.1	0.0	0.0
94b	-0.1	-0.3	0.0	-0.1	-0.2	0.2	0.4	0.2	0.2	-0.2

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
1a	-0.8	0.0	-0.1	-0.3	0.1	-1.0	0.1	0.1	0.3	0.2
1b	0.1	0.8	0.6	0.1	0.1	0.5	0.6	0.2	0.2	0.3
2	0.5	1.0	0.8	0.2	0.3	0.1	0.6	0.3	0.7	0.3
4a	0.2	-0.4	-1.0	0.1	-0.3	0.3	-0.3	-0.2	-0.4	0.0
4b	-0.8	-1.3	-1.1	-0.6	-0.5	-1.9	-0.5	-0.3	0.0	-0.2
5	0.0	0.1	0.3	0.1	0.3	-0.1	0.5	0.5	0.3	0.4
6	0.3	1.1	0.0	0.4	0.0	3.3	0.0	0.4	-0.3	-0.3
8a	-0.2	-0.1	0.0	-0.2	0.0	-0.5	0.0	0.1	0.3	0.1
8b	0.0	0.4	0.1	0.2	0.4	-0.7	0.6	0.4	0.5	0.6
10	0.4	0.8	0.2	0.3	0.6	1.7	0.6	0.1	0.2	0.8
11a	0.0	-0.4	-0.4	0.1	0.0	-0.7	0.3	0.2	0.0	0.4
11b	-0.4	-0.3	0.1	-0.3	0.2	-1.0	0.4	0.2	0.5	0.7
11e	0.0	0.1	-0.2	0.2	-0.2	0.5	-0.5	-0.3	-0.1	-0.3
12	-0.6	-0.5	-0.1	0.0	-0.5	-1.0	-0.2	-0.2	-0.7	-0.1
15	0.7	1.1	0.4	0.5	0.4	0.2	0.4	0.0	0.3	0.1
17	-0.5	-0.3	-0.3	-0.2	-0.1	-1.3	0.0	0.0	0.1	0.2
18	-0.1	0.0	0.2	-0.3	0.1	0.0	-0.1	-0.1	0.1	-0.3
19	-0.4	-0.9	-0.4	-0.6	-0.3	-2.1	-0.4	-0.4	-1.1	-0.8
24	0.8	2.5	1.7	0.3	0.5	1.5	0.7	0.4	0.5	1.3
25	-0.6	-0.6	-0.6	-0.4	-0.3	-1.6	-1.0	-0.3	-0.3	-0.4
30b	1.0	0.3	0.2	0.9	0.3	-0.6	0.4	0.0	0.5	-0.1
30c	0.9	0.1	0.3	0.6	0.1	-1.0	-0.2	-0.3	-0.1	-0.2
30h	0.7	0.9	1.0	0.5	0.3	2.4	-0.4	0.1	-0.2	-0.3
32	-0.3	0.2	0.2	-0.1	-0.2	0.9	0.6	0.1	0.0	0.1
33	-0.3	0.0	0.2	0.1	0.0	2.4	-0.2	0.2	0.6	0.3
56	-0.5	-0.4	0.0	-0.1	-0.3	0.0	-0.5	-0.3	-0.3	-0.3
64	-0.2	-0.4	-0.4	-0.2	-0.5	-1.2	-0.6	-0.5	-0.4	-0.4
79a	1.2	0.6	0.3	0.7	0.4	0.2	0.4	0.4	0.1	0.1
79c	0.0	-0.4	0.0	-0.3	-0.2	2.9	-0.9	-0.1	-0.2	-0.2
80	0.2	0.4	0.1	-0.2	0.0	-0.8	0.4	-0.1	0.4	0.1
82	0.0	-0.2	-0.8	-0.2	-0.2	-1.1	-0.4	0.2	-0.3	-0.1
84	-0.4	-0.3	-0.1	-0.5	-0.2	0.7	-0.3	-0.1	-0.3	0.0
85	-0.9	-1.6	-1.5	-0.4	-1.2	-0.6	-0.8	-0.4	-0.9	-0.7
91	0.1	0.6	0.4	0.3	-0.2	0.9	-0.1	0.2	-0.1	0.2
94a	0.2	0.0	0.5	0.0	0.2	-0.7	0.6	0.0	0.5	-0.1
94b	-0.2	-0.3	-0.8	-0.6	-0.3	-0.7	-0.1	-0.4	-0.4	0.0

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 2022 all samples (2021 harvest)	Ref. methods	Local models	FOSS ANN
Protein, range	8.4 % - 13.7 %		
Mean (%)	11.67	11.72	11.70
deviation from mean		0.11	0.03
SD reproducibility	0.17	0.19	0.12
RSD reproducibility	1.4	1.7	1.0
Moisture, range	11.6 % - 16.0 %		
Mean (%)	13.30	13.34	13.25
deviation from mean		0.04	-0.05
SD reproducibility	0.17	0.18	0.07
RSD reproducibility	1.3	1.4	0.6

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

WGN 2022 Wheat (2021 samples)	Ref. methods	Local models	FOSS ANN
Protein, range	9.8% - 13.7 %		
Mean (%)	12.09	12.13	12.08
deviation from mean		0.04	0.00
SD reproducibility	0.16	0.16	0.08
RSD reproducibility	1.3	1.4	0.6
Moisture, range	11.6 % - 16.0 %		
Mean (%)	13.29	13.22	13.12
deviation from mean		-0.07	-0.16
SD reproducibility	0.22	0.17	0.05
RSD reproducibility	1.7	1.3	0.4

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

WGN 2022 Barley (2021 samples)	Ref. methods	Local models	FOSS ANN
Protein, range	8.4 % - 13.5 %		
Mean (%)	11.26	11.31	11.31
deviation from mean		0.05	0.05
SD reproducibility	0.18	0.22	0.16
RSD reproducibility	1.6	2.0	1.4
Moisture, range	11.7 % - 15.6 %		
Mean (%)	13.31	13.47	13.37
deviation from mean		0.15	0.06
SD reproducibility	0.13	0.19	0.09
RSD reproducibility	1.0	1.4	0.7

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

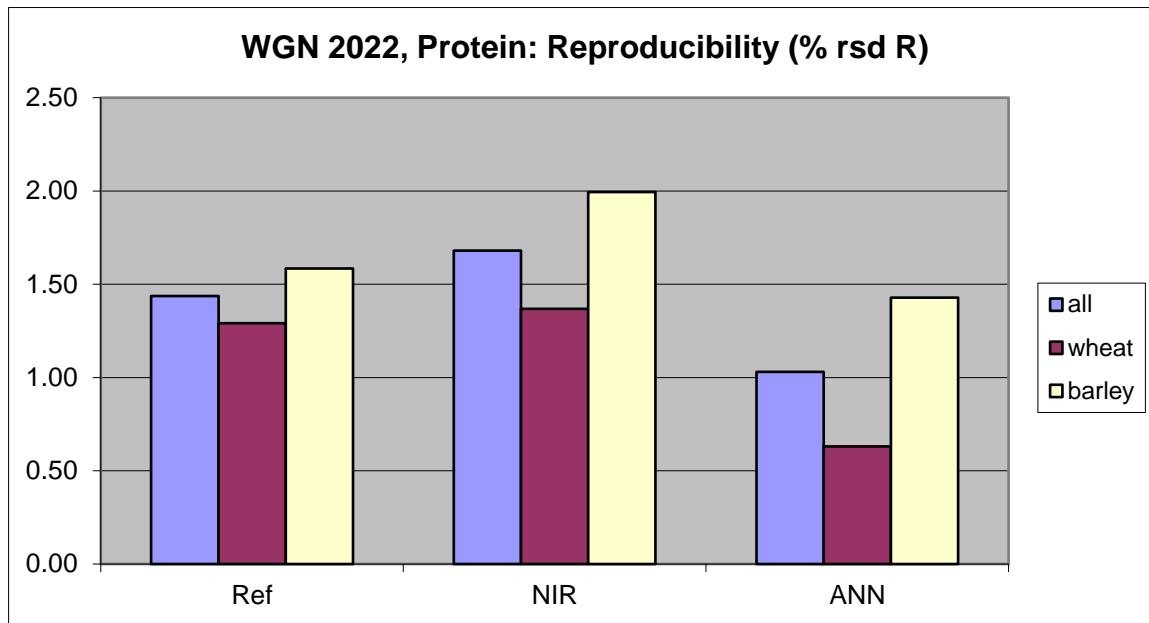


Fig. 5.3.1a: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model WB003034 (ANN) for the determination of **protein**.

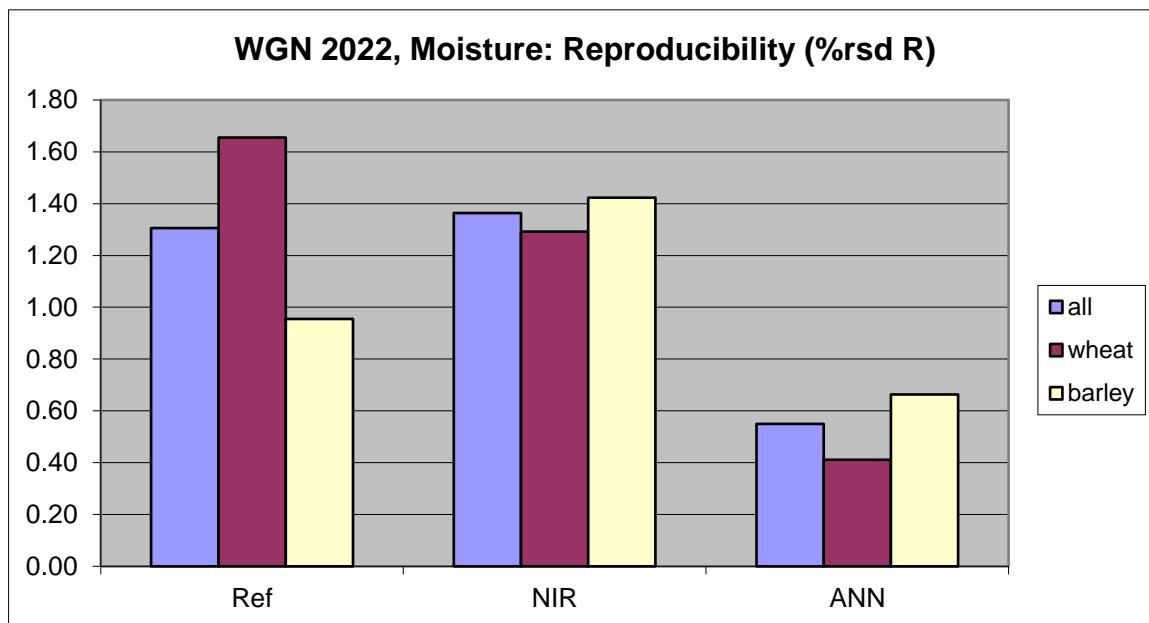


Fig. 5.3.1b: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model WB003034 (ANN) for the determination of **moisture**.

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

(0.11%) and for moisture (0.04%) 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 wheat and slightly worse for barley. For moisture, the reproducibility is better for the reference method compared to local prediction models for barley, but for wheat the local models are better. This indicate a larger spread of adjustments for the local prediction models applied to barley than seems to be justified.

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 (0.03%) and for moisture (-0.03%). The unadjusted ANN model has somewhat larger deviation for moisture in wheat (-0.16%) than the local models (-0.07%). 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. 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. Note that barley sample B6 deviate for both local and global ANN compared to moisture reference. This sample is showing more elevated Z-scores than the other for both local and global ANN. In addition, there has been more observations of outliers when analyzing this sample on NIR instruments. The deviation to reference is then most likely related to inhomogeneity problems.

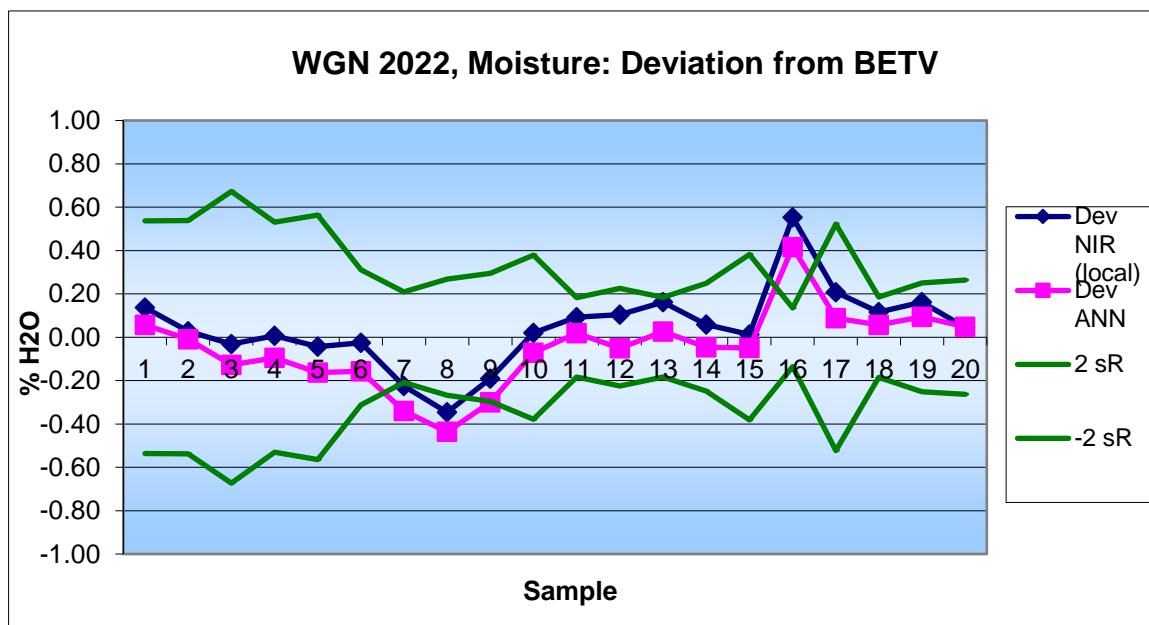


Fig. 5.3.2a: Deviations between predicted **moisture** values and the best estimate of the true value

The barley sample B6 is a French sample where it was reported during harvest of problems for protein analysis related to storage effects. Although, we can see some issues on moisture, the average behavior on protein is very good for both local and global ANN in terms of deviation to reference.

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 for all but one barley sample. It is the barley sample B3, which is an ecological spring barley from Denmark with a very low protein content (BETV=8.4% by reference). It is too low to be used as malting barley and hence is to be considered a feed barley. In any case this shows that it is important to keep updating the ANN models with new sample types.

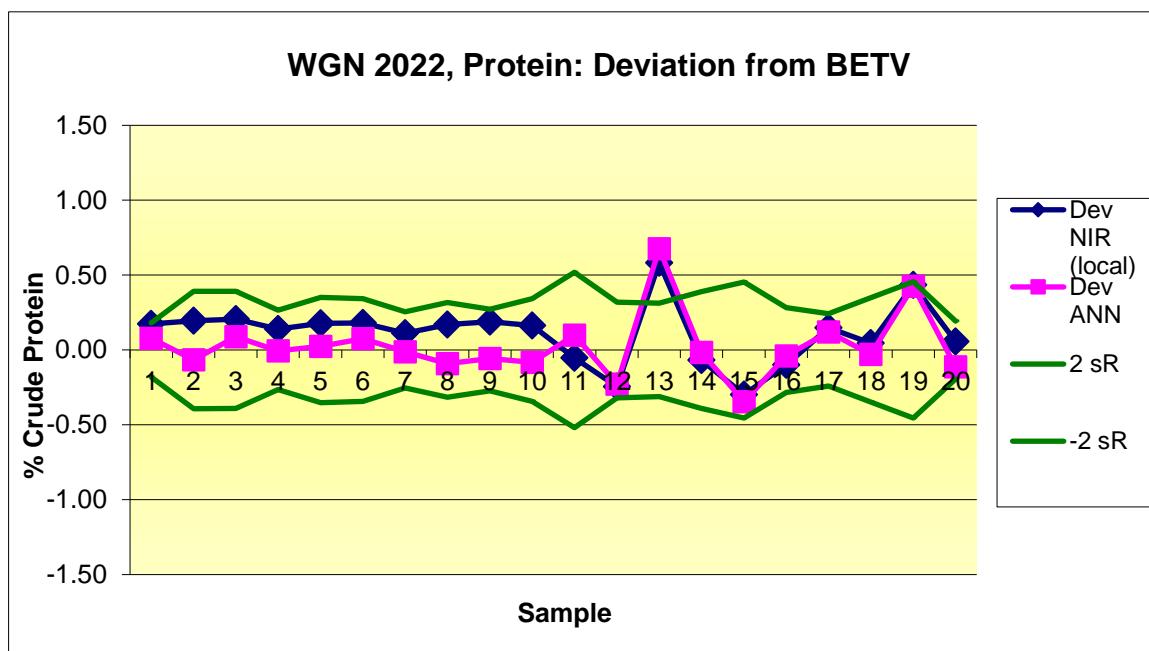


Fig. 5.3.2b: Deviations between predicted **protein** values and the best estimate of the true value

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

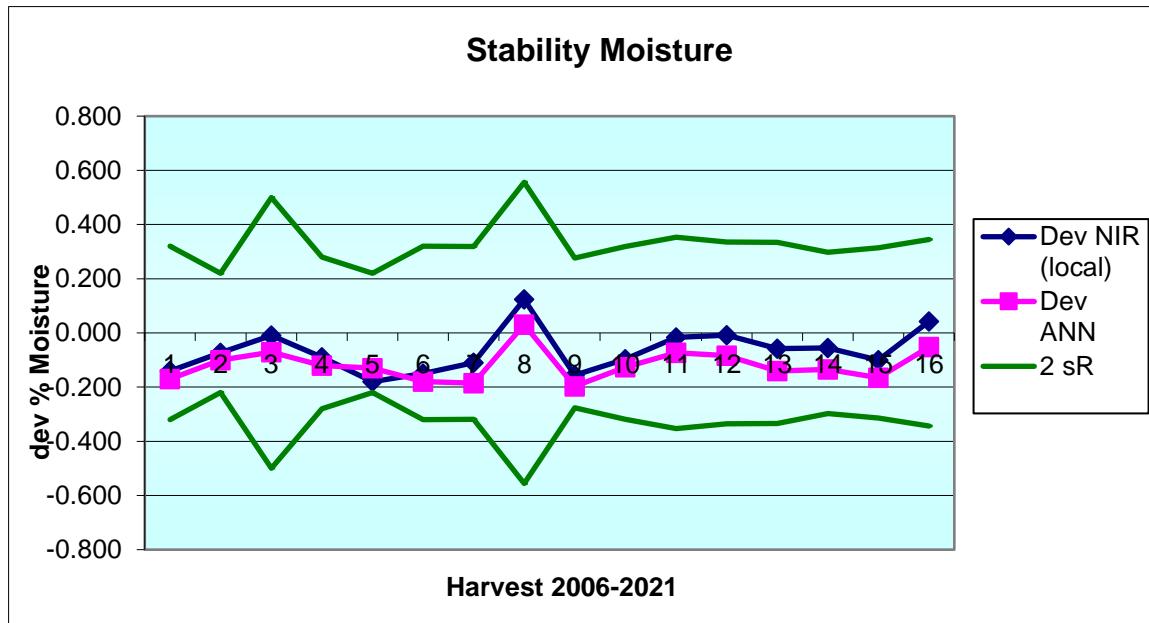


Figure 5.3.3 a: Average deviations of predicted moisture results from the best estimate of the true value during the past thirteen years. Blue = Local and Pink = ANN.

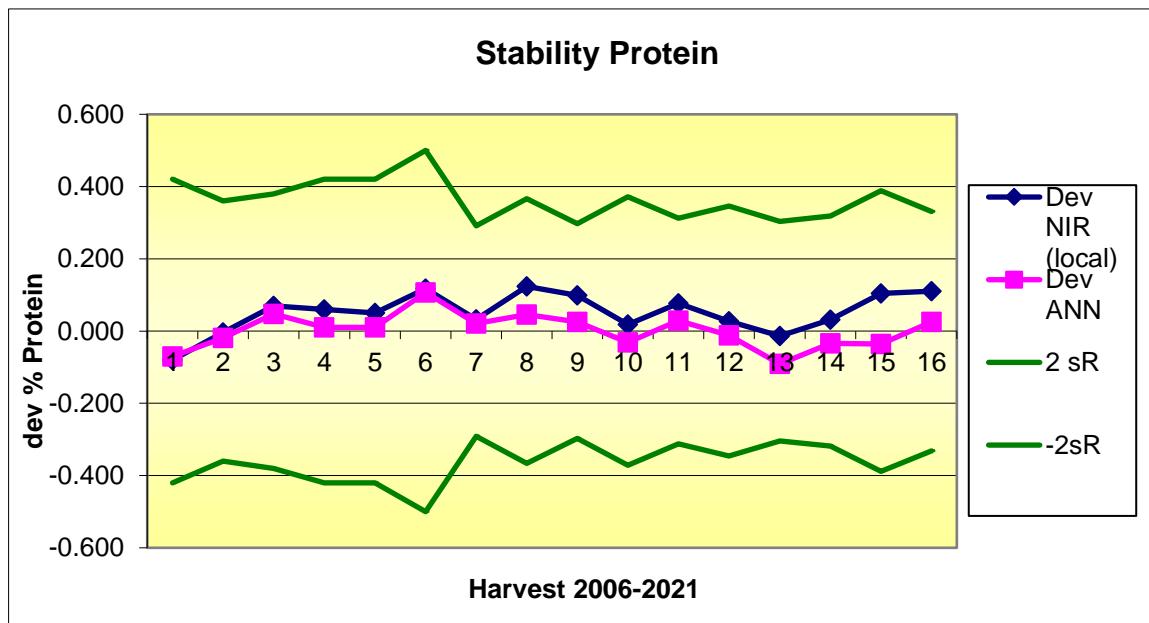


Figure 5.3.3 b: Average deviations of predicted protein results from the best estimate of the true value during the past thirteen years. Blue = Local and Pink = ANN.

6 Results for oil and moisture in Rapeseed

6.1 Collation of results

6.1.1 Oil content by reference methods

Nineteen sets of reference data were reported:

Labcode	Method code	Standard
2	O1	ISO 659:2009
4	O3	Foss Analytical ASN 3134
8	O1	ISO 659:2009
12	O4	ISO 10565:1998 (NMR)
15c	O4	ISO 10565:1998 (NMR)
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
33	O1	ISO 659:2009
35	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
64	O1	ISO 659:2009
68	O1	ISO 659:2009
80	O1	ISO 659:2009
85	O1	ISO 659:2009
91	O3	Foss Analytical ASN 3134
93	O1	ISO 659:2009
94	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-four sets of reference values from 23 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 665:2020	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	M1	ISO 665:2000	103° C, 1 h, whole seed
15b	M1	ISO 665:2000	103° C, 1 h, whole seed
15c	M2	ISO 10565:1998 (NMR)	NMR
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
30	M1	ISO 665:2000	103° C, 17 h, whole seed
33	M1	ISO 665:2000	103° C, 1 h, whole seed
35	M1	ISO 665:2000	103° C, 1 h, whole seed
64	M1	ISO 665:2000	103° C, 1 h, whole seed
68	M1	ISO 665:2000	103° C, 1 h, whole seed
80	M1	ISO 665:2000	103° C, 1 h, whole seed
82	M1	ISO 665:2000	103° C, 1 h, whole seed
91	M1	ISO 665:2000	103° C, 1 h, whole seed
93	M1	ISO 665:2000	103° C, 1 h, whole seed
94	M1	ISO 665:2000	103° C, 1 h, whole seed

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.

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

See table III.1 in Annex III.

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

See table III.2 in Annex III.

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

See table IV.1 in Annex IV.

6.1.6 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	46.66	45.47	47.31	46.75	47.23	45.87	47.55	48.76	50.10	48.08	47.4	-0.28	0.36
4	46.74	44.94	48.79	46.99	47.70	45.10	48.10	50.08	51.39	48.96	47.9	0.22	0.54
8	47.20	45.30	48.00	47.10	47.70	45.90	48.00	49.40	50.90	48.40	47.8	0.13	0.26
12	47.20	45.80	48.30	47.40	47.70	45.60	46.60	49.00	49.90	48.70	47.6	-0.04	0.55
15c	46.74	44.96	47.83	46.90	47.50	45.76	47.23	49.05	50.30	48.60	47.5	-0.17	0.17
17	46.80	45.40	47.80	47.10	48.10	45.40	47.20	48.90	50.20	48.40	47.5	-0.13	0.30
18	46.40	45.40	47.60	47.80	48.30	45.80	47.70	48.50	48.50	48.80	47.5	-0.18	0.77
19	45.92	44.36	47.02	46.17	47.06	45.14	47.20	48.67	50.20	48.39	47.0	-0.64	0.24
26	48.33	46.74	49.16	49.02	49.19	47.45	48.84	50.87	52.14	50.10	49.2	1.53	0.19
30a	43.12	42.18	45.68	45.31	45.83	43.33	45.61	46.58	48.93	45.30	45.2	-2.47	0.63
33	47.57	46.56	48.78	48.38	48.77	47.15	48.07	49.88	51.27	49.85	48.6	0.97	0.34
35	46.70	45.30	47.70	47.40	47.90	45.90	47.50	49.30	50.70	48.70	47.7	0.05	0.13
64	47.01	45.35	47.74	47.13	47.74	45.73	47.65	49.14	50.52	48.75	47.7	0.02	0.18
68	46.87	45.13	47.36	46.65	46.92	44.93	46.76	48.34	49.71	48.49	47.1	-0.54	0.43
80	46.32	44.58	47.21	46.56	47.40	45.38	47.55	48.84	49.98	47.87	47.2	-0.49	0.21
85	46.67	42.89	48.56	48.79	48.68	47.61	50.33	51.39	52.81	51.04	48.9	1.22	1.45
91	46.20	44.90	48.40	48.50	48.30	45.70	48.30	50.00	51.40	49.10	48.1	0.42	0.50
93	47.10	45.00	47.70	47.20	47.90	46.10	47.90	49.60	51.00	48.40	47.8	0.13	0.26
94	46.83	45.38	48.07	47.56	48.18	46.01	47.30	49.59	50.86	48.99	47.9	0.22	0.21
Average	46.7	45.0	47.8	47.3	47.8	45.8	47.7	49.3	50.6	48.7	47.7	0.0	0.4
Std	1.00	1.06	0.78	0.91	0.75	0.95	0.95	1.02	1.02	1.11	0.83	0.83	0.31
Min	43.1	42.2	45.7	45.3	45.8	43.3	45.6	46.6	48.5	45.3	45.2	-2.5	0.1
Max	48.3	46.7	49.2	49.0	49.2	47.6	50.3	51.4	52.8	51.0	49.2	1.5	1.4

*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	6.10	6.48	7.58	6.23	6.45	7.39	7.83	7.09	6.90	6.95	6.9	0.00	0.04
2	5.18	5.78	6.25	5.42	5.70	6.58	7.34	6.56	6.47	5.78	6.1	-0.80	0.27
4	6.18	6.64	7.71	6.32	6.63	7.58	7.87	7.24	6.95	6.92	7.0	0.10	0.04
5	6.20	6.60	7.40	6.30	6.40	7.60	7.70	7.20	6.60	6.80	6.9	-0.02	0.14
8	6.40	6.80	7.90	6.50	6.80	7.80	8.10	7.40	7.10	7.20	7.2	0.30	0.05
12	5.90	6.30	7.40	6.10	6.30	7.20	7.60	6.90	6.60	6.70	6.7	-0.20	0.04
15a	6.16	6.56	7.56	6.37	6.59	7.49	7.92	7.24	6.95	6.98	7.0	0.08	0.03
15b	5.84	6.42	7.30	6.10	6.33	7.35	7.78	7.12	6.89	6.84	6.8	-0.11	0.09
15c	5.62	5.98	7.26	6.00	6.28	6.85	7.91	6.98	6.90	6.70	6.6	-0.26	0.22
17	6.10	6.60	7.70	6.30	6.60	7.50	7.80	7.20	6.90	7.00	7.0	0.07	0.05
18	6.00	6.30	7.40	6.10	6.40	7.30	7.50	6.90	6.70	6.80	6.7	-0.16	0.07
19	6.21	6.67	7.77	6.37	6.61	7.58	7.96	7.27	7.00	7.04	7.0	0.14	0.04
25	6.00	6.50	7.60	6.30	6.50	7.50	7.90	7.00	6.70	6.70	6.9	-0.03	0.10
26	6.21	6.47	7.57	6.38	6.49	7.40	7.90	7.21	6.87	6.89	6.9	0.03	0.06
30	6.29	6.70	7.54	6.45	6.63	7.48	7.80	7.07	6.81	6.94	7.0	0.07	0.10
33	6.37	6.86	7.88	6.54	6.80	7.85	8.16	7.45	7.20	7.24	7.2	0.33	0.04
35	6.20	6.60	7.70	6.40	6.60	7.50	7.90	7.20	6.90	7.00	7.0	0.10	0.04
64	6.00	6.50	7.50	6.20	6.50	7.40	7.50	7.00	6.80	6.90	6.8	-0.07	0.10
68	6.07	6.53	7.62	6.30	6.53	7.45	7.81	7.10	6.87	6.93	6.9	0.02	0.03
80	6.33	6.80	7.89	6.52	6.79	7.57	7.99	7.27	7.03	7.09	7.1	0.22	0.07
82	6.17	6.54	7.62	6.29	6.61	7.45	7.81	7.11	6.90	6.87	6.9	0.03	0.04
91	6.00	6.50	7.50	6.10	6.50	7.50	7.80	7.40	6.80	6.80	6.9	-0.01	0.11
93	6.20	6.60	7.70	6.30	6.60	7.50	7.80	7.20	7.00	7.00	7.0	0.09	0.05
94	6.21	6.57	7.66	6.36	6.64	7.51	7.90	7.24	6.98	7.04	7.0	0.11	0.03
Average	6.1	6.5	7.5	6.3	6.5	7.4	7.8	7.1	6.9	6.9	6.9	0.0	0.1
Std	0.26	0.24	0.32	0.23	0.22	0.26	0.19	0.19	0.17	0.27	0.22	0.22	0.06
Min	5.2	5.8	6.3	5.4	5.7	6.6	7.3	6.6	6.5	5.8	6.1	-0.8	0.0
Max	6.4	6.9	7.9	6.5	6.8	7.9	8.2	7.5	7.2	7.2	7.2	0.3	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 WGN2022.

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 WGN2022.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	46.85	45.15	47.96	47.30	47.79	45.78	47.61	49.26	50.57	48.58
3	0.54	0.37	0.60	0.91	0.75	0.95	0.56	1.02	1.02	0.34
4	1.15	0.82	1.25	1.93	1.58	2.07	1.18	2.07	2.02	0.69

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:

For description of Z-score calculations, see section 4.2. The results show that the reference analyses for oil deviate significantly for all samples for labs 30a. In addition, labs 26 and 85 have two and six red marked, respectively. Lab 26 has all remaining sample results yellow marked and all samples with a positive sign meaning a tendency for a systematic shift. All Z-scores are not with the same sign for all samples of lab 85, so it might be a batch variation issue or simply a random issue with sample R2 (negative sign), whereas the other marked samples have a positive sign hence a systematic shift. Lab 18 has one sample red marked (R9) and all the other are fine, so a random problem. It is recommended to analyze the sample again.

It does not seem to be a matter of NMR versus conventional extraction methods since one of the deviating labs use NMR (lab 26) and two uses extraction (labs 30a and 85). In addition, we have another three labs using NMR with good performance (labs 12, 15a and 94).

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	-0.3	0.6	-1.2	-1.0	-1.0	0.2	-0.1	-0.9	-0.9	-0.9
4	-0.2	-0.4	1.5	-0.6	-0.2	-1.2	0.9	1.5	1.5	0.7
8	0.6	0.3	0.1	-0.4	-0.2	0.2	0.7	0.3	0.6	-0.3
12a	0.6	1.2	0.6	0.2	-0.2	-0.3	-1.8	-0.5	-1.2	0.2
15a	-0.2	-0.3	-0.2	-0.7	-0.5	0.0	-0.7	-0.4	-0.5	0.0
17	-0.1	0.5	-0.3	-0.4	0.6	-0.7	-0.8	-0.7	-0.7	-0.3
18	-0.8	0.5	-0.7	0.9	0.9	0.0	0.2	-1.4	-3.8	0.4
19	-1.7	-1.4	-1.7	-2.1	-1.3	-1.2	-0.8	-1.1	-0.7	-0.3
26	2.7	2.9	2.2	3.1	2.5	3.0	2.2	2.9	2.9	2.8
30a	-6.8	-5.4	-4.2	-3.6	-3.6	-4.5	-3.6	-4.9	-3.0	-6.0
33	1.3	2.6	1.5	2.0	1.8	2.5	0.8	1.1	1.3	2.3
35	-0.3	0.3	-0.5	0.2	0.2	0.2	-0.2	0.1	0.2	0.2
64	0.3	0.4	-0.4	-0.3	-0.1	-0.1	0.1	-0.2	-0.1	0.3
68	0.0	0.0	-1.1	-1.2	-1.6	-1.5	-1.6	-1.7	-1.6	-0.2
80	-1.0	-1.0	-1.4	-1.3	-0.7	-0.7	-0.1	-0.8	-1.1	-1.3
85	-0.3	-4.1	1.1	2.7	1.6	3.3	4.9	3.9	4.1	4.5
91	-1.2	-0.5	0.8	2.2	0.9	-0.1	1.2	1.3	1.5	1.0
93	0.5	-0.3	-0.5	-0.2	0.2	0.6	0.5	0.6	0.8	-0.3
94	0.0	0.4	0.2	0.5	0.7	0.4	-0.6	0.6	0.5	0.8

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 WGN2022.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	6.12	6.57	7.60	6.36	6.55	7.50	7.87	7.16	6.87	6.93
3	0.18	0.14	0.18	0.10	0.15	0.14	0.12	0.15	0.17	0.14
4	2.92	2.18	2.31	1.50	2.23	1.91	1.57	2.08	2.41	2.09

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:

For description of Z-score calculations, see section 4.2. The results show that the determination of moisture in rapeseed is not under control for lab 2 where there are nine red and one yellow marked, all with negative sign hence a systematic shift. Lab 15c has three red and two yellow marked, but even if most have negative sign it is not a clear systematic shift. It could be a batch variation issue. There are three other labs (18, 33 and 64) with yellow marked Z-scores, but results are just above limit and no action needed.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-0.1	-0.6	-0.1	-0.8	-0.6	-0.7	-0.2	-0.5	0.2	0.1
2	-5.9	-4.9	-8.4	-5.9	-5.3	-5.7	-3.3	-3.8	-2.5	-7.2
4	0.4	0.4	0.7	-0.2	0.5	0.5	0.0	0.5	0.5	0.0
5	0.5	0.2	-1.2	-0.4	-0.9	0.7	-1.1	0.2	-1.7	-0.8
8	1.8	1.4	1.9	0.9	1.6	1.9	1.4	1.5	1.5	1.7
12	-1.4	-1.7	-1.2	-1.6	-1.5	-1.8	-1.7	-1.7	-1.7	-1.4
15a	0.3	-0.1	-0.2	0.1	0.3	0.0	0.3	0.5	0.5	0.3
15b	-1.7	-0.9	-1.9	-1.6	-1.4	-0.9	-0.6	-0.3	0.1	-0.5
15c	-3.1	-3.7	-2.1	-2.2	-1.7	-4.0	0.3	-1.2	0.2	-1.4
17	-0.1	0.2	0.6	-0.4	0.3	0.0	-0.4	0.2	0.2	0.5
18	-0.7	-1.7	-1.2	-1.6	-0.9	-1.2	-2.3	-1.7	-1.0	-0.8
19	0.6	0.6	1.1	0.1	0.4	0.5	0.6	0.7	0.8	0.7
25	-0.7	-0.4	0.0	-0.4	-0.3	0.0	0.2	-1.0	-1.0	-1.4
26	0.6	-0.6	-0.2	0.1	-0.4	-0.6	0.2	0.3	0.0	-0.2
30	1.1	0.8	-0.4	0.6	0.5	-0.1	-0.4	-0.6	-0.4	0.1
33	1.6	1.8	1.8	1.1	1.6	2.2	1.8	1.8	2.1	2.0
35	0.5	0.2	0.6	0.3	0.3	0.0	0.2	0.2	0.2	0.5
64	-0.7	-0.4	-0.6	-1.0	-0.3	-0.6	-2.3	-1.0	-0.4	-0.2
68	-0.3	-0.3	0.1	-0.4	-0.1	-0.3	-0.4	-0.4	0.0	0.0
80	1.3	1.4	1.8	1.0	1.5	0.5	0.8	0.7	1.0	1.0
82	0.3	-0.2	0.1	-0.4	0.4	-0.3	-0.4	-0.3	0.2	-0.4
91	-0.7	-0.4	-0.6	-1.6	-0.3	0.0	-0.4	1.5	-0.4	-0.8
93	0.5	0.2	0.6	-0.4	0.3	0.0	-0.4	0.2	0.8	0.5
94	0.6	0.0	0.4	0.0	0.6	0.1	0.2	0.5	0.7	0.7

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 WGN2022.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	47.82	46.25	48.09	47.58	48.20	45.73	47.57	48.85	49.88	48.91
3	0.97	1.10	0.12	0.28	0.41	-0.05	-0.05	-0.41	-0.69	0.33
4	0.85	0.73	1.05	0.49	0.47	1.06	0.47	0.52	0.76	0.42
5	1.77	1.58	2.18	1.03	0.97	2.32	0.98	1.06	1.53	0.86

Table 6.2.3.1 - Results of statistical analysis for the determination of the oil content in rapeseed 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:

For description of Z-score calculations, see section 4.2. Three labs (30a, 79c and 85) have a significant systematic shift with all Z-scores red marked. These instruments should be adjusted. Some labs (35a-35c and 80) have some samples red marked, but other samples are fine hence it is not clear why the performance is so different for different samples. Lab 33 has one red and t yellow marked, but it does not seem to be a big problem. Check for outlier warning. Several labs have one or more yellow marked results which could be due to inhomogeneity and should then be observed with an outlier warning.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	2.0	2.3	0.4	0.8	-0.4	0.5	0.1	-0.6	-0.7	-0.4
2	-2.0	-0.5	-0.2	-0.4	-0.6	-0.8	-0.8	-1.3	0.0	1.0
4a	1.0	1.6	1.7	1.5	1.2	2.0	1.1	0.7	0.4	0.5
4b	0.5	1.4	0.4	0.6	1.1	1.4	1.3	0.3	0.2	0.2
5	2.3	0.9	1.0	1.3	1.0	0.6	0.5	0.8	0.6	1.1
8a	0.3	0.3	0.9	0.4	0.2	-0.8	1.3	-0.1	0.2	0.7
8b	0.3	0.6	-0.9	-0.9	-1.3	-0.1	-1.2	-1.0	-0.3	-1.5
11a	0.6	-0.4	0.2	0.2	0.8	0.0	0.2	0.2	0.7	0.3
11b	0.2	0.2	0.7	-0.4	0.8	-0.3	0.2	0.6	0.6	-0.1
12	-0.9	0.3	1.3	2.4	0.7	-0.2	0.6	1.4	0.4	0.3
15a	0.9	0.6	1.2	0.4	0.9	0.1	-0.4	0.5	0.4	-0.1
15b	0.9	0.6	1.2	0.4	0.9	0.1	-0.4	0.5	0.4	-0.1
15c	-1.9	-0.2	0.3	-0.4	-2.0	-0.7	0.5	-1.1	-0.6	0.2
17	-2.2	-1.3	-0.8	-0.8	0.2	-0.8	-0.8	0.3	1.0	-0.7
18	-0.8	-0.8	-0.7	-0.3	-0.5	-0.8	-0.5	-0.6	-2.5	-0.2
19	-0.8	-0.3	0.4	0.2	-0.2	-0.4	-0.1	-0.5	0.4	0.0
24	-2.0	-1.4	-0.2	-1.1	-0.1	-1.2	-1.4	0.0	0.6	-0.1
25	1.1	1.5	0.2	0.6	0.2	1.0	-0.3	-0.5	-0.3	-0.4
27a	1.0	-0.1	0.9	0.8	1.0	0.8	0.9	1.3	0.6	0.4
30a	-6.3	-5.1	-4.2	-4.7	-4.5	-5.0	-5.1	-4.9	-4.2	-5.0
31	0.7	-2.3	1.3	0.4	-0.2	-0.2	0.6	1.5	0.8	1.3
33	1.8	-0.5	2.4	0.4	-0.9	2.1	1.5	1.0	3.1	1.3
35a	1.6	2.1	-3.2	-0.7	-0.5	3.9	0.2	-1.9	-3.0	-3.3
35b	0.3	1.5	-3.8	-0.7	-0.2	3.8	-0.5	-1.7	-1.6	-3.3
35c	1.2	1.5	-4.3	-1.2	0.0	4.3	0.6	-1.0	-2.0	-3.1
35d	1.4	0.3	-0.5	0.2	-0.5	-0.4	-0.3	-1.9	-1.4	-1.3
35e	-0.6	-1.7	0.8	-0.7	0.7	0.3	0.1	1.7	1.3	-0.7
35f	-1.5	-2.5	-0.9	-2.0	-1.5	-1.2	-1.0	0.3	0.2	-1.3
35g	-0.6	-1.4	0.8	-0.5	0.9	-0.2	0.2	0.8	1.5	-0.2
56	2.2	0.8	1.3	0.4	1.3	0.5	1.1	0.5	1.1	0.7
64	-0.8	-0.1	0.4	0.0	0.7	-0.6	0.3	0.0	0.6	0.2
68	-1.7	-1.4	0.3	0.0	-0.4	0.1	-0.6	0.1	0.0	-0.8
79a	-2.8	-1.2	-1.2	-0.7	-0.7	-1.2	-1.6	-0.3	-0.1	-2.0
79b	-1.8	-1.0	-0.3	-0.5	-0.4	-1.3	-0.5	-1.0	0.8	0.2
79c	-5.5	-5.8	-4.2	-4.5	-3.8	-5.1	-4.5	-3.6	-2.9	-3.9
80	-3.1	-2.2	-1.1	-1.9	-1.5	-3.4	-2.1	-1.1	0.4	-0.3
82	-0.8	-0.3	0.6	0.2	0.0	0.0	0.5	0.3	0.7	0.6
85	3.5	3.3	6.0	5.2	4.7	3.8	3.7	6.8	7.3	4.7
91	-0.5	-0.8	0.8	1.2	-1.3	0.0	0.9	0.6	1.4	0.8
94a	1.2	0.6	0.9	0.8	0.2	-0.4	-0.1	0.3	0.6	0.3
94b	-0.6	-0.1	0.2	-0.1	0.4	-0.1	-0.1	0.8	0.4	0.0

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 WGN2022.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	5.95	6.56	7.68	6.30	6.45	7.62	7.69	7.14	6.89	7.06
3	-0.17	-0.01	0.08	-0.05	-0.09	0.12	-0.17	-0.03	0.02	0.13
4	0.48	0.29	0.19	0.34	0.28	0.25	0.20	0.32	0.29	0.34
5	8.13	4.41	2.52	5.42	4.30	3.26	2.64	4.52	4.27	4.88

Table 6.2.4.1 - Results of statistical analysis for the determination of the moisture content in rapeseed 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:

For description of Z-score calculations, see section 4.2. There are many deviating results. We have some labs that deviate systematically such as 8a-8b and 35d with a positive bias and labs 18, 35e and 35g with a negative bias. These should be adjusted accordingly.

Some labs (35a-35c) have red or yellow marked with both signs, which makes it difficult to find out the root cause without further investigation. There are labs (12, 33, 79b, 79c, 80 and 85) with red marked Z-score for sample R1 only, which could indicate a higher degree of inhomogeneity for that samples.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-1.9	-0.1	0.1	-1.3	-1.3	-1.9	-1.1	-0.5	0.9	1.1
2	-1.3	1.0	1.8	0.5	-0.4	1.3	1.5	0.7	0.7	0.4
4a	-2.9	0.6	-0.5	-0.4	-0.5	-1.0	0.5	-0.2	0.2	0.3
4b	1.6	-0.5	-0.9	-0.3	0.7	0.8	-0.5	0.5	-0.7	-0.9
5	0.3	-1.0	0.1	0.0	-0.3	0.5	-0.6	1.0	0.1	-1.0
8a	6.6	2.8	2.6	3.1	2.8	2.4	2.5	2.9	3.2	4.0
8b	1.6	3.4	3.9	3.1	1.5	3.7	3.2	4.1	3.8	2.8
11a	-0.4	-0.2	0.6	-0.1	-1.3	-0.1	-0.2	0.6	0.5	-0.2
11f	0.0	0.0	0.9	1.3	0.8	0.4	0.7	2.0	1.2	0.7
12	-3.4	-1.0	-0.5	-1.3	-1.6	-2.0	-0.6	-0.9	-1.8	-1.0
15a	0.9	-2.2	0.7	0.6	-1.0	1.2	0.0	1.0	-0.6	-1.6
15b	-2.2	-2.9	-1.8	-1.3	-1.6	-0.7	-1.8	-0.2	-1.2	-2.9
15c	-1.6	-1.7	-2.9	-2.1	1.5	-1.8	-1.7	-1.7	-2.2	-2.8
17	2.8	2.8	1.1	1.2	-0.7	0.2	0.0	0.1	1.3	1.5
18	-5.9	-2.2	-4.3	-3.2	-4.1	-3.2	-3.1	-3.4	-3.1	-3.5
19	1.2	0.5	-0.6	0.1	0.6	0.4	0.7	1.8	1.6	0.8
24	-0.9	1.5	1.4	0.0	0.3	1.8	0.0	-0.2	-0.6	0.3
25	2.2	0.3	0.1	0.0	0.3	-0.1	1.3	0.4	0.7	1.5
27	-2.6	1.6	-0.2	0.7	-0.2	-0.4	0.7	2.0	0.8	0.9
30a	2.4	3.3	1.2	1.0	1.2	0.2	0.3	2.4	1.1	2.8
33	4.7	0.3	-0.5	1.2	1.5	-2.0	0.0	1.0	0.7	0.3
35a	5.9	3.4	-1.8	9.3	10.3	-0.1	-3.1	1.0	2.6	2.8
35b	0.3	-2.2	-4.3	8.7	3.4	-7.0	-7.5	-5.2	0.1	4.6
35c	1.6	-1.6	-7.4	5.0	7.8	-3.2	-8.1	-4.6	-3.1	-0.4
35d	8.4	7.8	3.9	6.8	4.7	0.5	4.4	2.9	4.4	4.0
35e	0.3	-3.5	-4.3	-3.8	-2.8	-4.5	-6.2	-4.0	-3.7	-4.1
35f	2.2	-0.4	-0.5	0.0	0.9	-0.1	-1.8	-0.2	-1.2	-1.6
35g	-0.3	-3.5	-4.3	-4.4	-2.8	-4.5	-6.2	-4.0	-4.3	-4.7
56	-1.6	-1.6	-1.1	-1.9	-2.8	-0.7	-2.5	-0.2	-1.8	-1.6
64	-1.6	0.9	0.1	0.0	-0.3	-0.7	-0.6	-0.2	0.7	-0.4
68	-2.8	1.5	2.0	1.2	-0.3	-0.1	0.0	0.4	0.7	2.1
79a	1.6	0.9	-0.5	0.6	-0.3	3.0	0.7	1.0	0.1	-1.6
79b	-3.4	0.3	-2.4	-0.7	-0.3	-0.1	-1.8	-0.2	0.1	-1.0
79c	-4.7	-0.4	0.1	-1.3	-0.3	-1.3	0.0	-0.9	-1.2	-0.4
80	-3.0	0.2	1.3	-0.1	-0.3	2.8	1.3	0.6	0.4	1.8
82	0.9	0.6	0.7	1.2	2.2	1.2	1.3	1.6	1.0	0.9
85	-3.4	1.5	0.1	0.6	0.3	0.5	1.3	-0.9	0.1	0.3
91	1.2	0.3	-0.5	0.0	1.5	-0.4	-0.9	-0.9	-0.9	-1.3
94a	-0.3	-1.0	0.1	0.0	-0.3	-0.1	-0.6	0.4	-0.6	-1.6
94b	-2.2	-1.6	-0.5	-0.7	-0.3	-0.7	-1.2	-0.2	0.1	-1.0

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 WGN2022 for an example.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	48.17	46.23	48.38	47.50	48.68	45.53	47.51	49.02	50.17	48.88
3	1.32	1.08	0.42	0.20	0.89	-0.25	-0.10	-0.24	-0.40	0.31
4	0.42	0.31	0.30	0.19	0.24	0.26	0.37	0.22	0.22	0.23
5	0.88	0.66	0.61	0.41	0.49	0.56	0.78	0.46	0.44	0.47

Table 6.2.5.1 - Results of statistical analysis for the determination of the oil content in rapeseed 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:

For description of Z-score calculations, see section 4.2. Results show very good agreement among all Infratec instruments.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1a	1.2	1.1	0.7	0.3	0.0	1.2	0.8	0.7	0.4	0.6
1b	-0.2	-0.2	-1.1	-0.4	0.0	0.2	-0.1	-0.4	-0.1	0.2
2	1.4	0.4	0.5	1.1	0.3	0.2	0.5	-0.4	0.1	1.6
4a	-0.7	-0.6	0.7	-0.1	-0.5	0.3	-0.8	0.4	0.1	-0.3
4b	0.3	-0.8	-0.5	0.3	-0.6	-0.7	-0.4	-1.1	-0.3	-0.5
5	1.1	0.2	0.2	0.9	-0.1	0.0	0.2	0.2	0.0	0.8
8a	-0.9	0.3	0.0	0.1	-0.1	-0.1	1.0	-0.2	-0.8	0.0
8b	0.1	0.1	-0.2	-0.5	-0.1	-0.4	-0.3	0.1	0.0	-0.2
11a	0.0	-0.4	-0.3	0.3	-0.1	0.3	0.3	-0.1	0.2	0.3
11b	-0.4	0.3	0.1	-0.3	-0.1	0.0	0.3	0.3	0.0	-0.1
11e	1.7	0.4	0.5	-0.2	-0.2	0.2	0.6	-0.4	0.4	-0.2
12	-1.2	-0.4	-0.2	-0.1	-0.4	0.3	-0.5	0.5	-0.3	-0.2
15a	0.3	0.1	0.2	0.5	0.4	-0.4	-0.4	0.4	0.3	0.1
15b	0.4	0.9	0.0	-0.1	-0.1	-0.4	0.7	0.6	0.2	1.4
17	0.2	-0.6	-0.3	-0.4	0.5	0.6	-0.4	0.0	0.0	0.2
18	0.4	0.0	-0.9	-0.1	-0.3	-0.2	0.3	0.1	-0.4	-0.2
19	0.1	0.6	0.9	0.4	0.8	0.5	1.3	0.2	-0.2	0.5
24	0.5	-0.3	0.8	0.1	0.7	-0.1	-1.1	0.2	0.2	0.3
31	-0.1	0.0	-0.4	0.1	0.3	-0.6	-0.6	0.1	-0.7	-0.1
33	-1.3	0.3	0.6	-0.5	-1.7	1.8	0.9	0.0	0.5	-0.1
35a	-0.1	-0.6	-0.8	-0.5	-0.1	0.4	-0.2	-0.2	-0.7	-0.1
35b	0.0	0.2	-0.6	-0.6	0.8	-0.9	-0.1	-0.2	0.0	-0.4
35c	0.5	0.0	-0.2	0.5	0.0	-0.2	0.3	-0.1	0.3	0.1
35d	-0.7	-0.2	-1.1	0.0	-0.3	-0.4	0.0	-0.6	-0.7	-0.7
56	0.3	0.0	0.2	0.0	-0.1	0.0	1.0	-0.2	0.3	0.3
64	0.4	-0.1	0.2	0.0	0.2	0.4	-0.4	0.1	-0.3	-0.4
68	-1.5	-0.9	0.0	0.3	-0.6	0.9	-0.5	0.2	-0.7	-1.0
79a	0.4	1.4	1.1	1.4	1.2	0.4	1.1	1.6	0.6	0.7
79b	-1.1	-0.3	0.0	-0.5	-0.2	-0.7	-0.1	-0.8	0.2	0.4
79c	-0.7	-1.0	-0.4	-0.1	-0.3	0.3	-0.3	0.2	0.2	-0.4
80	1.0	0.4	0.6	-0.1	0.3	-0.7	-1.0	-0.1	0.1	0.4
82	-0.3	-0.5	-0.3	0.1	-0.5	0.4	-0.1	-0.1	-0.1	-0.2
85	-1.1	-0.7	0.0	-0.1	-0.3	0.5	-1.8	1.3	0.9	-0.3
94a	0.2	0.3	0.2	0.5	-0.6	-0.8	0.0	-0.2	0.1	0.6
94b	-0.1	0.5	-0.1	0.2	-0.2	0.6	-0.2	0.8	0.3	-0.1

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 RA002635 (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 WGN2022 for an example.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	5.92	6.42	7.65	6.32	6.34	7.64	7.59	7.23	6.89	6.91
3	-0.20	-0.15	0.05	-0.03	-0.20	0.15	-0.28	0.07	0.02	-0.02
4	0.26	0.14	0.18	0.13	0.14	0.17	0.16	0.14	0.16	0.15
5	4.4	2.1	2.4	2.0	2.2	2.3	2.1	1.9	2.3	2.2

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

For description of Z-score calculations, see section 4.2. The results show that there are one or more red marked results for labs (8a, 11e, 12, 68 and 94b). These are more of a random nature.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1a	2.2	-0.7	0.9	0.0	-0.4	-0.2	0.2	0.7	0.7	1.1
1b	-0.2	-0.6	0.4	-0.2	-0.3	1.0	-0.6	1.1	-0.1	-0.4
2	1.2	-0.5	-0.1	0.0	-1.2	1.2	0.5	-0.8	-1.1	-0.3
4a	-2.0	-0.4	-0.9	-0.5	-0.9	-2.9	0.2	-0.9	-0.3	0.2
4b	-0.3	-0.2	-0.8	-0.5	-0.4	1.4	-1.6	0.7	-0.2	-2.0
5	0.7	-0.1	0.1	-0.1	0.1	0.9	0.1	0.4	0.1	-0.3
8a	4.7	2.0	1.3	1.7	1.9	0.5	2.1	0.7	2.3	3.2
8b	1.0	0.5	0.7	-0.6	-0.7	0.5	0.2	-0.3	0.7	0.1
11a	-0.2	0.7	0.8	-0.2	-0.6	-0.3	0.4	0.0	0.5	0.8
11b	0.2	0.9	1.1	1.1	1.5	0.2	1.4	1.4	1.2	1.7
11e	-0.4	-2.2	-3.0	-0.3	-1.4	-0.5	-2.4	-1.5	-1.0	-1.6
12	-3.6	0.0	0.3	-2.3	-0.6	-1.9	0.4	-0.8	-1.9	0.3
15a	0.0	-1.0	-0.7	-0.8	-0.4	-0.4	-0.4	0.1	-0.4	-0.6
15b	1.7	-0.8	1.2	1.3	0.2	1.8	1.1	0.8	-0.5	-0.4
17	-1.7	0.2	0.5	-0.2	0.2	-0.5	0.7	-0.2	0.0	0.7
18	0.9	-0.7	-2.4	-0.4	-1.0	0.2	-0.3	0.6	-0.6	-0.9
19	-0.7	1.4	0.4	0.0	-0.2	0.0	0.4	-0.4	1.2	2.1
24	1.1	0.1	-0.2	0.5	0.2	0.9	-0.9	-0.5	-0.5	-0.2
31	0.6	-0.1	0.1	-0.2	-0.1	0.2	-0.8	-0.2	0.0	-0.8
33	1.7	1.8	1.8	1.6	2.3	-0.3	1.3	0.8	2.3	2.3
35a	-1.7	0.3	-0.5	-0.3	0.7	-1.1	-1.1	-0.2	0.7	-0.9
35b	0.6	-1.2	-0.7	-0.4	-0.4	0.3	0.1	0.3	-0.7	-0.4
35c	0.7	-1.0	-0.2	0.1	-1.1	-0.1	-1.4	-0.7	-1.1	0.1
35d	-0.4	0.1	0.0	0.5	0.8	-0.3	0.4	0.6	-0.1	0.0
56	0.4	-0.4	0.6	-0.3	-1.0	1.0	-0.2	0.4	-1.0	0.1
64	0.2	0.4	0.1	-0.2	0.1	-1.0	-0.3	-0.5	1.1	0.6
68	1.2	3.1	2.8	1.2	1.7	1.3	2.2	1.7	2.0	3.9
79a	1.2	0.5	-0.9	1.2	0.4	1.5	-0.7	1.9	-0.9	-1.5
79b	-1.5	0.0	-2.0	-0.7	-0.3	-1.3	-1.4	-1.0	-0.6	-0.7
79c	-2.0	0.1	0.7	-0.7	0.2	-1.9	-0.3	-1.1	-0.3	-0.1
80	0.6	-0.3	0.2	0.6	-0.5	1.5	0.0	-0.4	-0.2	0.5
82	-2.1	0.5	-0.7	-0.5	0.8	-0.5	0.0	-0.7	-1.0	0.3
85	-1.0	0.9	-0.6	-0.1	0.3	-0.1	0.8	-1.2	-0.3	-0.3
94a	0.6	0.5	0.8	0.2	-0.1	0.2	0.3	0.2	0.0	0.0
94b	-3.2	-0.5	-0.7	-0.6	0.4	-1.2	-0.1	-0.9	0.0	0.1

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 2022 all samples (2021 harvest)	Ref. methods	Local models	FOSS ANN
Oil, range	45.2 % - 50.6 %		
Mean (%)	47.69	47.89	48.01
deviation from mean		0.20	0.32
SD reproducibility	0.71	0.68	0.28
RSD reproducibility	1.5	1.4	0.6
Moisture, range	6.1 % - 7.9 %		
Mean (%)	6.95	6.93	6.89
deviation from mean		-0.02	-0.06
SD reproducibility	0.15	0.30	0.16
RSD reproducibility	2.1	4.4	2.4

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

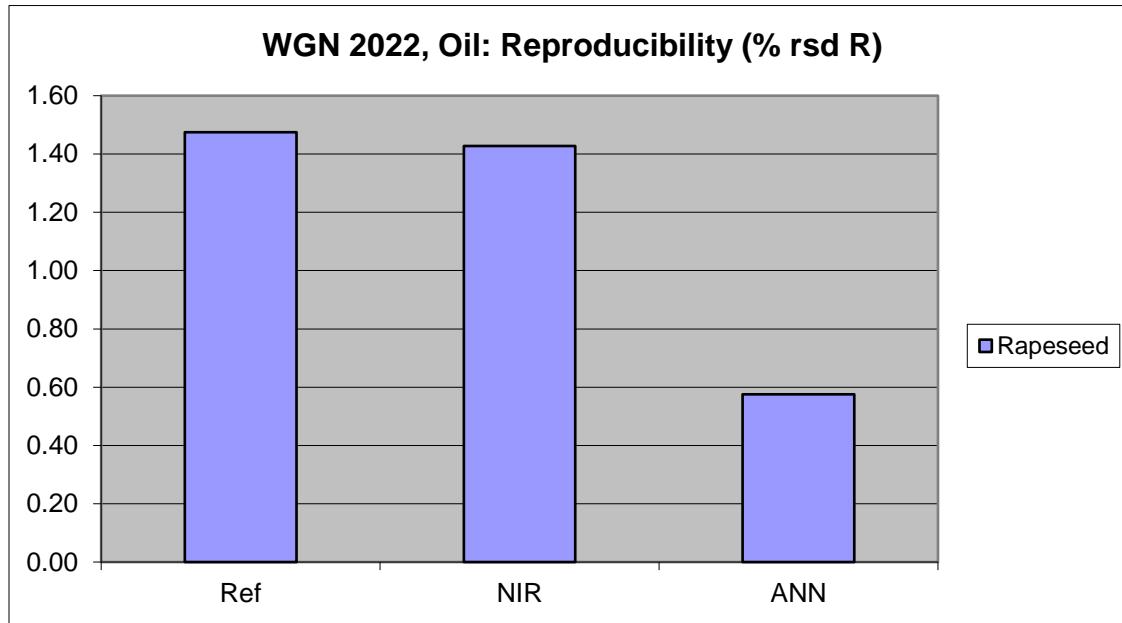


Fig. 6.3.1a: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model RA002635 (RAOI0035) (ANN) for the determination of oil in rapeseed.

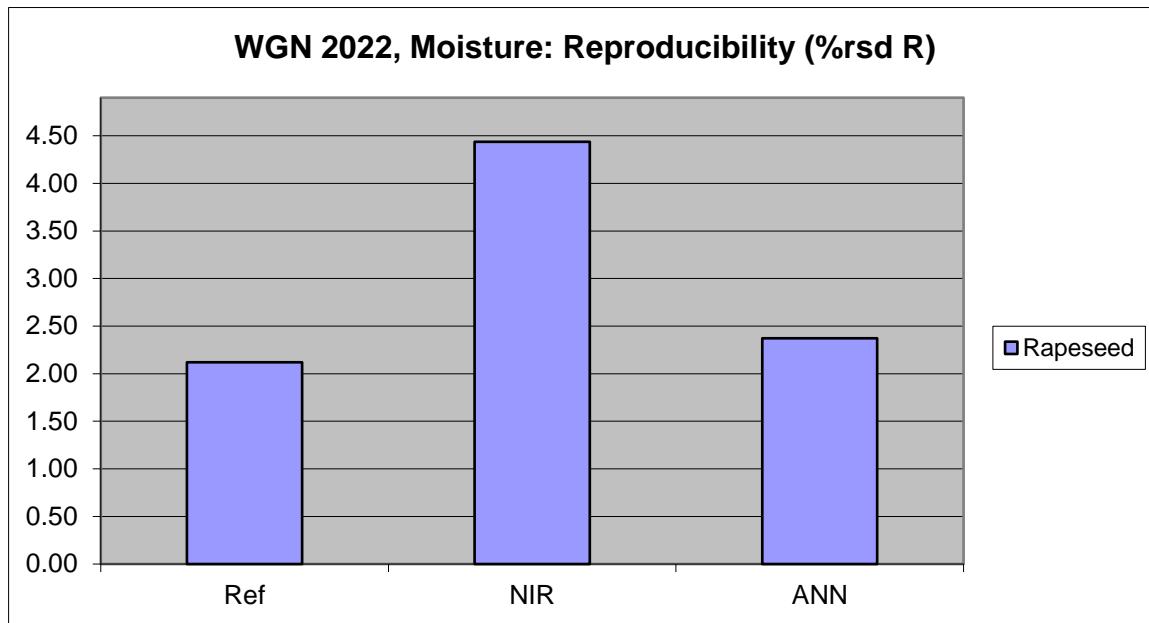


Fig. 6.3.1b: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model RA002635 (RAMO0026) (ANN) for the determination of **moisture in rapeseed**.

Reproducibility for global FOSS ANN models is better than reference methods for oil and similar for moisture. For local NIR models, reproducibility is equally good as the reference method for oil, but significantly worse 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 almost all samples are within the error limits of the reference methods for moisture. Only sample R7 deviate slightly more for the global unadjusted ANN model. For oil, R1 and R2 deviate slightly for local and global ANN compared to reference. The reason could be the varieties of these samples originating from Finland and Latvia, where the Finnish sample belongs to a type with the botanical name "Brassica Rapa".

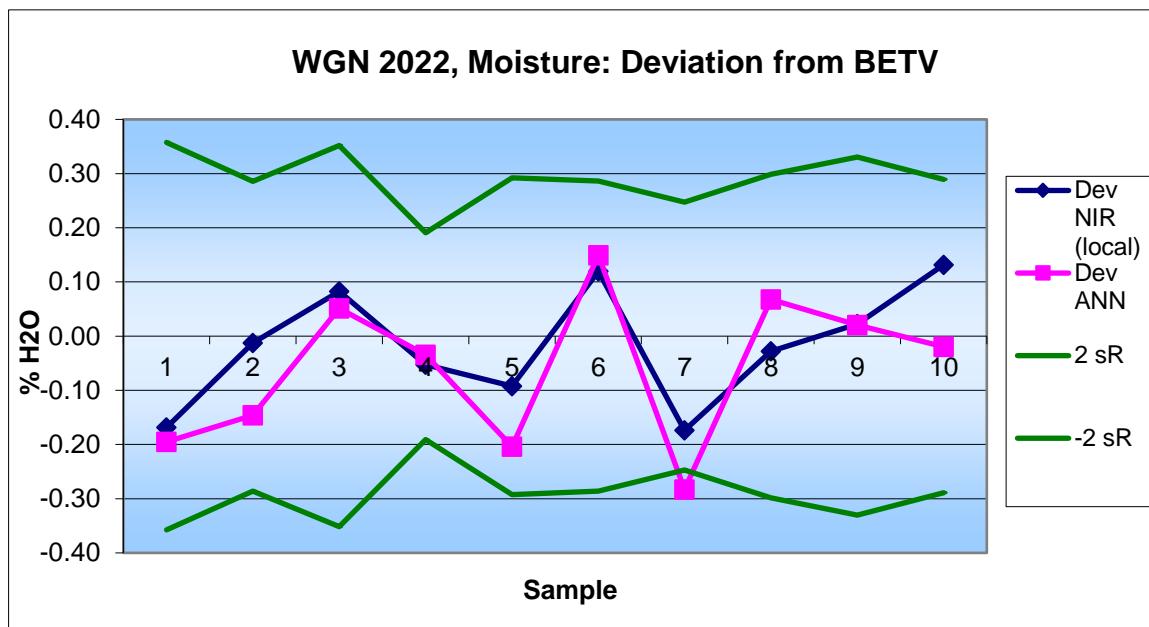


Fig. 6.3.2a: Deviations between predicted **moisture** values and the best estimate of the true value

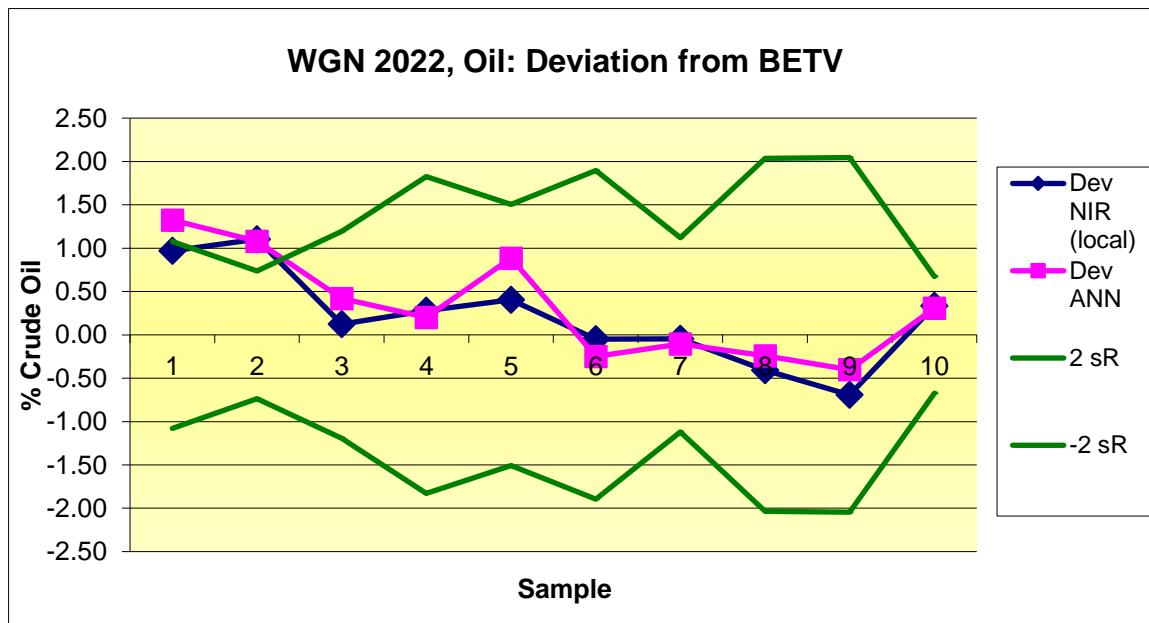


Fig. 6.3.2b: Deviations between predicted **oil** values and the best estimate of the true value

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.

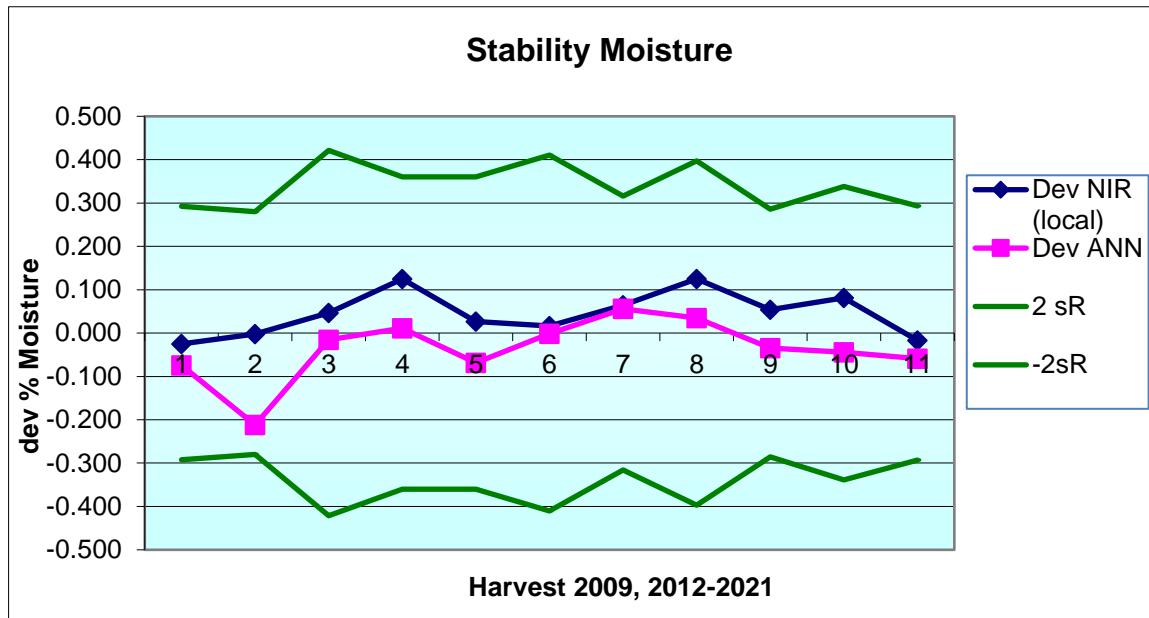


Figure 6.3.3 a: Average deviations of predicted moisture results from the best estimate of the true value for eight years of harvest (2009 and 2012-2020). Blue=Local and Pink = ANN.

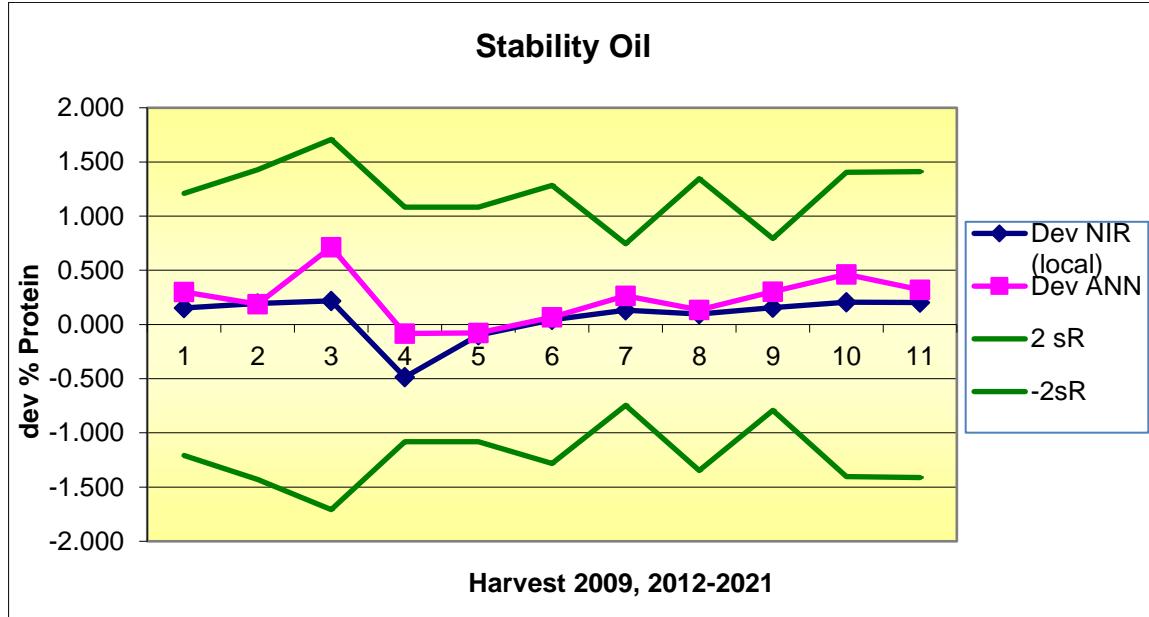


Figure 6.3.3 b: Average deviations of predicted oil results from the best estimate of the true value for eight years of harvest (2009 and 2012-2020). Blue=Local and Pink = ANN.

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 WGN2022 exercise.

Parameter	# labs reporting (ref + pred)
TWM (Mass per hectolitre)	23 + 35
Falling number	20
Zeleny	5 + 28
Wet gluten	11 + 41
Starch in wheat	9 + 27
Starch in barley	4+6
Hardness	3 + 8

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-three participants reported reference results for the test weight (mass per hectolitre, kg/hL). There were also reported TWM results from 35 instruments.

7.1.1 Reference method

Fifteen participants were using a 1 L device according to ISO 7971-3 (labs 2, 4, 17, 18, 19, 24, 30a, 33, 35, 64, 68, 77a, 80 and 94). One participant (lab 15) used a 1 Liter device according to ISO 7971-2 and one lab (32) used 0.5 L according to ISO 7971.2. Seven participants used 250 ml device according to ISO 7971-3 (labs 1, 5, 8, 10, 12, 25 and 81). One participant used ½ L device according to an In-house Franklin drop weight chondrometer (27). Two labs (17 and 24) 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, all labs are well aligned. 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	80.6	80.8	84.5	80.5	81.4	77.8	83.3	83.3	80.9	81.1

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	69.3	65.6	64.4	70.6	68.2	64.8	65.7	65.2	68.6	68.5

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	80.8	81.2	84.7	80.9	81.4	78.0	83.1	83.3	81.1	81.2	81.6	0.15
2	79.9	79.7	83.7	80.0	81.2	77.7	82.9	82.5	80.4	80.5	80.9	-0.56
4	81.2	81.2	84.8	80.9	81.8	78.2	83.7	83.7	81.3	81.4	81.8	0.40
5	80.2	80.9	84.3	80.3	81.1	77.7	83.0	83.0	80.7	80.8	81.2	-0.22
8	80.7	80.8	84.5	80.6	81.1	77.9	83.0	83.2	80.8	81.0	81.4	-0.06
10	81.2	81.7	85.8	81.3	82.7	78.6	84.8	84.3	81.8	82.0	82.4	1.00
12	80.9	80.8	84.5	80.4	81.3	77.7	83.2	83.3	80.7	81.4	81.4	0.00
15	80.8	80.8	84.2	80.3	81.3	77.8	83.3	83.3	80.9	81.1	81.4	-0.04
17	80.6	N/A	84.5	80.4	81.4	77.8	83.5	83.3	80.9	80.9	81.5	0.06
18	80.3	80.5	84.5	80.1	81.0	77.6	83.1	83.0	80.4	80.6	81.1	-0.31
19	80.6	80.8	84.4	80.7	81.5	77.9	83.4	83.4	81.1	81.3	81.5	0.10
24	80.8	N/A	84.4	80.6	81.2	77.6	83.1	83.2	80.9	81.0	81.4	0.00
25	80.8	80.8	84.0	80.0	80.8	77.6	82.4	83.2	80.4	80.8	81.1	-0.34
30a	80.9	81.2	84.7	80.9	81.5	77.9	83.4	83.6	81.0	81.5	81.7	0.24
33	79.9	80.1	83.8	80.1	81.4	77.7	82.9	82.5	80.3	80.4	80.9	-0.51
35	80.6	80.4	84.9	80.1	81.6	78.1	83.7	83.5	81.2	81.1	81.5	0.10
64	80.5	80.8	84.4	80.4	81.2	77.9	83.2	83.3	80.9	81.1	81.4	-0.05
68	80.7	80.9	84.7	80.8	81.4	77.8	83.3	83.5	81.1	81.7	81.6	0.17
77a	80.1	80.8	84.6	80.1	81.0	77.0	83.0	83.0	80.3	80.6	81.1	-0.37
80	80.7	80.9	84.5	80.4	81.3	77.8	83.3	83.4	81.0	81.6	81.5	0.07
81	80.5	81.3	84.7	80.9	81.3	77.3	83.3	83.7	80.5	80.9	81.4	0.02
94	80.8	81.0	84.5	80.8	81.3	77.9	83.4	83.5	81.0	81.3	81.5	0.12
Average	80.6	80.8	84.5	80.5	81.4	77.8	83.3	83.3	80.9	81.1	81.4	0.0
sd	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.3
min	79.9	79.7	83.7	80.0	80.8	77.0	82.4	82.5	80.3	80.4	80.9	-0.6
max	81.2	81.7	85.8	81.3	82.7	78.6	84.8	84.3	81.8	82.0	82.4	1.0

Z-scores kg/hL, wheat:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.4	0.7	0.4	0.8	0.1	0.4	-0.4	0.0	0.5	0.2
2	-1.5	-2.3	-1.5	-1.0	-0.3	-0.2	-0.7	-1.5	-0.9	-1.2
4	1.1	0.8	0.5	0.8	0.8	0.8	0.9	0.7	1.0	0.7
5	-0.8	0.1	-0.4	-0.4	-0.5	-0.2	-0.6	-0.6	-0.3	-0.6
8	0.2	-0.1	0.0	0.2	-0.5	0.2	-0.6	-0.2	-0.1	-0.2
10	1.2	1.7	2.6	1.6	2.7	1.6	3.0	2.0	1.9	1.7
12	0.6	-0.1	0.0	-0.2	-0.1	-0.2	-0.2	0.0	-0.3	0.6
15	0.4	-0.1	-0.6	-0.4	-0.1	0.0	0.0	0.0	0.1	0.0
17	0.0	N/A	0.0	-0.2	0.1	0.0	0.4	0.0	0.1	-0.4
18	-0.6	-0.7	0.0	-0.8	-0.7	-0.4	-0.4	-0.6	-0.9	-1.0
19	0.0	-0.1	-0.3	0.4	0.3	0.3	0.2	0.2	0.5	0.5
24	0.4	N/A	-0.2	0.2	-0.3	-0.4	-0.4	-0.2	0.1	-0.2
25	0.4	-0.1	-1.0	-1.0	-1.1	-0.4	-1.8	-0.2	-0.9	-0.6
30a	0.6	0.7	0.4	0.8	0.3	0.2	0.2	0.6	0.3	0.8
33	-1.4	-1.5	-1.4	-0.8	0.1	-0.2	-0.8	-1.6	-1.1	-1.4
35	0.0	-0.9	0.8	-0.8	0.5	0.6	0.8	0.4	0.7	0.0
64	-0.2	-0.1	-0.2	-0.2	-0.3	0.2	-0.2	0.0	0.1	0.0
68	0.2	0.1	0.4	0.6	0.1	0.0	0.0	0.4	0.5	1.2
77a	-1.0	-0.1	0.2	-0.8	-0.7	-1.6	-0.6	-0.6	-1.1	-1.0
80	0.2	0.1	0.0	-0.2	-0.1	0.0	0.0	0.2	0.3	1.0
81	-0.2	0.9	0.4	0.8	-0.1	-1.0	0.0	0.8	-0.7	-0.4
94	0.3	0.4	0.0	0.5	-0.1	0.1	0.2	0.3	0.3	0.4

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	69.6	65.7	64.5	71.2	68.6	64.7	65.8	65.5	68.5	68.6	67.3	0.2
2	69.7	65.9	64.8	70.6	68.4	64.9	66.0	65.5	68.8	68.1	67.3	0.2
4	69.1	65.5	64.2	70.1	68.1	64.9	65.3	65.0	68.4	68.2	66.9	-0.2
5	69.2	65.2	64.3	70.5	68.2	64.8	65.6	64.9	68.2	68.4	66.9	-0.2
8	69.2	65.0	64.2	70.8	68.5	64.3	65.6	65.3	68.4	68.9	67.0	-0.1
10	69.9	66.0	64.6	71.0	68.5	65.4	66.0	65.3	68.8	68.5	67.4	0.3
12	69.0	65.2	64.3	70.3	68.2	64.8	66.0	64.8	68.3	68.3	66.9	-0.2
15	69.6	65.2	64.4	70.4	68.2	64.6	65.5	65.2	68.4	68.2	67.0	-0.2
17	N/A	N/A	64.3	70.5	67.9	N/A	65.6	N/A	68.3	68.4	67.5	0.4
18	69.2	65.8	64.7	71.0	68.3	64.9	66.1	65.6	69.0	68.6	67.3	0.2
19	69.1	65.2	64.1	70.1	68.0	64.2	65.2	64.9	68.2	67.8	66.7	-0.4
25	68.8	65.6	64.0	70.4	68.0	64.4	65.2	64.8	68.8	68.0	66.8	-0.3
30a	69.4	65.5	64.5	70.7	68.3	65.1	65.7	65.2	68.5	69.0	67.2	0.1
32	69.4	66.6	65.0	71.0	68.4	65.7	66.2	65.7	68.8	68.9	67.6	0.5
33	69.6	65.7	64.3	70.5	68.3	64.7	66.0	65.3	69.0	68.3	67.2	0.1
64	69.1	65.3	64.3	70.3	68.1	65.0	65.5	65.1	68.3	68.5	67.0	-0.2
68	69.2	65.4	64.4	70.1	68.1	64.9	65.6	65.4	68.5	68.7	67.0	-0.1
94	69.4	66.0	64.5	70.7	68.4	64.9	65.5	65.1	68.9	69.0	67.2	0.1
Average	69.3	65.6	64.4	70.6	68.2	64.8	65.7	65.2	68.6	68.5	67.1	0.0
sd	0.3	0.4	0.2	0.3	0.2	0.4	0.3	0.3	0.3	0.4	0.2	0.2
min	68.8	65.0	64.0	70.1	67.9	64.2	65.2	64.8	68.2	67.8	66.7	-0.4
max	69.9	66.6	65.0	71.2	68.6	65.7	66.2	65.7	69.0	69.0	67.6	0.5

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

Z-scores kg/hL barley:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	0.6	0.2	0.2	1.3	0.7	-0.3	0.2	0.6	-0.1	0.3
2	0.8	0.7	0.8	0.0	0.3	0.2	0.6	0.6	0.5	-0.8
4	-0.5	-0.3	-0.4	-0.9	-0.4	0.0	-0.7	-0.4	-0.3	-0.6
5	-0.2	-0.8	-0.2	-0.1	-0.1	-0.1	-0.2	-0.6	-0.7	-0.1
8	-0.2	-1.2	-0.4	0.5	0.5	-1.1	-0.2	0.2	-0.3	0.9
10	1.2	0.8	0.3	0.9	0.5	1.1	0.6	0.2	0.5	0.1
12	-0.6	-0.7	-0.2	-0.5	0.0	0.0	0.6	-0.8	-0.5	-0.2
15	0.5	-0.8	0.0	-0.3	-0.1	-0.5	-0.4	0.0	-0.3	-0.5
17	N/A	N/A	-0.2	-0.1	-0.7	N/A	-0.2	N/A	-0.5	-0.1
18	-0.2	0.4	0.6	0.9	0.1	0.1	0.8	0.8	0.9	0.3
19	-0.5	-0.7	-0.6	-0.9	-0.6	-1.4	-1.0	-0.6	-0.7	-1.4
25	-1.0	0.0	-0.8	-0.3	-0.5	-0.9	-1.0	-0.8	0.5	-0.9
30a	0.2	-0.2	0.2	0.3	0.1	0.5	0.0	0.0	-0.1	1.1
32	0.2	2.0	1.2	0.9	0.3	1.7	1.0	1.0	0.5	0.9
33	0.6	0.2	-0.2	-0.1	0.1	-0.3	0.6	0.2	0.9	-0.3
64	-0.4	-0.6	-0.2	-0.5	-0.3	0.3	-0.4	-0.2	-0.5	0.1
68	-0.2	-0.4	0.0	-0.9	-0.3	0.1	-0.2	0.4	-0.1	0.5
94	0.1	0.8	0.1	0.3	0.3	0.2	-0.5	-0.2	0.6	1.0

7.1.2 Mass per hectolitre by Infratec TWM

The average results for TWM after outlier removal are 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	80.5	80.8	84.7	80.2	81.4	77.8	83.3	83.3	80.8	80.8
3	-0.1	0.0	0.2	-0.3	0.0	0.0	0.0	0.0	-0.1	-0.3

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	69.6	65.9	64.8	70.7	68.6	64.9	66.1	65.5	68.9	68.5
3	0.3	0.3	0.4	0.2	0.4	0.0	0.5	0.3	0.3	0.0

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	80.7	80.6	84.6	80.3	81.3	78.2	83.3	83.3	80.8	80.9	81.4	0.1
2	80.5	80.3	84.7	80.2	81.2	77.8	83.1	83.2	80.9	80.7	81.3	-0.1
4a	80.9	81.1	85.0	80.5	81.3	78.0	83.4	83.4	80.8	80.7	81.5	0.2
4b	80.6	80.9	84.7	80.2	81.2	77.6	83.0	83.2	80.7	81.0	81.3	0.0
5	80.4	80.7	84.5	80.3	81.3	78.8	83.2	83.2	80.7	80.8	81.4	0.1
8a	80.8	80.7	84.9	80.3	81.4	78.1	83.3	83.4	81.0	80.9	81.5	0.1
10	81.9	82.1	86.2	81.6	82.7	79.1	84.7	84.7	82.3	82.0	82.7	1.4
11e	81.4	81.7	85.7	81.1	82.5	78.8	84.1	84.3	81.7	81.7	82.3	1.0
12	81.6	81.6	85.2	80.9	82.0	78.6	83.9	84.0	81.4	81.4	82.1	0.7
15	80.8	81.2	84.9	80.5	81.8	78.5	83.5	83.6	81.1	81.2	81.7	0.4
17	80.5	80.9	84.5	80.4	81.3	77.9	83.3	83.4	80.8	80.8	81.4	0.0
18	80.9	80.9	84.4	80.3	81.5	78.4	83.3	83.4	81.0	81.1	81.5	0.2
24	80.7	81.4	85.3	80.8	81.9	78.4	83.9	83.9	81.3	80.7	81.8	0.5
25	80.7	80.8	84.9	79.5	81.4	77.5	83.2	83.2	80.5	80.3	81.2	-0.1
26	80.4	80.5	84.4	80.1	81.1	77.7	83.4	83.0	80.6	80.9	81.2	-0.1
27	78.9	79.9	83.4	79.0	79.9	75.5	81.4	81.7	79.2	79.6	79.8	-1.5
30a	80.8	80.9	84.8	80.4	81.6	77.7	83.3	83.5	80.9	81.2	81.5	0.2
30b	79.8	80.9	84.4	80.0	81.5	77.6	83.3	83.4	80.5	80.3	81.2	-0.2
30c	80.2	81.0	84.4	80.3	81.4	77.9	83.6	83.4	80.8	80.8	81.4	0.0
30h	79.3	80.4	84.0	79.7	80.9	77.4	83.1	82.8	80.3	80.3	80.8	-0.5
56	81.3	81.4	85.1	80.9	81.9	78.4	83.8	83.9	81.4	81.6	82.0	0.6
66	66.6	82.2	85.4	79.9	81.2	77.7	83.9	83.4	80.8	80.5	80.2	-1.2
68	81.7	81.7	85.6	81.2	82.4	78.6	84.2	84.3	81.6	81.9	82.3	1.0
77a	79.8	80.9	84.7	79.9	81.1	76.9	83.1	83.0	80.2	80.3	81.0	-0.3
79a	77.4	76.8	80.8	76.6	77.7	73.9	79.0	79.8	77.0	77.1	77.6	-3.7
79b	80.2	80.7	85.0	80.2	81.3	78.0	83.3	83.4	80.7	80.8	81.4	0.0
79c	80.7	80.7	84.8	80.2	81.4	77.7	83.2	83.3	81.0	80.7	81.4	0.0
80	80.7	80.8	84.8	80.3	81.4	77.6	83.3	83.3	80.8	80.9	81.4	0.1
82	80.4	80.5	84.4	80.2	81.2	77.8	83.2	83.2	80.6	80.9	81.2	-0.1
85	79.9	80.3	84.5	79.8	80.9	77.3	83.1	83.0	80.5	80.6	81.0	-0.3
91	80.6	80.8	84.8	80.5	81.5	78.0	83.5	83.4	81.0	81.0	81.5	0.2
94a	80.8	81.2	85.0	80.8	81.7	78.4	83.8	83.9	81.4	81.4	81.8	0.5
94b	81.3	81.6	85.4	81.2	82.1	78.9	84.3	84.3	81.7	81.9	82.3	0.9
Average	80.5	80.8	84.7	80.2	81.4	77.8	83.3	83.3	80.8	80.8	81.3	0.0
sd	0.9	0.9	0.9	0.8	0.8	1.0	0.9	0.8	0.9	0.8	0.9	0.9
min	77.4	76.8	80.8	76.6	77.7	73.9	79.0	79.8	77.0	77.1	77.6	-3.7
max	81.9	82.2	86.2	81.6	82.7	79.1	84.7	84.7	82.3	82.0	82.7	1.4

Z scores for wheat:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.4	-0.5	-0.2	0.1	-0.1	0.7	0.0	-0.1	0.0	0.2
2	0.1	-1.0	0.0	-0.2	-0.3	0.0	-0.3	-0.3	0.1	-0.2
4a	0.8	0.4	0.5	0.5	-0.2	0.3	0.1	0.1	0.1	-0.2
4b	0.1	0.1	-0.1	0.0	-0.3	-0.4	-0.5	-0.3	-0.1	0.4
5	-0.2	-0.3	-0.4	0.1	-0.1	1.9	-0.2	-0.3	-0.2	0.0
8a	0.6	-0.3	0.4	0.1	0.1	0.5	0.0	0.1	0.4	0.2
10	2.8	2.5	3.0	2.7	2.7	2.5	2.8	2.7	3.0	2.4
11e	1.7	1.8	2.0	1.7	2.2	1.9	1.6	1.9	1.8	1.7
12	2.2	1.5	1.0	1.3	1.3	1.5	1.2	1.3	1.2	1.2
15	0.6	0.7	0.4	0.5	0.9	1.3	0.4	0.5	0.6	0.8
17	0.0	0.1	-0.5	0.3	-0.1	0.0	-0.1	0.0	-0.1	0.0
18	0.8	0.1	-0.6	0.1	0.3	1.1	0.0	0.1	0.4	0.6
24	0.4	1.1	1.2	1.1	1.1	1.1	1.2	1.1	1.0	-0.2
25	0.4	-0.1	0.4	-1.5	0.1	-0.7	-0.2	-0.3	-0.6	-1.0
26	-0.2	-0.7	-0.6	-0.3	-0.5	-0.3	0.2	-0.7	-0.4	0.2
27	-3.3	-1.9	-2.7	-2.5	-2.9	-4.7	-3.9	-3.3	-3.2	-2.4
56	1.6	1.1	0.8	1.3	1.1	1.1	1.0	1.1	1.2	1.6
66	-27.8	2.7	1.4	-0.7	-0.3	-0.3	1.2	0.1	0.0	-0.6
68	2.4	1.7	1.8	1.9	2.1	1.5	1.8	1.9	1.6	2.2
77a	-1.4	0.1	0.0	-0.7	-0.5	-1.9	-0.4	-0.7	-1.2	-1.0
79a	-6.2	-8.1	-7.8	-7.4	-7.4	-7.9	-8.5	-7.0	-7.5	-7.5
79b	-0.6	-0.3	0.6	-0.1	-0.1	0.3	0.0	0.1	-0.2	0.0
79c	0.4	-0.3	0.2	-0.1	0.1	-0.3	-0.2	-0.1	0.4	-0.2
80	0.4	-0.2	0.1	0.2	0.2	-0.4	0.0	0.0	0.0	0.1
82	-0.3	-0.8	-0.6	0.0	-0.4	-0.1	-0.3	-0.3	-0.5	0.1
85	-1.2	-1.1	-0.4	-0.9	-0.9	-1.1	-0.4	-0.7	-0.6	-0.4
91	0.2	-0.1	0.2	0.5	0.3	0.3	0.4	0.1	0.4	0.4
94a	0.6	0.7	0.6	1.1	0.7	1.1	1.0	1.1	1.2	1.2
94b	1.6	1.5	1.4	1.9	1.5	2.1	2.0	1.9	1.8	2.2

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 79a has a negative systematic shift and should be adjusted accordingly. Lab 66 has one incorrect measurement for W1 and is excluded in the determination of BETV. Lab 27 has a negative systematic shift with 5 red and 4 yellow marked sample results.

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

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
1	69.0	64.9	63.9	70.1	67.7	64.1	65.3	64.5	68.0	68.0	66.6	-0.8
2	68.8	65.0	63.6	70.2	67.9	63.8	65.0	64.3	68.1	67.5	66.4	-0.9
4a	69.2	65.3	64.2	70.6	68.6	64.7	65.9	65.3	68.3	68.2	67.0	-0.3
4b	69.3	65.5	64.3	70.4	68.4	65.1	65.4	64.9	68.3	68.3	67.0	-0.4
5	69.3	65.2	64.1	70.3	68.0	64.5	65.8	64.7	68.5	67.8	66.8	-0.5
6	68.5	64.6	63.3	69.7	67.5	63.3	64.7	63.6	67.8	67.0	66.0	-1.4
8a	69.3	65.2	64.0	70.4	68.1	63.9	65.4	64.8	68.3	68.1	66.8	-0.6
10	70.0	66.1	65.0	71.5	68.9	64.5	66.3	65.6	69.5	68.9	67.6	0.3
11e	70.1	66.0	64.5	70.5	68.2	65.0	65.9	65.6	68.7	68.3	67.3	-0.1
12	69.9	65.6	64.3	70.9	68.7	65.1	66.2	65.1	68.7	68.3	67.3	-0.1
15	69.7	65.4	64.7	70.8	68.5	65.1	66.0	65.6	68.9	68.4	67.3	0.0
17	69.3	65.5	64.0	70.3	67.8	64.2	65.3	64.6	68.2	67.7	66.7	-0.7
18	69.0	65.1	64.0	70.1	68.1	64.7	65.1	65.0	68.1	68.1	66.7	-0.6
24	67.4	63.7	62.5	69.0	66.7	62.3	63.7	62.9	66.7	65.9	65.1	-2.3
25	68.8	64.8	63.7	69.8	67.7	64.2	64.9	64.6	68.2	67.5	66.4	-0.9
27	68.4	65.1	63.3	69.7	67.0	63.6	64.7	64.3	68.0	67.9	66.2	-1.2
30a	69.0	65.2	64.0	70.2	68.0	63.7	65.4	64.4	68.2	67.8	66.6	-0.8
30b	69.8	66.2	64.7	71.0	68.5	65.2	66.0	65.4	68.8	68.5	67.4	0.0
30c	70.1	66.2	64.7	71.2	68.9	65.3	65.9	65.5	69.1	68.7	67.6	0.2
30h	79.3	80.4	84.0	79.7	80.9	77.4	83.1	82.8	80.3	80.3	80.8	13.5
32	69.4	65.3	64.4	70.5	68.2	64.6	65.6	65.3	68.5	68.3	67.0	-0.3
56	69.4	65.6	64.3	70.8	68.9	64.8	66.2	64.8	68.9	68.1	67.2	-0.2
68	69.3	65.8	64.4	70.6	68.4	64.0	65.9	65.0	68.8	68.0	67.0	-0.3
79a	68.9	63.7	62.9	68.7	66.5	62.9	63.9	63.1	66.5	66.6	65.4	-2.0
79c	69.4	64.9	63.7	70.3	67.9	64.2	65.3	64.4	68.2	67.8	66.6	-0.7
80	68.8	65.0	64.0	69.7	67.7	64.2	65.2	64.6	68.0	67.5	66.5	-0.9
82	69.1	65.4	64.0	70.6	68.2	64.6	65.4	65.1	68.3	68.1	66.9	-0.5
85	68.8	64.6	63.2	69.6	67.3	64.0	64.7	64.2	67.7	67.2	66.1	-1.2
91	69.8	65.7	64.7	70.7	68.5	64.8	66.1	65.3	68.8	68.4	67.3	-0.1
94a	69.4	65.6	64.3	70.6	68.5	64.2	65.5	65.1	68.8	68.1	67.0	-0.3
94b	69.5	66.0	64.6	70.8	68.6	64.8	65.7	65.2	69.1	68.4	67.3	-0.1
Average	69.6	65.9	64.8	70.7	68.6	64.9	66.1	65.5	68.9	68.5	67.4	0.0
sd	1.9	2.8	3.7	1.8	2.4	2.5	3.3	3.4	2.2	2.3	2.6	2.6
min	68.4	64.6	63.2	69.6	67.0	63.3	64.7	63.6	67.7	67.0	66.0	-1.4
max	79.3	80.4	84.0	79.7	80.9	77.4	83.1	82.8	80.3	80.3	80.8	13.5

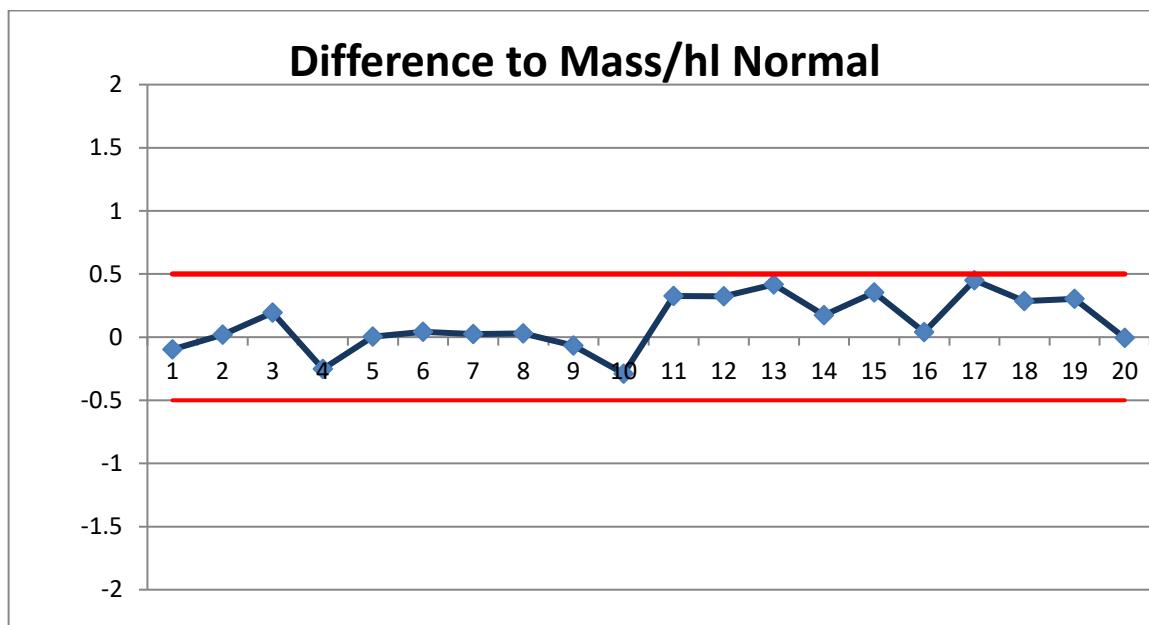
Z –scores for TWM / barley:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	-1.3	-2.0	-1.9	-1.3	-1.8	-1.5	-1.7	-2.0	-1.7	-0.9
2	-1.8	-1.9	-2.4	-1.2	-1.5	-2.2	-2.2	-2.5	-1.5	-1.9
4a	-0.9	-1.1	-1.2	-0.3	-0.1	-0.4	-0.5	-0.3	-1.1	-0.5
4b	-0.6	-0.8	-1.1	-0.7	-0.5	0.4	-1.5	-1.3	-1.2	-0.2
5	-0.7	-1.4	-1.5	-0.9	-1.2	-0.7	-0.7	-1.6	-0.7	-1.3
6	-2.3	-2.6	-3.1	-2.1	-2.2	-3.1	-2.9	-3.8	-2.1	-2.9
8a	-0.7	-1.4	-1.7	-0.7	-1.0	-1.9	-1.5	-1.4	-1.1	-0.7
10	0.7	0.4	0.3	1.5	0.6	-0.7	0.3	0.2	1.3	0.9
11e	0.9	0.1	-0.7	-0.4	-0.8	0.2	-0.4	0.2	-0.4	-0.3
12	0.5	-0.6	-1.1	0.3	0.2	0.5	0.2	-0.8	-0.3	-0.4
15	0.1	-1.0	-0.3	0.1	-0.2	0.5	-0.3	0.2	0.1	-0.1
17	-0.8	-0.9	-1.7	-0.9	-1.7	-1.3	-1.7	-1.8	-1.3	-1.5
18	-1.3	-1.6	-1.7	-1.3	-1.0	-0.3	-2.1	-1.0	-1.5	-0.7
24	-4.5	-4.4	-4.7	-3.5	-3.8	-5.1	-4.9	-5.2	-4.3	-5.1
25	-1.7	-2.2	-2.3	-1.9	-1.8	-1.3	-2.5	-1.8	-1.3	-1.9
32	-0.5	-1.2	-0.9	-0.5	-0.8	-0.5	-1.1	-0.4	-0.7	-0.3
56	-0.5	-0.6	-1.1	0.1	0.6	-0.1	0.1	-1.4	0.1	-0.7
68	-0.7	-0.2	-0.9	-0.3	-0.4	-1.7	-0.5	-1.0	-0.1	-0.9
79a	-1.6	-4.3	-3.9	-4.1	-4.2	-4.0	-4.4	-4.9	-4.7	-3.7
79c	-0.5	-2.0	-2.3	-0.9	-1.4	-1.3	-1.7	-2.2	-1.3	-1.3
80	-1.8	-1.8	-1.7	-2.0	-1.8	-1.4	-2.0	-1.7	-1.7	-1.9
82	-1.0	-0.9	-1.7	-0.4	-0.8	-0.6	-1.5	-0.9	-1.1	-0.8
85	-1.7	-2.6	-3.3	-2.3	-2.6	-1.7	-2.9	-2.6	-2.3	-2.5
91	0.3	-0.4	-0.3	-0.1	-0.2	-0.1	-0.1	-0.4	-0.1	-0.1
94a	-0.5	-0.6	-1.1	-0.3	-0.2	-1.3	-1.3	-0.8	-0.1	-0.7
94b	-0.3	0.2	-0.5	0.1	0.0	-0.1	-0.9	-0.6	0.5	-0.1

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 most labs have also good control of their TWM for barley measurements. However, labs 24 and 79a show a significant negative bias and need to be adjusted. The values from these two labs have been excluded for BETV of barley. Lab 6 has a negative bias where two samples are red marked and the remaining are yellow marked. Lab 85 has a negative bias with one red marked and 7 yellow marked. It is recommended to adjust these two instruments as well.

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.

7.2 Falling number

Twenty participants reported results for this parameter using ICC 107/1 (9 participants) and ISO 3093 (11 participants). No predictions were performed.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
4	385	279	319	334	379	354	358	516	297	377	360	-9
5	393	312	377	290	382	414	404	590	337	378	388	19
8	401	391	413	382	380	407	388	522	333	411	403	34
12	379	354	337	320	376	385	366	501	303	404	373	3
15	432	254	392	304	436	403	364	517	297	400	380	11
17	381	322	345	316	368	384	345	457	309	385	361	-8
18	374	348	324	291	374	352	350	510	288	364	358	-12
24	384	314	345	319	331	375	342	462	279	391	354	-15
25	350	298	298	328	365	354	379	505	293	375	355	-15
26	383	348	383	353	396	413	379	536	311	374	388	18
30	361	369	289	321	358	362	339	509	277	364	355	-15
35	407	348	383	344	382	389	392	510	341	393	389	20
64	370	316	285	319	346	376	364	474	283	369	350	-19
66	368	326	314	265	346	361	334	468	496	362	364	-5
68	373	320	304	309	364	356	359	476	318	351	353	-16
80	395	382	321	325	383	373	374	517	265	367	370	1
81	412	298	345	317	397	395	370	521	308	439	380	11
82	387	363	343	301	356	363	352	511	315	400	369	0
91	341	338	328	302	364	359	337	487	301	358	352	-18
94	392	385	340	334	386	381	372	513	324	400	383	14
Average	383	333	339	319	373	378	363	505	314	383	369	
sd	21.0	36.1	35.4	24.9	22.5	20.5	19.3	29.9	47.6	21.6	15.4	
Min	341	254	285	265	331	352	334	457	265	351	350	
Max	432	391	413	382	436	414	404	590	496	439	403	

Z - values

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
4	0.1	-2.2	-0.8	0.6	0.2	-1.0	-0.2	0.4	-0.7	-0.2
5	0.4	-0.8	1.5	-1.1	0.3	1.4	1.6	3.4	0.9	-0.2
8	0.7	2.3	3.0	2.5	0.3	1.2	1.0	0.7	0.8	1.1
12	-0.2	0.8	-0.1	0.1	0.1	0.3	0.1	-0.2	-0.4	0.8
15	1.9	-3.2	2.1	-0.6	2.5	1.0	0.0	0.5	-0.7	0.7
17	-0.1	-0.4	0.2	-0.1	-0.2	0.2	-0.7	-1.9	-0.2	0.1
18	-0.4	0.6	-0.6	-1.1	0.0	-1.0	-0.5	0.2	-1.0	-0.8
24	0.0	-0.8	0.2	0.0	-1.7	-0.1	-0.9	-1.7	-1.4	0.3
25	-1.3	-1.4	-1.6	0.4	-0.3	-1.0	0.6	0.0	-0.8	-0.3
26	0.0	0.6	1.8	1.4	0.9	1.4	0.6	1.2	-0.1	-0.4
30	-0.9	1.4	-2.0	0.1	-0.6	-0.7	-1.0	0.1	-1.5	-0.8
35	0.9	0.6	1.8	1.0	0.3	0.4	1.1	0.2	1.1	0.4
64	-0.5	-0.7	-2.2	0.0	-1.1	-0.1	0.0	-1.2	-1.2	-0.6
66	-0.6	-0.3	-1.0	-2.2	-1.1	-0.7	-1.2	-1.5	7.3	-0.8
68	-0.4	-0.5	-1.4	-0.4	-0.4	-0.9	-0.2	-1.2	0.2	-1.3
80	0.5	2.0	-0.7	0.3	0.4	-0.2	0.4	0.5	-1.9	-0.6
81	1.1	-1.4	0.2	-0.1	0.9	0.7	0.3	0.6	-0.2	2.2
82	0.1	1.2	0.2	-0.7	-0.7	-0.6	-0.5	0.2	0.1	0.7
91	-1.7	0.2	-0.4	-0.7	-0.4	-0.8	-1.1	-0.7	-0.5	-1.0
94	0.3	2.1	0.0	0.6	0.5	0.1	0.3	0.3	0.4	0.7

For the calculation of the z-scores a fixed value of sR = 25 has been chosen in accordance with ISO/ICC standards.

Only three red marked samples for three different labs (5, 15 and 66), which seems to be random problems. No indication of any systematic problems hence the overall performance looks good.

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.

Five participants submitted reference results for this parameter using ICC 116/1 (8 and 94) and ISO 5529 (2, 18 and 68). Twenty-eight participants predicted the sedimentation index using ANN prediction models WHZE16 (2, 4b, 17a, 18, 19, 24 and 79) or WHZE22 (1, 4a, 8, 11, 25, 33, 64, 68, 75 and 91). Labs submitting reference results, but no predicted have got their spectra re-predicted with the latest model version WHZE22 (66, 85 and 94).

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
2	33	47	61	31	41	32	23	34	29	31	36	-1
8	32	52	62	32	42	32	22	34	28	33	37	0
18	N/A	47	N/A	32	39	N/A	28	40	32	29	35	-2
68	39	56	67	40	50	36	28	38	35	39	38	1
94	34	52	64	33	43	32	24	37	29	33	38	1
AvG.	35	51	64	34	43	33	25	37	31	33	37	

Predicted values

1	44	55	53	36	55	29	28	51	42	45	44	9
2	35	48	43	28	44	20	19	41	33	33	34	-1
4a	35	47	45	30	43	19	21	42	34	37	35	0
4b	33	43	40	27	33	24	16	35	29	31	31	-4
8a	33	46	42	27	43	18	18	42	33	32	33	-2
8b	37	47	43	29	44	20	20	40	34	36	35	0
11a	36	48	43	30	43	21	21	41	34	35	35	0
11b	36	47	43	29	45	21	19	42	34	33	35	0
11e	36	46	42	29	43	20	20	41	33	35	35	-1
17	37	49	46	30	38	29	18	42	33	37	36	1
18	40	50	48	33	47	25	25	46	39	38	39	4
19	35	46	43	29	44	20	21	41	33	34	35	-1
24	34	47	42	28	44	21	20	42	33	33	34	-1
25	33	45	41	26	44	20	18	39	32	32	33	-2
33	38	47	44	31	40	25	19	38	35	40	36	0
64	37	47	42	29	44	20	20	41	34	34	35	-1
66	34	45	42	30	43	22	20	41	33	32	34	-1
68	46	59	56	41	49	41	32	51	43	46	46	11
75a	35	47	43	30	43	20	21	40	33	34	35	-1
75b	35	47	43	30	43	20	21	40	34	36	35	0
79a	34	48	41	28	45	21	22	42	35	35	35	0
79b	33	46	42	27	45	20	21	41	34	35	34	-1
79c	34	47	41	28	44	21	22	40	34	35	35	-1
82	35	48	43	30	45	21	20	41	34	36	35	0
85	30	38	36	26	34	17	17	33	27	29	29	-7
91	36	47	43	29	45	21	21	41	35	35	35	0
94a	34	47	42	29	44	21	20	41	33	34	34	-1
94b	36	47	42	30	45	21	21	41	34	34	35	0

AvG.	36	47	43	30	44	22	21	41	34	35	35	
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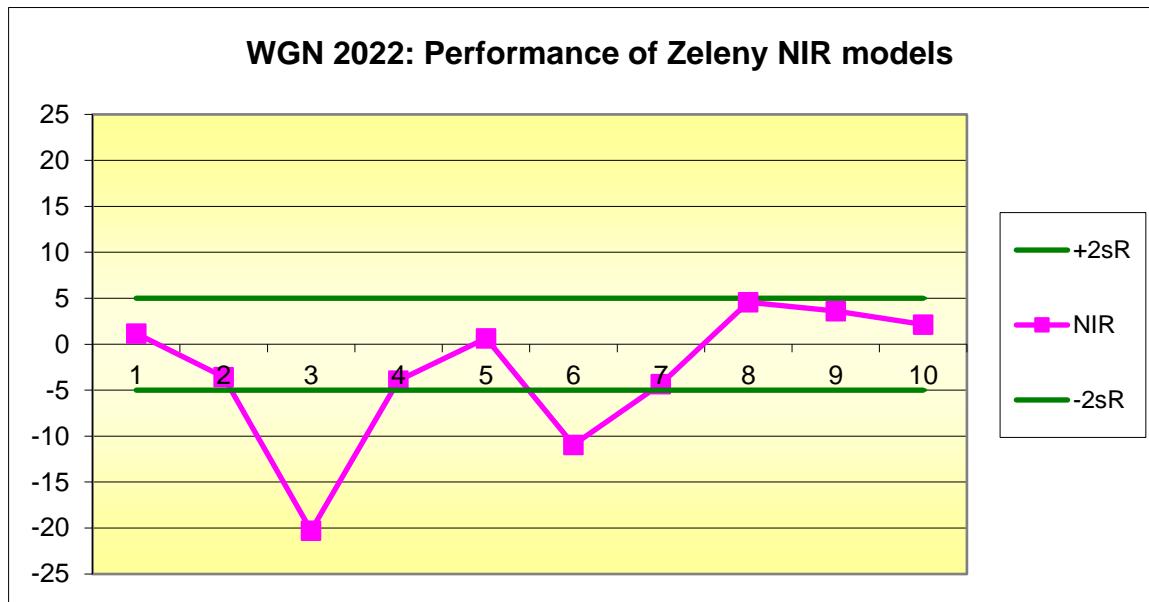


Figure 7.3.1: Deviations of average predicted values against average reference values.

It is a significant deviation between the predicted and reference value for W3 and W6. The other samples have good comparison between predicted and reference methods.

7.4 Wet gluten

Eleven participants reported reference values for wet gluten using ICC 155 (labs 8 and 12), ISO 21415-2 (mechanical) (labs 2, 4, 17, 24, 68 and 82), ISO 21415-1 (manual) (lab 19) and AACC 38-12.02 (labs 26 and 35) methods. Thirty-eight sets of results from twenty 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 26, 35 and 66).

Compilation of reported results (wheat samples):

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev
2	27.9	28.2	24.9	21.5	30.5	17.1	17.2	26.1	22.6	29.0	24.5	0.1
4	29.4	29.4	24.4	21.4	30.9	17.6	17.1	27.1	22.8	28.7	24.9	0.5
8	28.9	26.8	22.7	19.3	28.6	16.5	15.1	24.1	20.8	27.4	23.0	-1.4
12	28.3	28.0	24.8	19.8	32.0	16.5	16.9	25.8	21.9	28.5	24.3	-0.1
17	28.6	28.8	23.8	20.7	30.4	16.5	17.1	26.2	22.4	28.2	24.3	-0.1
19	25.9	28.1	26.3	22.4	30.0	17.4	17.0	26.2	22.2	26.0	24.2	-0.2
24	28.7	28.6	24.5	21.4	30.8	16.8	16.6	26.3	22.5	30.2	24.6	0.3
26	26.2	26.7	24.1	20.6	27.6	19.9	17.7	24.7	21.3	26.9	23.6	-0.8
35	30.2	28.5	24.2	20.5	32.0	16.5	16.7	25.3	22.5	29.5	24.6	0.2
68	31.1	30.5	27.6	22.1	31.8	18.1	17.8	27.6	22.4	30.5	26.0	1.6
82	29.5	28.3	23.8	20.7	31.0	16.6	16.3	25.9	22.3	29.1	24.4	0.0
Average	28.6	28.3	24.7	21.0	30.5	17.2	16.9	25.9	22.2	28.6	24.4	0.0
sd	1.6	1.1	1.3	0.9	1.4	1.0	0.7	1.0	0.6	1.4	0.7	0.7
Min	25.9	26.7	22.7	19.3	27.6	16.5	15.1	24.1	20.8	26.0	23.0	-1.4
Max	31.1	30.5	27.6	22.4	32.0	19.9	17.8	27.6	22.8	30.5	26.0	1.6

Predicted values

1	27.1	30.3	28.7	22.4	30.4	20.5	20.2	28.0	22.4	28.2	25.8	1.1
2	26.0	29.7	27.7	20.9	29.2	18.7	19.7	27.9	21.3	26.8	24.8	0.1
4a	26.6	28.7	28.5	25.4	28.5	20.4	20.5	28.0	22.3	26.5	25.5	0.8
4b	25.8	29.3	27.1	19.5	28.0	17.6	15.8	26.7	18.9	25.4	23.4	-1.3
8a	26.3	29.7	27.7	22.2	27.7	19.3	19.7	26.7	21.7	27.4	24.8	0.1
8b	26.2	29.5	26.6	22.1	27.1	20.1	20.0	25.5	21.5	27.3	24.6	-0.1
11a	25.8	29.1	27.6	20.9	29.0	20.0	19.6	27.8	22.3	25.8	24.8	0.1
11b	26.1	28.7	27.4	20.9	29.2	19.8	19.0	27.4	22.3	26.2	24.7	0.0
11e	25.9	27.7	27.5	21.1	28.9	20.2	20.1	28.2	22.2	25.4	24.7	0.0
12	24.3	27.3	25.7	19.8	27.2	18.6	18.4	25.8	21.4	24.3	23.3	-1.4
17	25.6	28.6	27.4	20.9	26.9	20.7	20.0	26.0	22.8	25.4	24.4	-0.3
18	27.6	30.5	29.4	21.9	30.6	20.4	20.7	29.3	22.9	28.3	26.2	1.4
19	25.8	28.2	27.2	19.7	29.8	19.4	18.3	27.5	21.3	25.3	24.3	-0.5
24	26.3	29.0	27.9	21.6	28.7	20.0	19.8	28.3	21.4	26.8	25.0	0.3
25	25.6	28.8	27.1	21.1	27.9	19.9	18.8	26.5	21.2	26.1	24.3	-0.4
26	26.2	28.0	27.4	21.0	29.1	20.1	19.6	27.6	22.6	25.6	24.7	0.0
35a	25.9	28.5	27.5	21.4	28.8	19.9	20.0	27.8	23.4	25.8	24.9	0.2
35b	25.9	28.0	27.6	20.8	29.2	20.8	20.2	27.5	23.3	25.6	24.9	0.2
35c	25.6	28.0	27.6	21.0	29.1	20.8	20.1	27.8	23.2	25.8	24.9	0.2
35d	25.4	27.8	27.0	20.8	28.2	19.8	19.2	27.2	22.2	25.3	24.3	-0.4
56	25.7	27.6	27.5	20.4	28.6	20.5	19.5	27.8	22.2	25.3	24.5	-0.2
66	30.4	31.3	31.7	24.3	33.0	24.5	23.0	32.3	26.3	29.0	28.6	3.9
68	26.2	28.6	27.6	21.7	29.8	21.2	20.4	27.4	23.5	25.8	25.2	0.5
75a	25.5	28.6	27.0	20.4	29.2	19.8	19.5	26.9	22.3	25.9	24.5	-0.2
75b	25.3	28.3	26.9	20.6	29.0	19.7	19.4	26.7	22.7	25.9	24.4	-0.3
79a	26.1	28.4	26.6	21.1	29.8	19.8	20.9	28.2	23.1	25.9	25.0	0.3
79b	30.9	33.2	32.0	25.3	33.1	24.1	24.4	32.4	26.0	30.6	29.2	4.5

79c	28.2	30.6	29.0	21.8	31.7	20.9	20.8	30.0	24.0	27.6	26.5	1.7
80	26.3	28.9	28.4	20.6	30.6	20.2	18.6	29.6	22.3	25.9	25.1	0.4
82	25.7	27.9	26.9	20.1	29.3	19.6	17.8	27.6	21.6	24.8	24.1	-0.6
85	29.0	31.0	30.0	26.0	30.0	20.0	20.0	30.0	22.0	27.0	26.5	1.8
91	26.2	28.6	28.2	20.4	30.3	20.4	18.4	29.0	22.4	25.6	24.9	0.2
94a	24.5	26.5	26.0	19.9	27.4	19.0	18.5	26.3	21.2	24.4	23.4	-1.4
94b	23.8	26.3	24.7	18.9	27.2	18.1	17.9	25.0	20.8	23.6	22.6	-2.1
Average	26.0	28.7	27.5	21.2	28.9	19.9	19.4	27.6	22.1	26.0	24.7	

z-values:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	
2	-0.7	-0.1	0.2	0.6	0.0	-0.1	0.3	0.2	0.4	0.4	
4	0.8	1.0	-0.2	0.5	0.4	0.3	0.2	1.2	0.6	0.2	
8	0.3	-1.5	-2.0	-1.7	-1.9	-0.7	-1.8	-1.8	-1.4	-1.2	
12	-0.3	-0.3	0.1	-1.2	1.5	-0.7	0.0	-0.1	-0.3	-0.1	
17	0.0	0.5	-0.9	-0.3	-0.1	-0.7	0.2	0.3	0.2	-0.4	
19	-2.7	-0.2	1.6	1.4	-0.5	0.2	0.1	0.3	0.0	-2.6	
24	0.1	0.3	-0.2	0.4	0.3	-0.4	-0.3	0.4	0.3	1.6	
26	-2.4	-1.6	-0.6	-0.4	-2.9	2.7	0.8	-1.2	-0.9	-1.7	
35	1.6	0.2	-0.5	-0.4	1.4	-0.7	-0.2	-0.6	0.4	1.0	
68	2.5	2.1	3.0	1.2	1.3	0.9	0.9	1.7	0.3	2.0	
82	0.9	0.0	-0.9	-0.3	0.5	-0.6	-0.6	0.0	0.1	0.5	
p1	1.1	1.6	1.2	1.2	1.4	0.6	0.7	0.4	0.3	2.2	
p2	0.0	1.0	0.2	-0.3	0.2	-1.2	0.3	0.3	-0.9	0.8	
p4a	0.5	0.1	1.0	4.3	-0.4	0.5	1.0	0.5	0.2	0.5	
p4b	-0.2	0.6	-0.3	-1.7	-0.9	-2.3	-3.6	-0.9	-3.2	-0.6	
p8a	0.3	1.0	0.2	1.0	-1.2	-0.6	0.3	-0.9	-0.4	1.4	
p8b	0.2	0.8	-0.9	0.9	-1.8	0.2	0.6	-2.1	-0.6	1.3	
p11a	-0.2	0.4	0.1	-0.3	0.1	0.1	0.2	0.3	0.1	-0.1	
p11b	0.1	0.1	0.0	-0.3	0.2	0.0	-0.4	-0.1	0.2	0.2	
p11e	-0.2	-0.9	0.0	-0.1	0.0	0.3	0.7	0.7	0.1	-0.6	
p12	-1.7	-1.4	-1.8	-1.4	-1.7	-1.3	-1.0	-1.8	-0.7	-1.7	
p17	-0.4	-0.1	-0.1	-0.3	-2.0	0.8	0.6	-1.6	0.6	-0.6	
p18	1.6	1.8	1.9	0.7	1.7	0.5	1.3	1.7	0.8	2.3	
p19	-0.2	-0.5	-0.3	-1.5	0.9	-0.5	-1.1	-0.1	-0.8	-0.7	
p24	0.3	0.3	0.4	0.4	-0.2	0.1	0.4	0.7	-0.7	0.8	
p25	-0.4	0.2	-0.4	-0.1	-1.1	0.0	-0.6	-1.1	-0.9	0.1	
p26	0.2	-0.6	-0.1	-0.2	0.1	0.3	0.1	0.0	0.5	-0.3	
p35a	-0.1	-0.2	0.0	0.2	-0.1	0.1	0.6	0.3	1.2	-0.2	
p35b	-0.1	-0.6	0.1	-0.3	0.2	0.9	0.8	-0.1	1.1	-0.3	
p35c	-0.4	-0.6	0.1	-0.2	0.2	0.9	0.7	0.2	1.1	-0.2	
p35d	-0.6	-0.8	-0.5	-0.3	-0.7	-0.1	-0.2	-0.4	0.1	-0.6	
p56	-0.3	-1.1	0.0	-0.8	-0.3	0.6	0.1	0.2	0.1	-0.7	
p66	4.4	2.7	4.2	3.2	4.0	4.7	3.6	4.7	4.2	3.0	

p68	0.2	0.0	0.1	0.5	0.9	1.3	1.0	-0.1	1.3	-0.2
p75a	-0.5	0.0	-0.5	-0.7	0.2	-0.1	0.1	-0.7	0.2	-0.1
p75b	-0.8	-0.3	-0.6	-0.6	0.0	-0.2	0.0	-0.9	0.6	-0.1
p79a	0.1	-0.3	-0.9	-0.1	0.9	-0.1	1.5	0.6	1.0	-0.1
p79b	4.9	4.5	4.5	4.1	4.2	4.2	5.0	4.8	3.9	4.6
p79c	2.2	1.9	1.5	0.6	2.8	1.0	1.4	2.4	1.9	1.6
p80	0.3	0.2	1.0	-0.5	1.6	0.3	-0.8	2.0	0.1	-0.1
p82	-0.3	-0.8	-0.6	-1.1	0.4	-0.3	-1.6	0.0	-0.5	-1.2
p85	3.0	2.3	2.5	4.8	1.1	0.1	0.6	2.4	-0.1	1.0
p91	0.2	-0.1	0.7	-0.8	1.4	0.5	-1.1	1.4	0.3	-0.4
p94a	-1.5	-2.2	-1.5	-1.3	-1.5	-0.9	-0.9	-1.3	-0.9	-1.6
p94b	-2.2	-2.4	-2.8	-2.3	-1.7	-1.8	-1.5	-2.6	-1.3	-2.4

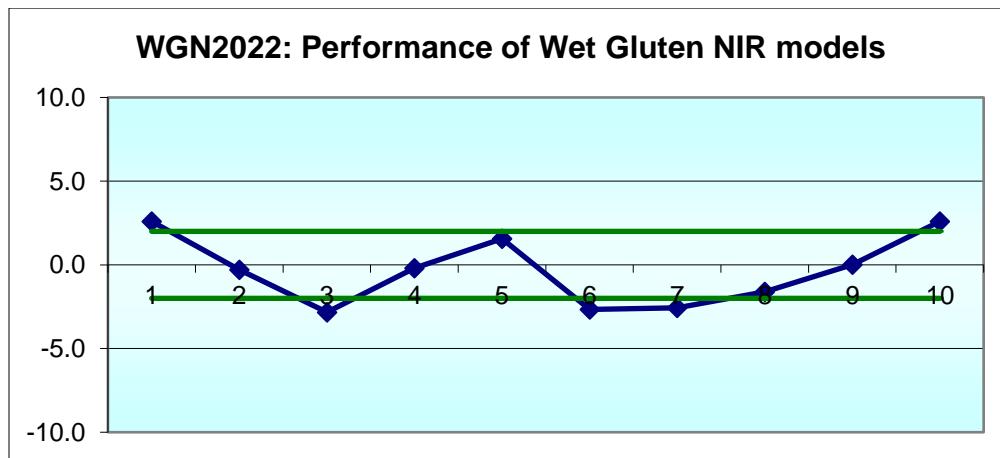


Fig. 7.4.1: Deviation of average results from prediction models against average values of reference results for wet gluten. Green lines = +/- 2 s_R.

The overall performance of the Infratec prediction models is rather good where half of the samples falls within the error limits of the reference method, except for W1, W3, W6, W7 and W10, 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:

S03	Lab 2	EU regulation (EC) 152/2009 (polarimetric, HCl)
S04	Lab 8, 80, 81	EN ISO 10520 (Ewers)
S06	Lab 12, 18, 24	EN ISO 6493 (polarimetric, HCl)
S06	Lab 5	Enzymatic + HPLC
S06	Lab 68	MSZ 6830-18:1988 Sec.2. (Polarimetric, HCl)

In addition, twenty-seven 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
2	67.3	67.4	68.6	69.3	68.5	68.7	72.6	68.3	71.0	67.3	68.9	1.1
5	67.9	66.6	68.3	67.2	68.1	65.6	67.3	66.1	66.2	66.6	67.0	-0.8
8	69.2	67.6	68.7	68.1	69.0	68.8	70.2	69.5	69.1	69.9	69.0	1.2
12	67.5	66.9	68.5	67.0	67.9	68.2	67.9	67.8	67.5	67.5	67.7	-0.2
18	69.3	69.1	68.2	67.6	68.6	69.0	69.2	69.2	69.5	69.7	68.9	1.1
24	67.3	66.7	67.4	66.4	65.0	65.7	68.0	64.9	63.0	66.1	66.1	-1.8
68	67.3	66.7	67.4	66.4	65.0	65.7	68.0	64.9	63.0	66.1	66.1	-1.8
80	66.6	65.9	66.5	65.6	66.3	66.5	67.1	67.0	66.8	67.8	66.6	-1.2
81	70.3	69.1	70.3	69.2	70.4	70.1	71.1	70.4	70.1	71.0	70.2	2.4
AvG	68.1	67.3	68.2	67.4	67.6	67.6	69.0	67.6	67.4	68.0	67.8	
sd	1.2	1.1	1.1	1.3	1.8	1.7	1.9	2.0	2.9	1.8	1.5	
rsd	1.8	1.6	1.5	1.9	2.7	2.6	2.7	2.9	4.3	2.6	2.2	

Predicted values:

2	67.8	67.3	69.5	70.6	69.6	70.5	73.6	69.2	73.1	67.3	69.8	0.0
4a	68.1	67.8	69.2	70.9	69.3	69.9	72.4	68.9	72.0	67.6	69.6	-0.2
4b	65.8	65.9	66.0	68.0	67.6	64.6	69.0	65.3	67.8	67.2	66.7	-3.1
5	66.9	66.2	68.6	69.3	70.1	70.0	72.2	68.5	71.8	66.1	69.0	-0.9
8a	68.3	68.1	68.9	71.2	71.4	70.3	72.7	68.5	72.1	69.4	70.1	0.3
8b	69.1	69.2	69.9	72.2	71.8	70.3	73.3	69.3	72.5	69.5	70.7	0.9
11a	68.2	68.1	69.5	70.4	71.6	70.5	73.0	69.4	72.9	67.9	70.2	0.3
11b	67.8	68.0	69.0	70.3	70.5	70.6	72.8	69.4	72.1	67.7	69.8	0.0
11e	68.3	68.1	69.6	70.6	70.9	70.9	73.4	69.6	73.2	67.9	70.2	0.4
12	66.6	67.3	69.2	69.9	68.9	69.6	71.7	69.0	71.3	67.1	69.1	-0.8

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb/March 2022

17	68.8	67.4	68.6	69.9	69.8	69.3	71.8	67.9	70.8	68.6	69.3	-0.5
18	68.4	68.1	69.6	71.1	71.0	70.0	73.7	69.4	73.1	68.4	70.3	0.5
19	68.2	68.0	70.1	71.3	70.6	70.3	73.7	69.2	72.8	67.3	70.2	0.3
24	68.9	68.0	69.7	71.0	70.7	70.7	73.2	69.5	72.5	68.0	70.2	0.4
25	66.8	66.2	68.4	69.6	70.0	69.7	72.1	68.5	71.6	66.1	68.9	-0.9
56	68.3	67.6	69.0	68.6	68.5	68.2	69.3	68.1	68.2	69.1	68.5	-1.3
68	68.5	68.5	70.3	71.5	71.1	69.7	73.9	69.6	73.4	69.4	70.6	0.8
75a	68.9	68.9	70.5	71.3	71.9	70.8	73.4	70.4	73.5	68.6	70.8	1.0
75b	69.0	69.1	70.5	71.1	72.0	70.5	73.4	70.6	73.2	68.8	70.8	1.0
79b	68.6	68.7	69.5	71.0	71.2	70.7	71.8	69.0	71.7	68.9	70.1	0.3
79c	69.4	69.2	71.5	71.7	71.8	71.1	74.1	70.9	73.7	68.9	71.2	1.4
80	67.2	67.0	69.0	70.0	70.0	69.7	73.0	68.7	72.3	66.7	69.4	-0.5
81	69.2	69.5	70.1	72.3	72.0	71.3	73.1	69.0	72.3	69.4	70.8	1.0
82	68.1	67.9	69.7	70.0	70.6	69.9	72.9	69.5	72.5	67.5	69.9	0.0
91	67.9	67.9	69.6	70.2	70.6	69.9	73.4	69.5	72.9	67.3	69.9	0.1
94a	67.8	67.0	69.6	70.0	70.8	70.7	72.9	69.2	72.6	67.0	69.8	-0.1
94b	67.6	67.5	69.5	69.8	70.1	69.6	71.9	69.2	71.7	67.3	69.4	-0.4
AvG	68.1	67.9	69.4	70.5	70.5	70.0	72.7	69.1	72.1	68.0	69.8	0.0

Z-Scores:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	-0.8	0.0	0.4	1.8	0.8	1.1	3.6	0.7	3.7	-0.7
5	-0.2	-0.7	0.1	-0.2	0.4	-2.0	-1.8	-1.4	-1.2	-1.4
8	1.1	0.2	0.5	0.7	1.4	1.2	1.1	1.9	1.7	1.9
12	-0.6	-0.4	0.3	-0.4	0.3	0.6	-1.1	0.2	0.1	-0.5
18	1.2	1.8	0.0	0.2	1.0	1.4	0.2	1.6	2.1	1.7
24	-0.8	-0.6	-0.8	-1.0	-2.6	-1.9	-1.0	-2.7	-4.4	-1.9
68	-0.8	-0.6	-0.8	-1.0	-2.6	-1.9	-1.0	-2.7	-4.4	-1.9
80	-1.5	-1.4	-1.7	-1.8	-1.3	-1.1	-1.9	-0.6	-0.5	-0.2
81	2.2	1.8	2.1	1.8	2.7	2.5	2.0	2.9	2.7	3.0
p2	-0.3	-0.6	0.1	0.1	-0.9	0.5	1.0	0.1	1.0	-0.7
p4a	0.0	-0.1	-0.2	0.3	-1.2	-0.1	-0.2	-0.2	-0.2	-0.4
p4b	-2.3	-2.0	-3.4	-2.5	-2.9	-5.4	-3.7	-3.8	-4.3	-0.8
p5	-1.2	-1.7	-0.8	-1.2	-0.4	0.0	-0.5	-0.6	-0.3	-1.9
p8a	0.2	0.2	-0.5	0.7	0.9	0.3	0.0	-0.6	0.0	1.4
p8b	1.0	1.3	0.5	1.7	1.3	0.3	0.6	0.2	0.4	1.5
p11a	0.1	0.3	0.1	-0.1	1.1	0.5	0.4	0.3	0.8	-0.1
p11b	-0.3	0.1	-0.4	-0.2	-0.1	0.6	0.1	0.3	0.0	-0.3
p11e	0.2	0.2	0.1	0.1	0.3	0.9	0.7	0.5	1.1	-0.1
p12	-1.5	-0.6	-0.2	-0.6	-1.6	-0.4	-1.0	-0.1	-0.8	-0.9
p17	0.7	-0.5	-0.8	-0.6	-0.7	-0.7	-0.9	-1.2	-1.3	0.6
p18	0.3	0.2	0.2	0.6	0.5	0.0	1.0	0.3	0.9	0.4
p19	0.1	0.1	0.7	0.8	0.1	0.3	1.0	0.1	0.7	-0.7
p24	0.8	0.1	0.3	0.5	0.2	0.7	0.5	0.4	0.4	0.0
p25	-1.3	-1.7	-1.0	-0.9	-0.5	-0.3	-0.6	-0.6	-0.5	-1.9
p56	0.2	-0.3	-0.4	-1.9	-2.0	-1.8	-3.4	-1.0	-3.9	1.1
p68	0.4	0.7	0.9	1.0	0.5	-0.3	1.3	0.5	1.2	1.4
p75a	0.8	1.1	1.1	0.8	1.3	0.8	0.8	1.3	1.4	0.7
p75b	0.9	1.2	1.0	0.6	1.5	0.5	0.7	1.5	1.1	0.9
p79b	0.5	0.8	0.1	0.5	0.7	0.7	-0.9	-0.1	-0.4	0.9
p79c	1.3	1.3	2.1	1.2	1.3	1.1	1.4	1.8	1.6	0.9
p80	-0.9	-0.9	-0.4	-0.6	-0.6	-0.2	0.3	-0.4	0.1	-1.3
p81	1.1	1.6	0.7	1.8	1.5	1.3	0.4	-0.1	0.2	1.4
p82	0.0	0.0	0.3	-0.5	0.1	-0.1	0.2	0.4	0.4	-0.5
p91	-0.2	0.0	0.2	-0.3	0.1	-0.1	0.7	0.4	0.8	-0.7
p94a	-0.3	-0.9	0.2	-0.5	0.3	0.7	0.2	0.1	0.5	-1.0
p94b	-0.5	-0.4	0.1	-0.7	-0.4	-0.4	-0.8	0.1	-0.4	-0.7

P = predicted

Lab 81 show a tendency for a positive shift on reference results, but otherwise the performance looks good irrespective of the different methods applied. The predicted values from lab 4b show significant negative bias and should be adjusted.

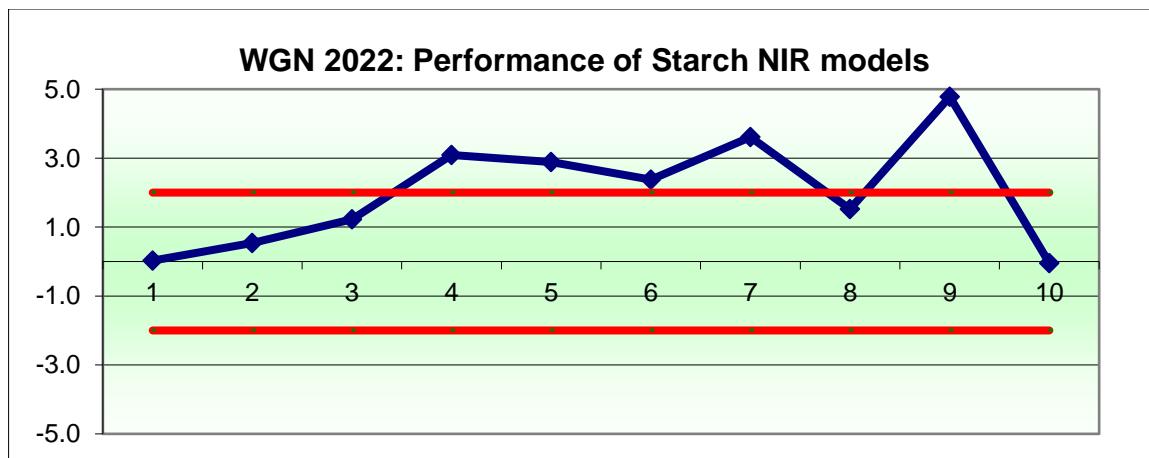


Fig. 7.5.1: Performance of average results of predictions against average reference values for starch in wheat. Red lines = $\pm 2 S_R$.

The overall performance of the starch NIR models is only aligned for half of the samples inside the limits. Samples W4-W7 and W9 are predicted too high compared to the reference BETV. Lab 81 is shifted by 2.4 above the average of reference results. If average predicted is compared against lab 81 reference values, then deviations are within the limits for all but samples W10. This illustrates the difficulty with the starch reference method and the importance of aligning the prediction models accordingly.

7.6 Starch in barley

Four labs (5, 12, 68 and 93) submitted results by reference method. Lab 93 use method S03 and the other use the same as for wheat (see section 7.5). Six sets of predicted results from four participants were submitted for starch in barley. The models used were BAST12 (5 and 12) and WBST10 (11). Re-predictions using WBST10 have also been done (68).

Collation of data:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
5	56.7	56.7	60.6	57.4	57.3	59.1	61.1	60.5	62.0	56.1	58.7	-1.7
12	59.4	59.6	63.2	61.4	61.2	61.2	60.7	62.5	65.0	59.4	61.4	0.9
68	57.9	59.6	59.8	59.4	58.4	57.7	61.6	61.8	60.2	58.9	59.5	7.0
93	58.5	59.0	64.6	61.4	62.0	61.3	66.0	64.5	65.5	59.3	62.2	7.0
AvG	58.1	58.7	62.0	59.9	59.7	59.8	62.3	62.3	63.2	58.4	60.5	3.3
sd	1.2	1.4	2.2	1.9	2.2	1.8	2.5	1.7	2.5	1.6	1.6	
rsd	2.0	2.4	3.6	3.2	3.7	2.9	4.0	2.7	4.0	2.7	2.7	

Predicted values:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
5	60.7	58.9	62.4	59.2	60.3	58.9	62.6	62.3	63.0	62.0	61.0	-0.2
11a	62.7	58.5	63.7	59.8	61.4	62.6	63.5	63.1	64.0	62.0	62.1	0.9
11b	62.3	58.4	62.6	59.0	60.5	58.9	62.4	63.0	63.3	61.0	61.1	0.0
11e	60.9	59.2	63.0	59.5	61.2	58.9	62.2	62.7	63.5	61.8	61.3	0.1
12	59.2	58.7	60.5	60.6	60.7	56.8	61.9	63.8	62.8	62.3	60.7	-0.5
68	61.9	56.8	61.8	58.8	60.4	61.2	62.8	62.0	62.4	60.4	60.8	-0.4
AvG	61.3	58.4	62.3	59.5	60.8	59.5	62.5	62.8	63.2	61.6	61.2	

Too few reference data for statistical analysis.

7.7 Hardness

Three participants reported values for the parameter “Hardness”. The methods used was SKCS (lab 10) and AACC 39-70A (labs 2 and 33). In addition, two labs reported predicted values using WHHA26 (10) and WHHA36 (lab 11). Re-predictions were also made with WHHA36 (2, 33 and 75).

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 Perner 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	82.2	98.4	92.3	81.3	89.1	62.8	83.9	99.9	81.2	94.9
10	80.0	73.0	67.5	62.0	51.0	44.0	44.0	55.0	48.0	79.0
33	78.5	76.0	83.5	63.5	71.0	62.5	67.0	85.5	60.0	72.5
Average	80.2	82.5	81.1	68.9	70.4	56.4	65.0	80.1	63.1	82.1
SD	1.9	13.9	12.6	10.8	19.1	10.8	20.0	22.9	16.8	11.5

Predicted values

2	66.1	66.3	70.0	41.0	29.6	38.6	13.2	44.3	54.0	61.9
10	79.0	86.9	77.3	61.9	43.2	34.8	25.6	48.4	46.4	80.6
11a	69.0	67.6	65.6	52.4	41.9	30.3	13.8	36.0	51.5	79.8
11b	71.1	67.8	64.2	52.5	39.0	29.7	15.8	32.7	51.9	78.7
11e	64.6	61.7	66.9	56.9	32.7	33.8	16.1	34.0	52.4	69.1
33	75.0	63.1	67.8	44.2	33.2	40.4	16.0	36.5	51.3	76.7
75a	71.3	68.8	61.4	47.2	34.7	29.7	14.4	31.2	50.5	78.7
75b	73.0	69.5	62.9	49.4	41.4	29.6	16.6	34.6	51.0	79.7
Average	71.1	69.0	67.0	50.7	37.0	33.4	16.4	37.2	51.1	75.6

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 WGN2022 exercise.

Parameter	# labs reporting (ref + pred)
Protein	4+18
Glucosinolates	3+8
Erucic acid	4+10
Oleic acid	3+12
Linolenic acid	3+12
Linoleic acid	3+3
FFA (Acidity index)	2+1
Saturated fats	1+4
Iodine values	1+3

8.1 Protein

Reference results for protein in rapeseed were submitted from four labs (12, 33, 35 and 68). One participant reported Infratec predictions with local PLS model RAPR10 (35a and 35d), one with RAPR11 (19) and RAPR12 (5, 12). Re-predictions were made with RAPR12 (labs 11, 33, 35b-35c and 68). In addition, two results were submitted from NIRS DS2500 (35e and 35g), one from NIRS 6500 and one from an XDS (91).

Collation of results

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
12	21.0	21.8	19.5	20.3	21.6	22.6	19.9	20.2	19.2	18.4	20.45	-0.07
33	21.3	21.8	19.5	20.3	21.7	22.8	20.1	20.5	19.2	18.4	20.56	0.03
35	21.3	21.9	19.9	20.5	21.5	23.0	19.5	20.2	19.4	18.3	20.55	0.03
68	21.2	21.8	19.9	20.4	21.6	23.1	19.6	20.2	19.1	18.5	20.54	0.01

Average	21.2	21.8	19.7	20.4	21.6	22.9	19.8	20.3	19.2	18.4	20.5	0.0
sd	0.1	0.1	0.2	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.0	0.0
min	21.0	21.8	19.5	20.3	21.5	22.6	19.5	20.2	19.1	18.3	20.5	-0.1
max	21.3	21.9	19.9	20.5	21.7	23.1	20.1	20.5	19.4	18.5	20.6	0.0

2	21.24	21.03	19.45	19.59	20.95	22.83	19.32	20.84	18.45	17.43	20.11	-0.37
5	20.55	21.81	20.33	20.49	21.70	22.97	19.84	20.71	19.56	18.85	20.68	0.20
11a	20.05	21.40	19.85	20.05	21.33	22.50	19.16	20.27	18.53	18.27	20.14	-0.34
11b	20.42	21.49	19.55	19.88	21.11	22.44	19.36	19.90	18.94	18.36	20.14	-0.34

11e	20.28	21.64	20.00	20.48	21.22	22.70	19.87	20.73	19.30	18.86	20.51	0.02
12	19.90	21.40	19.50	20.10	21.30	22.90	19.70	20.40	19.10	18.30	20.26	-0.22
19	25.25	24.70	23.00	23.40	24.80	25.50	22.50	23.60	22.60	21.80	23.72	3.23
33	20.35	21.81	19.62	20.07	21.33	22.42	19.30	20.41	18.60	18.44	20.23	-0.25
35a	20.30	20.90	21.40	20.80	20.50	20.70	20.80	21.60	22.40	22.70	21.21	0.73
35b	20.66	21.44	20.13	20.36	21.13	22.84	19.71	20.54	19.25	18.75	20.48	0.00
35c	20.52	21.67	20.27	20.20	21.35	22.76	19.71	20.47	19.51	18.72	20.52	0.03
35d	20.50	21.10	20.20	20.50	22.00	23.80	19.80	21.90	20.10	18.80	20.87	0.39
35e	21.60	22.10	19.60	20.70	21.50	22.70	19.70	20.20	19.30	19.00	20.64	0.16
35f	20.80	22.00	19.80	20.50	21.60	22.60	19.60	20.20	19.20	18.70	20.50	0.02
35g	21.60	22.20	19.90	20.60	21.70	22.80	19.80	20.50	19.20	18.90	20.72	0.24
56	20.40	21.30	19.50	20.10	20.80	22.70	19.10	20.20	19.00	18.60	20.17	-0.31
68	20.31	21.51	19.45	19.96	21.11	22.62	19.72	21.15	19.28	18.84	20.39	-0.09
91	21.70	22.40	19.60	20.30	22.40	23.20	19.60	20.50	18.90	17.90	20.65	0.17
AvG.	20.66	21.60	19.89	20.27	21.35	22.68	19.65	20.62	19.33	18.79	20.48	

Lab 19 deviate significantly and have been excluded from the average results.

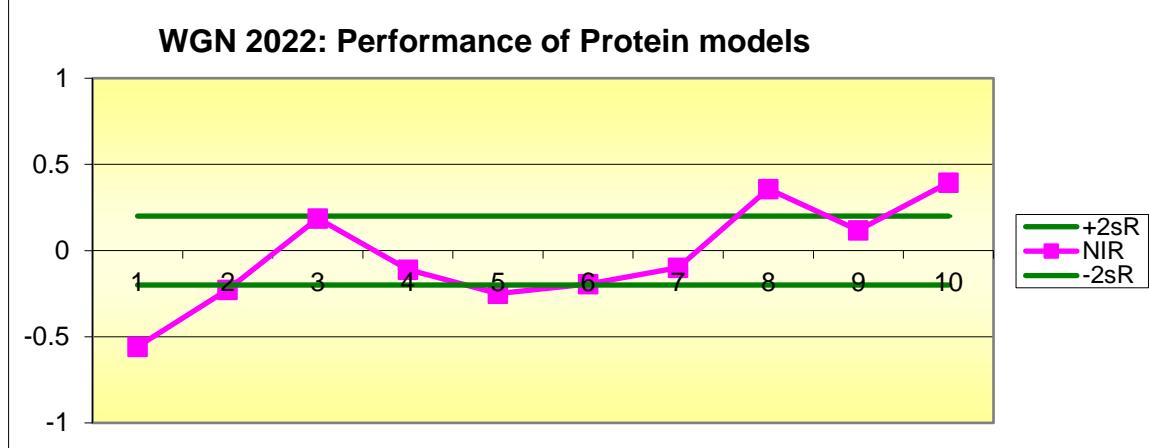


Fig. 8.2.1: Performance of average results of predictions against average reference values for protein in Rapeseed. Red lines = +/- 2sR.

8.2 Glucosinolates

Three participants submitted results for Glucosinolates using HPLC-UV (4), EN ISO 9167-1 (33) and one using a national standard method (68). Predicted results using model RAGU4 were performed for 3 instruments using extended range (11e, 35a and 35d). In addition, two results from NIRS DS2500 were submitted (35e and 35g), 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
4	8	19	17	15	9	17	15	17	17	18	15	2
33	6	17	17	14	9	15	14	17	16	19	14	1
68	7	16	16	14	9	12	14	15	15	17	13	0
AvG.	7	17	16	14	9	15	14	17	16	18	14	

2	3	14	14	13	6	12	13	14	15	16	12	-2
11e	0	24	25	19	5	39	11	28	13	9	17	3
35a	0	16	15	12	14	34	14	20	15	0	14	0
35d	0	19	22	18	15	41	18	29	18	13	19	5
35e	5	13	13	10	8	12	12	14	13	16	12	-3
35f	6	14	14	11	8	12	13	15	13	17	12	-2
35g	6	14	13	11	9	12	13	15	14	16	12	-2
91	10	20	18	16	13	19	14	18	18	23	17	2
AvG.	4	17	17	14	10	23	13	19	15	14	15	

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

8.3 Erucic acid

Three participants (33, 35 and 68) submitted results for Erucic acid using a GC method (EN ISO-12966-2). Spectra from 9 instruments were re-predicted using model RAEU7 (11, 33, 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
33	0.00	0.21	0.07	0.00	0.00	0.47	0.00	0.26	0.00	0.00	0.10	-0.01
35	0.00	0.12	0.05	0.00	0.00	0.49	0.07	0.27	0.07	0.00	0.11	-0.01
68	0.05	0.14	0.06	0.05	0.05	0.46	0.07	0.29	0.05	0.05	0.13	0.02
AvG.	0.02	0.16	0.06	0.02	0.02	0.47	0.05	0.27	0.04	0.02	0.11	

11a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.60	0.00	0.00	0.86	0.41
11b	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.01	-0.44
11e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.45
33	0.00	0.00	0.00	0.00	5.77	1.07	0.00	9.52	3.83	0.00	2.02	1.57
35a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.25	-0.20
35b	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.45

35c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.45
35d	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.05	-0.40	
68	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.84	0.00	0.00	0.16	-0.29
91	0.50	1.35	1.20	1.10	1.40	1.10	1.25	1.10	1.00	1.30	1.13	0.68

AvG.	0.05	0.14	0.12	0.11	0.79	0.22	0.13	2.32	0.48	0.13	0.45	
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8.4 Oleic acid

Three participants (33, 35 and 68) submitted results for Oleic acid using a GC method (EN ISO-12966-2). Spectra from 9 instruments were re-predicted using model RAOA3 (11, 33, 35a-35d and 68). Predicted results from NIRS DS2500 (35e and 35g) and NIRS 6500 (35f) were also received.

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
33	57.14	64.81	61.69	64.71	64.84	60.37	66.79	62.00	62.89	63.53	62.88	0.68
35	56.78	63.68	60.66	63.31	63.76	59.35	65.82	60.89	61.99	62.39	61.86	-0.34
68	56.78	63.68	60.66	63.31	63.76	59.35	65.82	60.89	61.99	62.39	61.86	-0.34
AvG.	56.90	64.06	61.00	63.78	64.12	59.69	66.14	61.26	62.29	62.77	62.20	

11a	52.55	66.12	64.75	64.96	67.41	63.76	68.42	67.07	65.95	67.99	64.90	1.78
11b	52.66	65.70	65.31	65.30	67.79	64.66	67.92	65.72	64.89	66.90	64.68	1.57
11e	51.98	66.08	66.31	66.51	68.79	64.88	68.74	66.68	66.32	66.76	65.31	2.19
33	52.23	66.20	65.24	65.74	67.19	62.30	67.93	66.25	66.01	66.38	64.55	1.43
35a	51.29	65.63	65.08	64.88	67.46	63.37	67.36	66.88	65.95	66.46	64.44	1.32
35b	51.90	66.47	66.29	66.10	67.06	64.78	68.12	67.64	66.72	67.57	65.27	2.15
35c	52.26	66.15	66.01	65.77	68.09	63.91	68.86	66.73	65.25	66.95	65.00	1.88
35d	52.06	65.10	64.12	64.85	68.08	63.58	67.31	65.77	65.33	66.36	64.26	1.14
35e	56.17	64.11	61.83	62.66	64.24	60.40	65.36	61.70	62.44	63.43	62.24	-0.88
35f	55.99	64.53	61.26	62.58	63.48	60.58	65.80	61.70	62.32	62.75	62.10	-1.01
35g	56.19	64.02	61.75	62.74	64.10	60.64	65.38	61.58	62.75	63.39	62.25	-0.86
68	52.92	65.91	65.83	65.49	66.74	63.73	67.54	65.77	66.45	67.51	64.79	1.67

AvG.	53.18	65.50	64.48	64.80	66.70	63.05	67.39	65.29	65.03	66.04	64.15	
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8.5 Linolenic acid

Three participants (33, 35 and 68) submitted results for Linolenic acid using a GC method (EN ISO-12966-2). Spectra from 9 instruments were re-predicted using model RALN3 (11, 33, 35a-35d and 68). Predicted results from NIRS DS2500 (35e and 35g) and NIRS 6500 (35f) were also received.

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
33	12.83	7.57	9.18	9.12	8.22	10.61	6.41	9.81	9.72	8.25	9.17	-0.19
35	12.88	7.55	9.31	9.27	8.34	10.76	6.47	9.87	9.75	8.34	9.25	-0.11
68	13.34	7.97	9.68	9.71	8.77	11.22	6.82	10.29	10.15	8.74	9.67	0.30
AvG.	13.02	7.70	9.39	9.37	8.44	10.86	6.57	9.99	9.87	8.44	9.36	

11a	14.48	6.65	7.70	7.71	6.29	7.89	5.58	6.60	7.18	5.89	7.60	-0.57
11b	14.41	6.83	6.99	7.06	5.43	7.71	5.53	7.39	7.71	6.50	7.56	-0.61
11e	14.15	6.28	6.35	6.22	4.87	6.90	4.86	6.38	5.88	5.95	6.78	-1.39
33	15.48	7.17	7.80	7.49	6.14	9.90	6.04	7.29	7.69	7.18	8.22	0.05
35a	15.62	7.09	7.72	7.54	6.06	8.36	6.29	6.52	7.49	7.12	7.98	-0.19
35b	14.14	6.15	6.40	6.78	5.52	7.27	5.23	5.82	6.29	5.80	6.94	-1.23
35c	13.71	6.07	6.35	6.22	4.95	7.33	5.09	6.20	7.13	5.99	6.90	-1.27
35d	15.64	7.61	8.43	7.91	6.02	8.89	6.36	7.75	8.13	7.21	8.39	0.22
35e	13.37	7.78	9.92	9.60	8.41	11.09	7.10	10.50	10.12	9.23	9.71	1.54
35f	13.09	7.80	9.84	9.30	8.39	10.60	7.81	10.63	10.29	8.32	9.61	1.44
35g	13.31	7.78	9.90	9.54	8.24	10.86	7.08	10.47	10.06	9.11	9.63	1.46
68	16.01	7.79	8.27	8.90	7.23	9.20	6.83	8.13	7.81	7.10	8.73	0.56
AvG.	14.45	7.08	7.97	7.86	6.46	8.83	6.15	7.81	7.98	7.12	8.17	

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).

8.6 Linoleic acid

Three participants (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 35g) and NIRS 6500 (35f).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
33	22.87	19.08	20.59	18.38	18.64	20.11	18.70	19.84	19.58	19.59	20.94	-1.01
35	22.29	18.49	20.24	18.05	18.15	19.65	18.04	19.26	18.91	19.20	20.66	-1.30
68	22.77	19.26	20.93	18.76	18.82	20.29	18.76	19.99	19.55	19.80	24.27	2.31
AvG.	22.64	18.94	20.59	18.40	18.54	20.02	18.50	19.70	19.35	19.53	21.96	
35e	20.54	18.79	19.16	18.28	18.24	18.86	17.97	18.90	18.98	18.05	18.78	-0.23
35f	22.17	18.27	19.66	18.57	19.27	19.41	17.09	18.86	18.41	19.15	19.09	0.08
35g	21.04	18.84	19.47	18.50	19.02	19.14	18.41	19.31	19.00	18.77	19.15	0.15
AvG.	21.25	18.64	19.43	18.45	18.84	19.14	17.82	19.03	18.80	18.66	19.01	

8.7 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	0.76	0.58	0.56	1.60	0.41	0.52	0.81	0.78	0.61	0.59	0.72	0.16
35	0.54	0.28	0.26	0.21	0.16	0.26	1.14	0.52	0.29	0.27	0.39	-0.16
AvG.	0.65	0.43	0.41	0.90	0.29	0.39	0.97	0.65	0.45	0.43	0.56	
91	1.90	1.05	1.40	1.35	1.85	1.05	1.45	1.35	1.45	1.75	1.46	0.03
AvG.	1.90	1.05	1.40	1.35	1.85	1.05	1.45	1.35	1.45	1.75	1.46	

8.8 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 35g) and NIRS 6500 (35f) as well as from Infratec (68).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
35	5.78	7.18	6.92	6.63	7.06	6.75	6.94	6.73	6.63	7.40	6.80	0.0
AvG.	5.78	7.18	6.92	6.63	7.06	6.75	6.94	6.73	6.63	7.40	6.80	
35e	6.66	7.18	6.83	6.97	6.83	6.86	7.07	6.73	6.79	7.05	6.90	-0.04
35f	6.63	7.16	6.77	6.89	6.70	6.70	7.10	6.61	6.69	6.85	6.81	-0.12
35g	6.70	7.23	6.87	7.04	6.95	6.92	7.10	6.83	6.81	7.05	6.95	0.02
68	5.99	7.49	7.23	6.87	7.33	7.02	7.20	7.05	6.91	7.68	7.08	0.14
AvG.	6.49	7.27	6.93	6.94	6.95	6.87	7.12	6.81	6.80	7.16	6.93	

8.9 Iodine Value

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

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
35	122.7	108.7	113.5	111.8	109.8	115.6	106.5	113.7	113.4	110.5	112.6	0.0
AvG.	122.7	108.7	113.5	111.8	109.8	115.6	106.5	113.7	113.4	110.5	112.6	
35e	122.1	109.2	113.6	112.4	110.4	115.7	107.5	114.4	113.6	111.3	113.0	0.6
35f	121.8	109.2	114.4	112.6	110.8	115.3	108.1	114.8	114.1	111.6	113.3	0.8
35g	122.0	109.2	113.6	112.2	110.3	115.1	107.4	114.4	113.3	111.3	112.9	0.4
AvG.	122.0	109.2	113.9	112.4	110.5	115.4	107.7	114.5	113.7	111.4	113.1	

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	12.40	13.30	12.85	10.70	13.55	10.50	9.70	13.15	11.05	12.30	11.95	-0.16	0.07
2	12.71	13.66	13.18	10.94	13.75	10.57	9.94	13.40	11.23	12.51	12.19	0.08	0.08
4a	12.53	13.51	13.20	11.06	13.57	10.53	9.85	13.41	11.35	12.69	12.17	0.06	0.10
4b	12.73	13.58	13.04	11.04	13.79	10.52	9.83	13.29	11.25	12.50	12.16	0.05	0.06
5	12.50	13.50	13.10	10.90	13.60	10.40	9.80	13.20	11.30	12.50	12.08	-0.03	0.07
8a	12.70	13.50	13.20	11.00	13.70	10.60	9.90	13.40	11.50	12.50	12.20	0.09	0.08
8b	12.60	13.60	13.10	11.10	13.90	10.60	10.00	13.40	11.50	12.60	12.24	0.13	0.07
10	12.50	13.40	12.30	11.30	14.20	10.70	10.10	13.20	11.50	12.60	12.18	0.07	0.33
11a	12.61	13.46	13.03	10.93	13.72	10.45	9.84	13.24	11.22	12.47	12.10	-0.01	0.04
11b	12.57	13.43	13.07	10.97	13.72	10.55	9.79	13.20	11.38	12.42	12.11	0.00	0.06
12	12.40	13.30	12.80	10.70	13.30	10.30	9.60	13.10	11.10	12.30	11.89	-0.22	0.07
15	12.56	13.65	13.11	11.00	13.85	10.91	9.84	13.16	11.19	12.56	12.18	0.08	0.14
17a	12.55	13.45	12.95	10.90	13.75	10.60	9.75	13.30	11.25	12.45	12.10	-0.01	0.05
18	12.70	13.40	13.10	11.00	13.90	10.60	9.90	13.50	11.40	12.50	12.20	0.09	0.10
19	12.43	13.30	12.95	10.74	13.53	10.41	9.72	13.23	11.08	12.37	11.98	-0.13	0.06
24	12.60	13.40	12.90	10.80	13.60	10.70	9.80	13.40	11.30	12.40	12.09	-0.02	0.11
25	12.40	13.40	12.90	10.90	13.80	10.50	9.70	13.20	11.30	12.40	12.05	-0.06	0.08
26	12.95	13.76	13.29	11.21	13.99	10.75	10.06	13.53	11.45	12.72	12.37	0.26	0.05
27	12.76	13.66	13.29	11.02	13.92	10.89	10.03	13.42	11.47	12.83	12.33	0.22	0.09
30a	12.83	13.65	13.14	11.21	13.80	10.65	9.90	13.32	11.63	12.70	12.28	0.18	0.09
30b	12.80	13.70	13.28	11.32	13.89	10.70	9.88	13.50	11.19	12.64	12.29	0.18	0.12
30c	12.65	13.56	13.11	11.01	13.85	10.53	9.88	13.31	11.20	12.57	12.17	0.06	0.06
30h	13.07	13.85	13.24	11.25	13.98	10.93	9.90	13.76	11.56	12.77	12.43	0.33	0.12
33	12.70	13.50	13.10	10.90	13.60	10.50	9.70	13.30	11.40	12.50	12.12	0.01	0.08
35a	12.80	13.80	13.20	11.30	13.80	10.60	10.00	13.50	11.60	12.80	12.34	0.23	0.09
35b	12.90	13.70	13.20	11.20	13.80	10.70	9.90	13.40	11.60	12.70	12.31	0.20	0.08
35c	12.80	13.80	13.30	11.30	13.80	10.80	9.90	13.50	11.50	12.80	12.35	0.24	0.08
35d	12.80	13.70	13.20	11.20	13.70	10.80	9.80	13.40	11.40	12.60	12.26	0.15	0.09

56	12.40	13.30	12.80	10.70	13.50	10.50	9.60	13.10	11.00	12.40	11.93	-0.18	0.07
64	12.60	13.40	12.90	10.90	13.70	10.40	9.80	13.20	11.30	12.40	12.06	-0.05	0.06
66	12.80	13.50	13.20	11.10	13.80	10.80	10.00	13.40	11.40	12.60	12.26	0.15	0.07
68	12.30	13.20	12.80	10.70	13.40	10.20	9.50	12.90	10.90	12.10	11.80	-0.31	0.06
75a	12.58	13.56	13.03	10.89	13.75	10.44	9.78	13.15	11.17	12.48	12.08	-0.02	0.07
75b	12.50	13.50	13.04	10.97	13.67	10.42	9.79	13.13	11.30	12.54	12.09	-0.02	0.06
77a	12.51	13.47	13.01	11.18	13.71	10.43	9.64	13.34	11.34	12.44	12.11	0.00	0.10
79a	12.50	13.70	12.90	11.00	13.70	10.50	9.90	13.40	11.30	12.60	12.15	0.04	0.10
79b	12.00	12.90	12.40	10.50	13.10	9.90	9.40	12.70	10.90	12.10	11.59	-0.52	0.10
79c	12.50	13.50	12.80	10.90	13.70	10.50	9.70	13.20	11.20	12.60	12.06	-0.05	0.08
80	12.43	13.38	12.94	10.93	13.54	10.55	9.84	13.21	11.22	12.46	12.05	-0.06	0.06
81	12.60	13.40	13.00	10.90	13.80	10.20	9.80	13.10	11.30	12.70	12.08	-0.03	0.15
82	12.30	13.40	12.90	10.86	13.45	10.30	9.55	13.10	11.10	12.45	11.94	-0.16	0.08
85	12.30	13.30	12.80	10.90	13.30	10.20	9.40	13.10	10.80	12.10	11.82	-0.29	0.13
91	12.40	13.40	12.90	10.90	13.50	10.40	9.70	13.10	11.20	12.40	11.99	-0.12	0.04
94a	12.40	13.20	12.70	10.80	13.50	10.40	9.60	13.10	10.90	12.40	11.90	-0.21	0.08
94b	12.30	13.10	12.50	10.60	13.30	10.20	9.50	12.90	10.90	12.10	11.74	-0.37	0.06
Average	12.58	13.48	12.99	10.97	13.68	10.53	9.79	13.26	11.27	12.50	12.11	0.00	0.09
Std	0.20	0.19	0.23	0.20	0.21	0.21	0.17	0.19	0.20	0.18	0.18	0.18	0.04
Min	12.0	12.9	12.3	10.5	13.1	9.9	9.4	12.7	10.8	12.1	11.6	-0.5	0.0
Max	13.1	13.9	13.3	11.3	14.2	10.9	10.1	13.8	11.6	12.8	12.4	0.3	0.3

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

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	12.70	13.00	9.50	13.10	11.95	13.10	9.90	10.10	9.60	10.60	11.36	0.05	0.24
2	12.49	13.01	8.57	13.20	11.95	12.35	9.68	10.17	9.68	10.57	11.17	-0.14	0.17
4a	12.38	13.39	9.16	13.08	12.11	12.97	9.71	9.92	9.33	10.69	11.27	-0.03	0.20
4b	12.34	13.24	8.99	13.09	11.89	12.89	9.40	10.18	9.84	10.67	11.25	-0.05	0.17
5	12.70	13.40	9.00	13.30	12.10	12.70	10.10	10.30	10.10	10.70	11.44	0.14	0.13
6	12.50	13.00	8.90	13.40	12.20	12.10	9.60	10.20	10.30	10.40	11.26	-0.04	0.32
8a	12.90	13.40	9.10	13.30	12.10	13.10	10.00	10.10	9.80	10.50	11.43	0.13	0.14
8b	12.70	13.30	9.00	13.30	12.10	12.80	9.80	9.80	9.90	10.50	11.32	0.02	0.12
10	12.00	12.60	9.80	12.60	11.70	11.90	10.00	10.00	10.00	10.30	11.09	-0.21	0.52
11a	12.54	13.33	9.08	13.54	11.91	11.86	10.14	9.95	9.51	10.46	11.23	-0.07	0.35
11b	12.91	13.59	9.36	13.55	12.24	12.69	9.83	9.86	9.77	10.40	11.42	0.12	0.22
12	12.60	12.90	8.70	12.90	12.30	12.70	8.80	9.80	9.70	10.40	11.08	-0.22	0.32
15	13.06	13.38	9.19	13.13	12.25	12.88	9.81	10.13	10.25	10.88	11.50	0.19	0.19
17a	12.70	13.45	9.05	13.15	11.75	12.75	9.60	10.00	9.60	10.70	11.28	-0.03	0.15
18	12.60	13.40	8.70	13.40	12.00	12.80	9.70	9.80	9.60	10.80	11.28	-0.02	0.17
19	12.31	13.23	8.19	13.10	11.92	12.55	9.84	9.89	9.64	10.50	11.12	-0.19	0.24
24	12.40	13.00	8.80	13.30	11.80	13.20	9.60	10.00	9.70	10.60	11.24	-0.06	0.21
25	12.50	12.80	9.00	13.30	11.90	12.80	10.00	10.10	9.80	10.60	11.28	-0.02	0.18
27	13.19	13.94	9.36	13.74	12.44	12.95	10.44	10.68	9.91	10.86	11.75	0.45	0.20
30a	12.34	13.28	9.56	13.50	12.16	12.47	9.81	10.38	9.91	10.53	11.39	0.09	0.26
30b	12.63	13.44	8.56	13.00	12.06	13.00	9.81	10.06	9.88	10.75	11.32	0.02	0.21
30c	13.00	13.44	9.31	13.13	12.13	13.25	9.75	10.31	9.81	10.88	11.50	0.20	0.19
30h	12.63	13.69	9.44	13.38	12.31	13.00	9.75	10.56	10.25	10.69	11.57	0.27	0.19
32	12.60	13.20	9.00	13.20	11.90	12.40	9.70	10.10	9.70	10.30	11.21	-0.09	0.13
33	12.50	13.30	9.30	13.40	12.30	12.90	9.70	10.20	10.00	10.60	11.42	0.12	0.14
56	12.60	13.40	9.10	13.00	11.90	12.60	9.70	10.00	9.70	10.50	11.25	-0.05	0.12
64	12.60	13.40	8.60	13.20	12.00	12.90	9.70	10.10	9.70	10.60	11.28	-0.02	0.15
68	12.97	13.20	8.89	14.04	12.04	12.70	10.07	9.92	9.90	10.58	11.43	0.13	0.29
79a	12.20	12.90	8.50	13.10	11.90	12.80	9.50	10.10	9.80	10.60	11.14	-0.16	0.20
79c	12.60	13.30	8.70	13.50	11.80	11.90	9.70	9.50	9.10	10.50	11.06	-0.24	0.35
80	12.51	13.24	8.77	13.40	12.12	12.85	9.72	9.98	9.53	10.68	11.28	-0.02	0.13

82	12.15	13.00	8.65	13.20	11.95	13.00	9.70	9.95	9.55	10.55	11.17	-0.13	0.19
84	12.50	13.50	8.70	13.30	12.00	13.20	9.70	9.90	9.20	10.70	11.27	-0.03	0.28
85	12.60	13.10	9.30	13.00	12.00	13.10	9.70	10.10	9.70	10.70	11.33	0.03	0.19
91	12.40	13.30	9.00	13.00	12.10	13.20	9.70	10.10	9.60	10.80	11.32	0.02	0.20
94a	12.80	13.30	8.90	13.20	12.00	12.70	9.90	10.10	9.80	10.60	11.33	0.03	0.09
94b	12.50	13.30	9.00	13.10	12.00	12.50	9.50	10.00	9.70	10.50	11.21	-0.09	0.10
Average	12.59	13.26	8.99	13.25	12.03	12.74	9.76	10.06	9.75	10.60	11.30	0.00	0.21
Std	0.25	0.25	0.34	0.25	0.17	0.36	0.26	0.21	0.26	0.15	0.14	0.14	0.09
Min	12.0	12.6	8.2	12.6	11.7	11.9	8.8	9.5	9.1	10.3	11.1	-0.2	0.1
Max	13.2	13.9	9.8	14.0	12.4	13.3	10.4	10.7	10.3	10.9	11.8	0.4	0.5

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	13.73	12.07	13.36	12.17	12.81	16.12	13.57	13.77	13.85	11.75	13.3	0.09	0.03
2	13.66	12.07	13.31	12.18	12.80	16.10	13.51	13.66	13.87	11.71	13.3	0.06	0.03
4a	13.93	12.06	13.59	12.27	13.02	16.59	13.87	14.00	14.14	11.73	13.5	0.29	0.17
4b	13.71	12.04	13.35	12.19	12.81	16.21	13.60	13.77	13.88	11.68	13.3	0.10	0.06
5	13.70	12.10	13.40	12.20	12.90	16.10	13.60	13.70	13.80	11.70	13.3	0.09	0.04
8a	13.60	12.00	13.30	12.10	12.80	16.10	13.50	13.60	13.80	11.60	13.2	0.01	0.05
8b	13.60	12.00	13.30	12.10	12.80	16.10	13.50	13.60	13.70	11.70	13.2	0.01	0.05
10	13.20	11.60	12.80	11.60	12.20	15.40	13.00	13.10	13.20	11.20	12.7	-0.50	0.06
11a	13.53	11.90	13.20	12.01	12.67	15.96	13.46	13.53	13.72	11.54	13.2	-0.08	0.04
11b	13.55	11.89	13.18	12.03	12.71	15.92	13.38	13.55	13.72	11.50	13.1	-0.08	0.04
12	13.60	12.00	13.30	12.10	12.70	16.00	13.60	13.70	13.80	11.60	13.2	0.01	0.06
15	13.60	12.00	13.30	12.20	12.70	16.00	13.40	13.60	13.80	11.70	13.2	0.00	0.05
17a	13.80	12.10	13.40	12.20	12.90	16.05	13.60	13.80	13.85	11.80	13.4	0.12	0.04
18	13.40	11.90	13.10	12.00	12.60	15.80	13.30	13.50	13.60	11.50	13.1	-0.16	0.03
19	13.78	12.12	13.42	12.25	12.88	16.19	13.68	13.81	13.95	11.81	13.4	0.16	0.03
24	13.60	11.90	13.20	12.10	12.60	15.90	13.40	13.50	13.70	11.50	13.1	-0.09	0.05
25	13.40	11.80	13.20	12.00	12.60	15.90	13.30	13.50	13.60	11.50	13.1	-0.15	0.05
26	13.70	12.10	13.40	12.20	12.80	16.10	13.50	13.70	13.90	11.70	13.3	0.08	0.04

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27	13.46	11.86	13.12	11.99	12.68	15.84	13.39	13.46	13.64	11.55	13.1	-0.13	0.03
30a	13.32	11.66	12.96	11.80	12.38	15.56	13.11	13.27	13.39	11.34	12.9	-0.35	0.04
30b	13.30	11.73	12.88	11.82	12.37	15.50	13.15	13.26	13.50	11.34	12.9	-0.34	0.07
30c	13.53	11.98	13.21	12.05	12.65	15.79	13.34	13.50	13.61	11.59	13.1	-0.10	0.05
30h	13.39	11.80	13.06	11.95	12.53	15.60	13.25	13.36	13.49	11.52	13.0	-0.23	0.06
33	13.90	12.20	13.50	12.40	13.00	16.20	13.70	13.80	14.00	12.00	13.5	0.24	0.05
35a	13.80	12.20	13.50	12.30	12.90	16.00	13.60	13.80	13.90	11.80	13.4	0.15	0.06
35b	13.70	12.20	13.40	12.30	12.90	16.00	13.60	13.70	13.90	11.90	13.4	0.13	0.06
35c	13.70	12.20	13.40	12.30	12.90	15.90	13.60	13.70	13.80	11.90	13.3	0.11	0.09
35d	13.70	12.10	13.40	12.30	12.90	15.90	13.60	13.70	13.80	11.80	13.3	0.09	0.07
56	13.60	12.00	13.30	12.10	12.80	16.10	13.40	13.60	13.70	11.70	13.2	0.00	0.06
64	13.69	12.06	13.31	12.21	12.85	16.08	13.60	13.78	13.84	11.76	13.3	0.09	0.03
66	13.50	11.90	13.20	12.00	12.60	15.90	13.30	13.50	13.60	11.50	13.1	-0.13	0.04
68	13.70	12.00	13.30	12.20	12.90	16.10	13.70	13.80	13.90	11.70	13.3	0.10	0.07
75a	13.53	11.92	13.17	12.04	12.65	15.88	13.41	13.52	13.67	11.55	13.1	-0.09	0.01
75b	13.53	11.89	13.17	12.02	12.62	15.92	13.39	13.51	13.68	11.54	13.1	-0.10	0.02
77a	14.00	12.40	13.60	12.60	13.20	16.30	13.80	14.00	14.00	12.20	13.6	0.38	0.09
79a	13.60	12.00	13.30	12.10	12.70	15.80	13.40	13.50	13.70	11.70	13.2	-0.05	0.07
79b	13.50	11.90	13.20	12.10	12.70	15.80	13.40	13.50	13.70	11.60	13.1	-0.09	0.04
79c	13.50	11.90	13.20	12.10	12.60	15.90	13.40	13.50	13.70	11.60	13.1	-0.09	0.04
80	13.78	12.20	13.46	12.30	12.93	16.22	13.69	13.80	13.93	11.84	13.4	0.19	0.02
81	13.80	12.20	13.50	12.30	13.00	16.20	13.70	13.80	14.00	11.90	13.4	0.21	0.03
82	13.75	12.10	13.40	12.33	12.95	16.16	13.70	13.90	13.95	11.80	13.4	0.18	0.05
85	13.40	11.70	13.10	11.90	12.50	15.80	13.30	13.40	13.60	11.40	13.0	-0.22	0.04
91	13.70	12.20	13.40	12.20	12.90	16.20	13.60	13.70	13.80	11.80	13.4	0.12	0.06
94a	13.60	12.00	13.30	12.10	12.70	16.00	13.40	13.60	13.70	11.60	13.2	-0.03	0.04
94b	13.50	11.80	13.10	12.00	12.60	15.90	13.40	13.60	13.70	11.50	13.1	-0.12	0.06
Average	13.61	11.99	13.28	12.13	12.75	15.98	13.48	13.62	13.76	11.66	13.23	0.00	0.05
Std	0.17	0.16	0.17	0.17	0.19	0.22	0.18	0.19	0.17	0.18	0.17	0.17	0.02
Min	13.2	11.6	12.8	11.6	12.2	15.4	13.0	13.1	13.2	11.2	12.7	-0.5	0.0
Max	14.0	12.4	13.6	12.6	13.2	16.6	13.9	14.0	14.1	12.2	13.6	0.4	0.2

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	12.12	12.87	13.56	12.47	13.03	12.07	15.84	14.54	14.24	14.24	13.5	0.04	0.11
2	12.40	13.46	13.91	12.92	13.18	12.52	16.08	14.70	14.43	14.44	13.8	0.34	0.10
4a	12.29	12.98	13.39	12.67	13.07	12.54	15.77	14.54	14.37	14.23	13.6	0.12	0.11
4b	11.97	12.63	13.24	12.39	12.92	11.80	15.73	14.47	14.14	14.10	13.3	-0.12	0.16
5	12.20	12.90	13.60	12.70	13.00	12.40	15.90	14.70	14.20	14.20	13.6	0.12	0.08
6	12.20	13.30	13.50	12.60	13.00	13.30	16.00	14.60	14.20	14.30	13.7	0.24	0.30
8a	12.10	12.80	13.40	12.40	12.90	12.00	15.70	14.40	14.00	14.10	13.4	-0.08	0.07
8b	12.00	12.90	13.40	12.40	13.00	12.10	15.80	14.50	14.10	14.20	13.4	-0.02	0.10
10	12.70	13.20	13.50	12.70	13.20	12.90	15.30	14.20	14.00	14.40	13.6	0.15	0.34
11a	12.06	12.69	13.28	12.41	12.88	12.00	15.71	14.43	14.04	14.17	13.4	-0.09	0.10
11b	12.00	12.70	13.36	12.34	12.91	11.96	15.73	14.42	14.13	14.22	13.4	-0.08	0.12
12	12.10	12.80	13.20	12.60	12.80	12.30	15.70	14.30	13.90	14.00	13.4	-0.09	0.11
15	12.10	13.00	13.60	12.40	12.80	12.20	15.70	14.30	14.00	14.00	13.4	-0.05	0.09
17a	12.05	12.85	13.50	12.60	13.00	12.50	15.75	14.50	14.15	14.15	13.5	0.04	0.09
18	12.20	12.80	13.40	12.40	12.90	12.20	15.80	14.40	14.20	14.00	13.4	-0.03	0.07
19	12.27	13.19	13.90	12.68	13.06	12.50	15.85	14.58	14.16	14.16	13.6	0.17	0.11
24	12.20	13.30	13.60	12.40	13.00	12.40	15.80	14.50	14.10	14.30	13.6	0.10	0.13
25	12.00	12.90	13.20	12.40	12.90	12.00	15.70	14.30	14.00	14.10	13.4	-0.11	0.10
27	11.97	12.59	13.22	12.32	12.91	11.37	15.53	14.24	13.94	13.96	13.2	-0.26	0.24
30a	12.25	12.70	13.53	12.43	12.84	12.44	15.99	14.51	13.98	14.11	13.5	0.02	0.14
30b	12.41	13.00	13.73	12.81	13.13	12.19	15.96	14.60	14.27	14.22	13.6	0.17	0.11
30c	12.16	12.56	13.06	12.12	12.47	11.57	15.25	13.93	13.61	13.61	13.0	-0.43	0.18
30h	12.16	12.95	14.21	12.50	12.95	12.89	15.65	14.58	14.36	13.97	13.6	0.16	0.30
32	12.00	12.80	13.40	12.50	12.80	12.20	15.90	14.40	14.00	14.00	13.4	-0.06	0.09
33	12.10	13.00	13.70	12.60	13.00	12.50	15.80	14.60	14.30	14.30	13.6	0.13	0.09
56	12.00	12.70	13.40	12.50	12.80	12.20	15.60	14.30	14.00	14.00	13.4	-0.11	0.06
64	12.04	12.69	13.21	12.45	12.77	11.88	15.56	14.26	13.90	13.93	13.3	-0.19	0.09

68	12.10	12.90	13.40	12.40	12.80	11.80	15.60	14.30	14.10	14.00	13.3	-0.12	0.13
79a	12.40	12.90	13.50	12.50	13.00	12.10	15.80	14.50	14.10	14.00	13.5	0.02	0.11
79c	12.00	12.70	13.40	12.40	12.80	13.20	15.60	14.40	14.20	14.00	13.5	0.01	0.34
80	12.35	13.13	13.68	12.59	13.11	12.28	16.00	14.60	14.36	14.27	13.6	0.18	0.07
82	12.35	13.00	13.53	12.60	13.10	12.12	15.90	14.65	14.30	14.25	13.6	0.12	0.10
84	11.90	13.00	13.40	12.30	12.80	12.30	15.80	14.40	14.00	14.00	13.4	-0.07	0.11
85	12.00	12.70	13.20	12.40	12.70	12.30	15.60	14.30	13.90	13.90	13.3	-0.16	0.09
91	12.45	13.20	13.95	12.70	13.00	12.20	15.85	14.60	14.20	14.25	13.6	0.18	0.15
94a	12.00	12.70	13.40	12.30	12.80	11.90	15.80	14.30	14.00	13.90	13.3	-0.15	0.11
94b	12.10	13.10	13.20	12.50	12.80	12.50	15.70	14.30	14.00	14.00	13.4	-0.04	0.15
Average	12.15	12.91	13.48	12.50	12.92	12.26	15.75	14.44	14.11	14.11	13.46	0.00	0.13
Std	0.17	0.22	0.24	0.16	0.15	0.39	0.17	0.16	0.17	0.16	0.15	0.15	0.07
Min	11.9	12.6	13.1	12.1	12.5	11.4	15.3	13.9	13.6	13.6	13.0	-0.4	0.1
Max	12.7	13.5	14.2	12.9	13.2	13.3	16.1	14.7	14.4	14.4	13.8	0.3	0.3

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
1a	12.65	13.47	13.10	10.85	13.82	10.61	9.91	13.30	11.34	12.50	12.16	0.07	0.07
1b	12.63	13.45	12.90	10.85	13.68	10.54	9.80	13.12	11.34	12.58	12.09	0.00	0.07
2	12.64	13.56	13.08	10.85	13.75	10.35	9.88	13.19	11.29	12.47	12.10	0.02	0.07
4a	12.55	13.46	13.18	10.97	13.57	10.37	9.78	13.30	11.36	12.66	12.12	0.03	0.11
4b	12.68	13.48	13.01	10.99	13.86	10.43	9.86	13.13	11.29	12.45	12.12	0.03	0.06
5	12.55	13.40	13.10	10.85	13.67	10.34	9.76	13.16	11.36	12.51	12.07	-0.02	0.07
8a	12.71	13.47	13.19	11.02	13.73	10.75	9.90	13.33	11.44	12.51	12.20	0.12	0.09
8b	12.66	13.47	12.96	10.96	13.71	10.42	9.81	13.24	11.32	12.53	12.11	0.02	0.03
10	12.56	13.58	12.91	10.98	13.97	10.62	9.77	13.10	11.22	12.50	12.12	0.04	0.12
11a	12.61	13.46	13.03	10.93	13.72	10.45	9.84	13.24	11.22	12.47	12.10	0.01	0.03
11b	12.57	13.43	13.07	10.97	13.72	10.55	9.79	13.20	11.38	12.42	12.11	0.03	0.06
11e	12.55	13.45	13.00	10.95	13.76	10.51	9.92	13.26	11.24	12.43	12.11	0.02	0.06
12	12.59	13.44	12.95	10.83	13.56	10.46	9.64	13.19	11.25	12.41	12.03	-0.05	0.06
15	12.55	13.52	13.05	10.95	13.84	10.65	9.84	13.07	11.19	12.51	12.12	0.03	0.10
17	12.56	13.38	12.90	10.81	13.73	10.52	9.70	13.20	11.21	12.42	12.04	-0.04	0.06
18	12.62	13.33	13.02	10.89	13.76	10.43	9.81	13.30	11.34	12.43	12.09	0.01	0.07
19	12.52	13.27	12.97	10.82	13.71	10.16	9.61	13.28	11.21	12.46	12.00	-0.08	0.11
24	12.58	13.39	12.87	10.79	13.60	10.48	9.77	13.24	11.25	12.42	12.04	-0.05	0.06
26	12.66	13.43	12.98	10.94	13.71	10.33	9.71	13.11	11.25	12.44	12.06	-0.03	0.05
30b	12.57	13.46	13.02	11.05	13.71	10.35	9.66	13.12	11.20	12.43	12.06	-0.03	0.07
30c	12.59	13.49	13.02	10.92	13.82	10.35	9.82	13.11	11.19	12.55	12.09	0.00	0.07
30h	12.72	13.48	12.87	10.88	13.70	10.47	9.60	13.27	11.27	12.44	12.07	-0.02	0.09
33	12.68	13.46	13.09	10.89	13.61	10.46	9.71	13.23	11.35	12.50	12.10	0.01	0.07
35a	12.52	13.52	12.90	11.04	13.69	10.38	9.83	13.16	11.42	12.48	12.09	0.01	0.08
35b	12.60	13.44	12.95	10.88	13.74	10.47	9.82	13.18	11.32	12.42	12.08	0.00	0.04
35c	12.55	13.50	13.00	11.02	13.75	10.51	9.81	13.25	11.31	12.49	12.12	0.03	0.04
35d	12.57	13.38	12.96	10.89	13.66	10.59	9.68	13.15	11.24	12.31	12.04	-0.04	0.08
56	12.62	13.42	13.01	10.88	13.71	10.50	9.80	13.23	11.20	12.48	12.09	0.00	0.04

64	12.75	13.50	12.93	11.01	13.73	10.45	9.84	13.20	11.34	12.46	12.12	0.04	0.06
66	12.69	13.39	13.04	10.97	13.73	10.53	9.85	13.21	11.31	12.51	12.12	0.04	0.04
68	12.54	13.38	13.00	10.87	13.67	10.50	9.77	13.10	11.12	12.31	12.03	-0.06	0.07
75a	12.58	13.56	13.03	10.89	13.75	10.44	9.78	13.15	11.17	12.48	12.08	0.00	0.05
75a	12.50	13.50	13.04	10.97	13.67	10.42	9.79	13.13	11.30	12.54	12.09	0.00	0.05
77a	12.70	13.62	13.08	10.88	13.62	10.70	9.93	13.25	11.24	12.59	12.16	0.08	0.11
79a	12.53	13.62	12.87	10.90	13.69	10.36	9.92	13.22	11.35	12.60	12.10	0.02	0.10
79b	12.65	13.31	12.93	10.89	13.50	10.37	9.75	13.12	11.27	12.46	12.03	-0.06	0.07
79c	12.54	13.45	12.82	10.87	13.66	10.40	9.73	13.09	11.18	12.58	12.03	-0.05	0.07
80	12.55	13.38	12.97	10.97	13.74	10.47	9.86	13.19	11.30	12.53	12.10	0.01	0.05
81	12.60	13.43	12.96	10.87	13.79	10.09	9.74	13.12	11.24	12.70	12.05	-0.03	0.14
82	12.45	13.43	12.96	10.89	13.72	10.34	9.64	13.13	11.25	12.49	12.03	-0.05	0.06
85	12.56	13.52	13.08	11.18	13.58	10.26	9.65	13.28	11.09	12.38	12.06	-0.03	0.15
91	12.56	13.35	12.97	10.89	13.73	10.29	9.78	13.11	11.30	12.49	12.05	-0.04	0.06
94a	12.62	13.43	12.97	11.00	13.73	10.46	9.83	13.20	11.19	12.55	12.10	0.01	0.05
94b	12.66	13.38	12.85	10.91	13.76	10.47	9.77	13.16	11.27	12.40	12.06	-0.02	0.06
Average	12.60	13.45	12.99	10.92	13.71	10.45	9.78	13.19	11.27	12.48	12.08	0.00	0.07
Std	0.06	0.07	0.08	0.08	0.08	0.13	0.08	0.07	0.07	0.08	0.04	0.04	0.03
Min	12.5	13.3	12.8	10.8	13.5	10.1	9.6	13.1	11.1	12.3	12.0	-0.1	0.0
Max	12.8	13.6	13.2	11.2	14.0	10.7	9.9	13.3	11.4	12.7	12.2	0.1	0.1

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

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1a	12.75	13.26	9.27	13.36	12.06	12.99	10.02	10.10	9.83	10.62	11.4	0.12	0.09
1b	12.96	13.24	9.34	13.23	11.85	12.78	9.75	10.08	9.80	10.47	11.3	0.05	0.12
2	12.77	13.21	8.76	13.34	11.98	12.48	9.81	10.12	9.88	10.41	11.3	-0.03	0.17
4a	12.62	13.30	9.30	13.21	12.10	12.90	9.75	9.83	9.41	10.48	11.3	-0.01	0.15
4b	12.60	13.32	9.22	13.34	11.94	13.23	9.48	10.05	9.91	10.49	11.4	0.05	0.18
5	12.85	13.36	8.90	13.18	12.02	12.86	9.81	10.07	9.86	10.50	11.3	0.04	0.10
6	12.53	12.91	8.78	13.31	11.99	11.98	9.33	9.97	10.08	10.15	11.1	-0.20	0.32
8a	12.99	13.44	9.10	13.28	12.07	12.94	9.96	10.11	9.96	10.52	11.4	0.13	0.08
8b	12.60	13.26	9.17	13.36	12.08	12.99	9.78	9.83	9.86	10.39	11.3	0.03	0.10
10	12.81	13.54	9.22	13.35	12.05	12.87	9.74	10.00	9.70	10.39	11.4	0.06	0.09
11a	12.54	13.33	9.08	13.54	11.91	11.86	10.14	9.95	9.51	10.46	11.2	-0.07	0.36
11b	12.91	13.59	9.36	13.55	12.24	12.69	9.83	9.86	9.77	10.40	11.4	0.12	0.16
11e	13.09	13.48	9.12	13.16	12.01	12.76	9.89	9.98	9.76	10.56	11.4	0.08	0.13
12	12.67	13.04	8.98	13.17	12.13	12.94	9.26	9.68	9.65	10.31	11.2	-0.12	0.18
15	12.86	12.74	9.27	13.14	11.99	12.50	9.56	9.94	10.04	10.44	11.2	-0.06	0.24
17	12.87	13.56	9.00	13.26	11.74	12.85	9.50	9.97	9.61	10.52	11.3	-0.02	0.17
18	12.89	13.19	8.63	13.43	11.97	12.63	9.66	9.81	9.75	10.59	11.3	-0.05	0.19
19	12.46	13.17	9.13	13.52	11.75	12.84	9.99	9.98	9.32	10.29	11.2	-0.06	0.22
24	12.66	13.22	9.26	13.40	11.93	12.93	9.76	9.96	9.86	10.51	11.3	0.04	0.09
25	12.76	13.24	8.91	13.27	11.84	12.86	9.63	9.96	9.77	10.40	11.3	-0.04	0.08
30b	12.81	13.38	8.70	13.05	11.99	13.04	9.87	9.88	9.89	10.37	11.3	-0.01	0.19
30c	13.02	13.26	9.39	13.04	11.98	13.24	9.76	9.99	9.69	10.47	11.4	0.08	0.20
30h	12.64	13.56	9.15	13.21	12.00	12.83	9.62	10.21	9.85	10.20	11.3	0.02	0.16
32	12.81	13.30	9.09	13.21	11.97	12.66	9.75	10.02	9.63	10.29	11.3	-0.03	0.08
33	12.45	13.04	9.28	13.30	12.07	13.25	9.60	9.90	9.89	10.32	11.3	0.01	0.22
56	12.69	13.48	9.06	13.15	12.05	12.61	9.64	9.93	9.76	10.45	11.3	-0.02	0.11
64	12.74	13.47	8.98	13.26	12.01	12.97	9.83	10.01	9.85	10.43	11.4	0.05	0.09
79a	12.44	13.08	8.80	13.22	12.03	12.98	9.76	10.20	9.97	10.45	11.3	-0.01	0.20

79c	12.89	13.25	8.91	13.60	11.86	12.10	9.74	9.56	9.31	10.36	11.2	-0.15	0.30
80	12.56	13.21	9.23	13.38	12.04	12.98	9.84	9.95	9.70	10.47	11.3	0.03	0.11
82	12.66	12.97	8.99	13.29	11.95	13.04	9.74	9.96	9.66	10.34	11.3	-0.05	0.13
84	12.76	13.49	8.88	13.39	12.00	12.66	9.76	9.80	9.35	10.48	11.3	-0.05	0.18
85	12.76	13.09	9.29	13.04	11.93	12.96	9.75	10.00	9.79	10.55	11.3	0.01	0.14
91	12.51	13.20	9.08	13.03	12.05	12.85	9.72	9.93	9.61	10.53	11.3	-0.05	0.12
94a	12.90	13.44	9.35	13.23	12.01	13.10	9.90	9.98	9.79	10.48	11.4	0.11	0.11
94b	12.67	13.42	9.14	13.12	11.98	12.84	9.58	9.95	9.74	10.45	11.3	-0.02	0.09
Average	12.74	13.28	9.09	13.28	11.99	12.81	9.74	9.96	9.74	10.43	11.30	0.00	0.16
Std	0.17	0.19	0.20	0.15	0.10	0.31	0.18	0.13	0.19	0.10	0.07	0.07	0.07
Min	12.4	12.7	8.6	13.0	11.7	11.9	9.3	9.6	9.3	10.2	11.1	-0.2	0.1
Max	13.1	13.6	9.4	13.6	12.2	13.2	10.1	10.2	10.1	10.6	11.4	0.1	0.4

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

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1a	13.52	11.86	13.15	11.97	12.60	15.91	13.37	13.56	13.65	11.52	13.1	-0.01	0.04
1b	13.55	11.92	13.20	12.02	12.66	15.85	13.38	13.51	13.71	11.58	13.1	0.02	0.02
2	13.54	11.92	13.18	12.03	12.62	15.89	13.34	13.50	13.69	11.57	13.1	0.01	0.02
4a	13.54	11.83	13.23	12.01	12.67	15.91	13.44	13.56	13.72	11.52	13.1	0.02	0.05
4b	13.51	11.87	13.14	12.02	12.61	15.81	13.35	13.51	13.66	11.54	13.1	-0.02	0.01
5	13.54	11.92	13.21	12.04	12.65	15.89	13.36	13.50	13.65	11.58	13.1	0.01	0.02
8a	13.51	11.88	13.18	12.00	12.64	16.07	13.38	13.55	13.64	11.51	13.1	0.01	0.08
8b	13.55	11.92	13.20	12.01	12.65	15.92	13.36	13.51	13.65	11.56	13.1	0.01	0.03
10	13.66	12.00	13.25	12.10	12.71	15.98	13.50	13.60	13.82	11.62	13.2	0.10	0.03
11a	13.53	11.90	13.20	12.01	12.67	15.96	13.46	13.53	13.72	11.54	13.2	0.03	0.05
11b	13.55	11.89	13.18	12.03	12.71	15.92	13.38	13.55	13.72	11.50	13.1	0.02	0.05
11e	13.43	11.84	13.08	11.96	12.55	15.72	13.28	13.43	13.56	11.52	13.0	-0.08	0.02
12	13.54	11.88	13.20	12.00	12.61	15.89	13.41	13.56	13.68	11.56	13.1	0.01	0.03
15	13.52	11.93	13.20	12.07	12.61	15.81	13.31	13.47	13.66	11.62	13.1	0.00	0.04
17	13.57	11.88	13.20	11.98	12.65	15.91	13.42	13.57	13.67	11.54	13.1	0.02	0.04
18	13.48	11.89	13.11	12.01	12.58	15.71	13.33	13.51	13.57	11.52	13.1	-0.05	0.04
19	13.49	11.88	13.15	12.00	12.58	15.80	13.35	13.53	13.63	11.51	13.1	-0.03	0.02
24	13.61	11.97	13.24	12.12	12.64	15.89	13.38	13.55	13.68	11.57	13.2	0.04	0.03
26	13.56	11.95	13.19	12.02	12.64	15.87	13.31	13.49	13.68	11.57	13.1	0.01	0.03
30b	13.64	12.04	13.20	12.13	12.67	15.76	13.43	13.56	13.72	11.67	13.2	0.06	0.06
30c	13.57	12.00	13.23	12.11	12.66	15.76	13.35	13.49	13.62	11.63	13.1	0.02	0.06
30h	13.58	11.99	13.24	12.12	12.67	15.72	13.38	13.52	13.68	11.70	13.2	0.04	0.07
33	13.56	11.93	13.21	12.06	12.63	15.93	13.44	13.57	13.74	11.60	13.2	0.04	0.03
35a	13.60	11.97	13.26	12.05	12.62	15.77	13.36	13.51	13.71	11.60	13.1	0.02	0.05
35b	13.52	11.93	13.20	12.04	12.61	15.80	13.32	13.48	13.69	11.60	13.1	0.00	0.03
35a	13.48	11.89	13.17	12.01	12.56	15.76	13.28	13.44	13.61	11.58	13.1	-0.04	0.04
35d	13.44	11.85	13.12	11.98	12.60	15.76	13.29	13.45	13.59	11.50	13.1	-0.06	0.02
56	13.43	11.84	13.10	11.96	12.56	15.78	13.24	13.40	13.56	11.52	13.0	-0.08	0.03
64	13.48	11.83	13.09	12.00	12.60	15.79	13.33	13.53	13.63	11.55	13.1	-0.04	0.03

66	13.51	11.92	13.17	12.02	12.61	15.81	13.31	13.49	13.60	11.56	13.1	-0.02	0.02
68	13.51	11.82	13.13	11.96	12.62	15.90	13.44	13.54	13.63	11.52	13.1	-0.02	0.05
75a	13.53	11.92	13.17	12.04	12.65	15.88	13.41	13.52	13.67	11.55	13.1	0.01	0.02
75a	13.53	11.89	13.17	12.02	12.62	15.92	13.39	13.51	13.68	11.54	13.1	0.00	0.03
77a	13.44	11.87	13.08	12.00	12.63	15.69	13.28	13.46	13.52	11.61	13.1	-0.07	0.06
79a	13.66	12.05	13.31	12.09	12.68	15.80	13.42	13.55	13.72	11.72	13.2	0.08	0.06
79b	13.58	11.97	13.24	12.08	12.67	15.89	13.44	13.52	13.73	11.64	13.2	0.05	0.02
79c	13.58	11.93	13.23	12.06	12.63	15.85	13.39	13.53	13.68	11.63	13.1	0.03	0.02
80	13.50	11.90	13.15	11.99	12.60	15.85	13.34	13.46	13.61	11.53	13.1	-0.03	0.02
81	13.57	11.96	13.23	12.05	12.64	15.85	13.37	13.52	13.66	11.60	13.1	0.02	0.02
82	13.52	11.84	13.17	12.03	12.67	15.93	13.43	13.58	13.69	11.54	13.1	0.02	0.05
85	13.41	11.75	13.08	11.90	12.48	15.79	13.29	13.42	13.62	11.45	13.0	-0.10	0.04
91	13.53	11.93	13.20	12.01	12.62	15.89	13.33	13.49	13.62	11.55	13.1	-0.01	0.03
94a	13.53	11.90	13.19	12.04	12.61	15.84	13.34	13.50	13.66	11.56	13.1	-0.01	0.01
94b	13.51	11.87	13.18	12.02	12.60	15.88	13.42	13.55	13.69	11.54	13.1	0.00	0.03
Average	13.53	11.91	13.18	12.03	12.63	15.85	13.37	13.51	13.66	11.57	13.12	0.00	0.03
Std	0.06	0.06	0.05	0.05	0.04	0.08	0.06	0.04	0.06	0.05	0.04	0.04	0.02
Min	13.4	11.8	13.1	11.9	12.5	15.7	13.2	13.4	13.5	11.5	13.0	-0.1	0.0
Max	13.7	12.0	13.3	12.1	12.7	16.1	13.5	13.6	13.8	11.7	13.2	0.1	0.1

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

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1a	11.93	12.76	13.32	12.34	12.88	11.96	15.68	14.41	14.10	14.14	13.4	-0.02	0.07
1b	12.08	12.88	13.45	12.42	12.89	12.21	15.77	14.42	14.07	14.15	13.4	0.06	0.04
2	12.15	12.92	13.47	12.43	12.92	12.14	15.76	14.45	14.16	14.16	13.5	0.08	0.05
4a	12.10	12.69	13.17	12.41	12.82	12.17	15.61	14.35	13.97	14.10	13.3	-0.04	0.06
4b	11.93	12.53	13.16	12.29	12.79	11.79	15.58	14.34	14.04	14.08	13.3	-0.12	0.10
5	12.07	12.76	13.40	12.41	12.92	12.10	15.75	14.47	14.08	14.19	13.4	0.04	0.04
6	12.12	12.94	13.35	12.45	12.87	12.69	15.65	14.46	13.99	14.07	13.5	0.08	0.18
8a	12.03	12.74	13.33	12.37	12.88	12.04	15.66	14.41	14.08	14.12	13.4	-0.01	0.04
8b	12.06	12.82	13.36	12.42	12.94	12.00	15.77	14.46	14.12	14.22	13.4	0.04	0.07
10	12.13	12.90	13.37	12.45	12.98	12.42	15.75	14.41	14.06	14.24	13.5	0.10	0.08
11a	12.06	12.69	13.28	12.41	12.88	12.00	15.71	14.43	14.04	14.17	13.4	-0.01	0.06
11b	12.00	12.70	13.36	12.34	12.91	11.96	15.73	14.42	14.13	14.22	13.4	0.00	0.08
11e	12.06	12.77	13.31	12.42	12.84	12.22	15.58	14.34	14.02	14.05	13.4	-0.02	0.05
12	11.97	12.67	13.32	12.40	12.78	11.95	15.62	14.36	13.93	14.08	13.3	-0.07	0.05
15	12.19	12.94	13.40	12.48	12.95	12.17	15.73	14.39	14.08	14.13	13.4	0.07	0.05
17	11.98	12.70	13.29	12.36	12.86	11.90	15.66	14.39	14.05	14.14	13.3	-0.04	0.07
18	12.05	12.75	13.37	12.34	12.89	12.12	15.65	14.38	14.06	14.05	13.4	-0.01	0.03
19	11.99	12.59	13.28	12.29	12.82	11.77	15.59	14.33	13.84	13.98	13.2	-0.13	0.09
24	12.20	13.17	13.63	12.44	12.96	12.38	15.77	14.47	14.13	14.33	13.5	0.17	0.11
25	11.97	12.66	13.23	12.33	12.81	11.86	15.50	14.33	13.98	14.05	13.3	-0.10	0.07
30b	12.23	12.80	13.38	12.54	12.92	12.02	15.72	14.39	14.11	14.09	13.4	0.05	0.08
30c	12.22	12.76	13.39	12.49	12.90	11.96	15.63	14.35	14.03	14.08	13.4	0.01	0.09
30h	12.18	12.90	13.52	12.47	12.92	12.54	15.59	14.41	14.00	14.06	13.5	0.08	0.14
32	12.01	12.78	13.38	12.37	12.83	12.27	15.77	14.41	14.03	14.12	13.4	0.02	0.06
33	12.02	12.75	13.38	12.42	12.87	12.53	15.63	14.42	14.14	14.17	13.4	0.06	0.13
56	11.98	12.68	13.35	12.37	12.82	12.12	15.57	14.33	13.99	14.06	13.3	-0.05	0.03
64	12.03	12.68	13.28	12.37	12.79	11.93	15.55	14.30	13.97	14.04	13.3	-0.08	0.05
79a	12.27	12.85	13.39	12.51	12.94	12.15	15.73	14.46	14.06	14.13	13.4	0.07	0.06

79c	12.06	12.68	13.34	12.34	12.83	12.62	15.51	14.37	14.00	14.08	13.4	0.01	0.18
80	12.09	12.82	13.35	12.36	12.86	11.98	15.72	14.37	14.11	14.12	13.4	0.00	0.06
82	12.06	12.71	13.21	12.35	12.84	11.93	15.60	14.42	13.99	14.09	13.3	-0.05	0.06
84	11.99	12.71	13.33	12.30	12.84	12.24	15.61	14.38	13.99	14.11	13.3	-0.03	0.06
85	11.91	12.48	13.08	12.33	12.67	12.02	15.52	14.32	13.89	14.00	13.2	-0.15	0.07
91	12.08	12.85	13.41	12.44	12.83	12.27	15.64	14.43	14.03	14.14	13.4	0.04	0.05
94a	12.10	12.76	13.42	12.39	12.91	12.01	15.76	14.40	14.12	14.10	13.4	0.02	0.06
94b	12.03	12.69	13.21	12.29	12.82	12.00	15.63	14.32	13.97	14.11	13.3	-0.07	0.04
Average	12.06	12.76	13.34	12.39	12.87	12.12	15.66	14.39	14.04	14.12	13.38	0.00	0.07
Std	0.09	0.13	0.10	0.06	0.06	0.23	0.08	0.05	0.07	0.07	0.07	0.07	0.04
Min	11.9	12.5	13.1	12.3	12.7	11.8	15.5	14.3	13.8	14.0	13.2	-0.2	0.0
Max	12.3	13.2	13.6	12.5	13.0	12.7	15.8	14.5	14.2	14.3	13.5	0.2	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	48.90	47.50	48.30	48.00	48.00	46.00	47.60	48.50	49.50	48.70	48.1	0.27	0.62
2	46.73	45.96	47.98	47.34	47.88	45.31	47.10	48.15	49.90	49.43	47.6	-0.25	0.43
4a	48.37	47.16	49.04	48.41	48.86	46.83	48.19	49.23	50.11	49.21	48.5	0.71	0.30
4b	48.10	47.00	48.30	47.90	48.80	46.50	48.30	49.00	50.00	49.00	48.3	0.46	0.30
5	49.07	46.76	48.64	48.30	48.74	46.04	47.86	49.29	50.22	49.51	48.4	0.62	0.34
8a	48.00	46.40	48.60	47.80	48.30	45.30	48.30	48.80	50.00	49.30	48.1	0.25	0.35
8b	48.00	46.60	47.60	47.10	47.50	45.70	46.90	48.30	49.70	48.10	47.6	-0.28	0.41
11a	48.17	46.01	48.19	47.68	48.63	45.72	47.68	48.95	50.25	49.05	48.0	0.21	0.20
11b	47.95	46.38	48.46	47.36	48.62	45.54	47.65	49.17	50.19	48.84	48.0	0.19	0.22
12	47.30	46.40	48.80	48.90	48.60	45.60	47.90	49.60	50.10	49.10	48.2	0.40	0.49
15a	48.30	46.59	48.76	47.82	48.72	45.78	47.35	49.14	50.11	48.88	48.1	0.32	0.27
15b	48.30	46.59	48.76	47.82	48.72	45.78	47.35	49.14	50.11	48.88	48.1	0.32	0.27
15c	46.79	46.14	48.24	47.35	47.09	45.36	47.82	48.24	49.55	49.00	47.6	-0.27	0.48
17	46.60	45.55	47.65	47.15	48.30	45.30	47.15	49.00	50.45	48.55	47.6	-0.26	0.44
18	47.40	45.80	47.70	47.40	47.90	45.30	47.30	48.50	48.50	48.80	47.5	-0.37	0.41
19	47.40	46.10	48.30	47.70	48.10	45.50	47.50	48.60	50.10	48.90	47.8	-0.01	0.18
24	46.71	45.49	47.99	46.96	48.13	45.06	46.80	48.87	50.21	48.87	47.5	-0.32	0.42
25	48.40	47.10	48.20	47.90	48.30	46.30	47.40	48.60	49.70	48.70	48.1	0.23	0.43
27a	48.39	46.22	48.58	48.00	48.78	46.15	48.07	49.57	50.18	49.15	48.3	0.48	0.21
30a	44.37	43.44	45.77	44.97	45.73	42.96	44.77	46.14	47.59	46.16	45.2	-2.64	0.27
31	48.20	45.00	48.80	47.80	48.10	45.60	47.90	49.70	50.30	49.60	48.1	0.27	0.60
33	48.80	46.00	49.40	47.80	47.70	46.90	48.40	49.40	51.60	49.60	48.6	0.73	0.66
35a	48.70	47.40	46.30	47.20	47.90	47.90	47.70	47.80	48.20	47.10	47.6	-0.21	1.38
35b	48.00	47.10	46.00	47.20	48.10	47.80	47.30	47.90	49.00	47.10	47.6	-0.28	1.23
35c	48.50	47.10	45.70	46.90	48.20	48.10	47.90	48.30	48.80	47.20	47.7	-0.16	1.39
35d	48.60	46.40	47.80	47.70	47.90	45.50	47.40	47.80	49.10	48.20	47.6	-0.19	0.57

35e	47.50	45.30	48.50	47.20	48.60	45.90	47.60	49.80	50.60	48.50	48.0	0.12	0.52
35f	47.00	44.90	47.60	46.50	47.40	45.10	47.00	49.00	50.00	48.20	47.3	-0.56	0.42
35g	47.50	45.50	48.50	47.30	48.70	45.60	47.70	49.30	50.70	48.80	48.0	0.13	0.42
56	49.00	46.70	48.80	47.80	48.90	46.00	48.20	49.10	50.50	49.30	48.4	0.60	0.32
64	47.40	46.20	48.32	47.60	48.61	45.41	47.73	48.87	50.22	49.03	47.9	0.11	0.24
68	46.88	45.49	48.26	47.59	47.97	45.78	47.24	48.92	49.89	48.49	47.7	-0.18	0.31
79a	46.30	45.60	47.40	47.20	47.80	45.10	46.70	48.70	49.80	47.80	47.2	-0.59	0.38
79b	46.80	45.70	47.90	47.30	48.00	45.00	47.30	48.30	50.30	49.00	47.6	-0.27	0.38
79c	44.78	43.04	45.76	45.11	46.09	42.93	45.11	46.85	48.26	46.74	45.5	-2.36	0.44
80	46.09	45.02	47.49	46.54	47.36	43.89	46.39	48.26	50.12	48.73	47.0	-0.84	0.62
82	47.35	46.08	48.40	47.70	48.20	45.73	47.85	49.00	50.25	49.25	48.0	0.15	0.24
85	49.74	48.09	51.39	50.45	50.80	47.85	49.62	52.58	53.88	51.51	50.6	2.76	0.71
91	47.55	45.80	48.55	48.25	47.50	45.75	48.05	49.20	50.65	49.35	48.1	0.24	0.47
94a	48.50	46.60	48.60	48.00	48.30	45.50	47.50	49.00	50.20	49.10	48.1	0.30	0.30
94b	47.50	46.20	48.20	47.50	48.40	45.70	47.50	49.30	50.10	48.90	47.9	0.10	0.18
Average	47.7	46.1	48.1	47.5	48.2	45.7	47.5	48.8	50.0	48.7	47.8	0.0	0.5
Std	1.09	0.97	1.05	0.87	0.80	1.06	0.80	0.94	0.98	0.91	0.80	0.80	0.28
Min	44.4	43.0	45.7	45.0	45.7	42.9	44.8	46.1	47.6	46.2	45.2	-2.6	0.2
Max	49.7	48.1	51.4	50.4	50.8	48.1	49.6	52.6	53.9	51.5	50.6	2.8	1.4

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

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	5.65	6.54	7.70	6.10	6.25	7.31	7.52	7.05	7.03	7.23	6.8	-0.09	0.18
2	5.75	6.71	7.97	6.39	6.39	7.82	7.93	7.24	7.00	7.13	7.0	0.10	0.19
4a	5.49	6.66	7.60	6.24	6.38	7.45	7.78	7.10	6.92	7.10	6.9	-0.06	0.18
4b	6.20	6.48	7.53	6.26	6.56	7.74	7.61	7.22	6.78	6.91	6.9	0.00	0.14
5	6.00	6.40	7.70	6.30	6.40	7.70	7.60	7.30	6.90	6.90	6.9	-0.01	0.13
8a	7.00	7.00	8.10	6.80	6.90	8.00	8.10	7.60	7.40	7.70	7.5	0.53	0.20
8b	6.20	7.10	8.30	6.80	6.70	8.20	8.20	7.80	7.50	7.50	7.4	0.50	0.18
11a	5.89	6.53	7.77	6.30	6.24	7.59	7.66	7.23	6.98	7.03	6.9	-0.01	0.13
11b	5.95	6.56	7.83	6.51	6.59	7.68	7.80	7.46	7.08	7.17	7.1	0.14	0.11
12	5.40	6.40	7.60	6.10	6.20	7.30	7.60	7.00	6.60	6.90	6.7	-0.22	0.17
15a	6.10	6.20	7.80	6.40	6.30	7.80	7.70	7.30	6.80	6.80	6.9	-0.01	0.22
15b	5.60	6.10	7.40	6.10	6.20	7.50	7.40	7.10	6.70	6.60	6.7	-0.26	0.15
15c	5.70	6.28	7.22	5.97	6.69	7.32	7.43	6.87	6.53	6.61	6.7	-0.27	0.18
17	6.40	7.00	7.85	6.50	6.35	7.65	7.70	7.15	7.10	7.30	7.1	0.17	0.18
18	5.00	6.20	7.00	5.80	5.80	7.10	7.20	6.60	6.40	6.50	6.4	-0.57	0.17
19	6.14	6.63	7.59	6.32	6.55	7.68	7.80	7.43	7.14	7.18	7.0	0.12	0.12
24	5.80	6.80	7.90	6.30	6.50	7.90	7.70	7.10	6.80	7.10	7.0	0.06	0.17
25	6.30	6.60	7.70	6.30	6.50	7.60	7.90	7.20	7.00	7.30	7.0	0.11	0.15
27	5.54	6.81	7.65	6.42	6.43	7.55	7.80	7.45	7.02	7.21	7.0	0.06	0.21
30a	6.33	7.09	7.87	6.46	6.65	7.64	7.74	7.52	7.06	7.50	7.2	0.26	0.16
33	6.70	6.60	7.60	6.50	6.70	7.30	7.70	7.30	7.00	7.10	7.1	0.12	0.25
35a	6.90	7.10	7.40	7.80	8.10	7.60	7.20	7.30	7.30	7.50	7.4	0.49	0.65
35b	6.00	6.20	7.00	7.70	7.00	6.50	6.50	6.30	6.90	7.80	6.8	-0.14	0.80
35c	6.20	6.30	6.50	7.10	7.70	7.10	6.40	6.40	6.40	7.00	6.7	-0.22	0.76
35d	7.30	7.80	8.30	7.40	7.20	7.70	8.40	7.60	7.60	7.70	7.7	0.77	0.35
35e	6.00	6.00	7.00	5.70	6.00	6.90	6.70	6.50	6.30	6.40	6.4	-0.58	0.24

35f	6.30	6.50	7.60	6.30	6.60	7.60	7.40	7.10	6.70	6.80	6.9	-0.04	0.17
35g	5.90	6.00	7.00	5.60	6.00	6.90	6.70	6.50	6.20	6.30	6.3	-0.62	0.23
56	5.70	6.30	7.50	6.00	6.00	7.50	7.30	7.10	6.60	6.80	6.7	-0.25	0.15
64	5.70	6.70	7.70	6.30	6.40	7.50	7.60	7.10	7.00	7.00	6.9	-0.03	0.12
68	5.50	6.80	8.00	6.50	6.40	7.60	7.70	7.20	7.00	7.40	7.0	0.08	0.24
79a	6.20	6.70	7.60	6.40	6.40	8.10	7.80	7.30	6.90	6.80	7.0	0.09	0.22
79b	5.40	6.60	7.30	6.20	6.40	7.60	7.40	7.10	6.90	6.90	6.8	-0.15	0.18
79c	5.20	6.50	7.70	6.10	6.40	7.40	7.70	7.00	6.70	7.00	6.8	-0.16	0.24
80	5.47	6.59	7.89	6.29	6.40	8.07	7.90	7.24	6.96	7.34	7.0	0.09	0.28
82	6.10	6.65	7.80	6.50	6.80	7.80	7.90	7.40	7.05	7.20	7.1	0.19	0.08
85	5.40	6.80	7.70	6.40	6.50	7.70	7.90	7.00	6.90	7.10	6.9	0.01	0.24
91	6.15	6.60	7.60	6.30	6.70	7.55	7.55	7.00	6.75	6.85	6.9	-0.02	0.00
94a	5.90	6.40	7.70	6.30	6.40	7.60	7.60	7.20	6.80	6.80	6.9	-0.06	0.00
94b	5.60	6.30	7.60	6.20	6.40	7.50	7.50	7.10	6.90	6.90	6.8	-0.13	0.00
Average	6.0	6.6	7.6	6.4	6.5	7.6	7.6	7.1	6.9	7.1	6.9	0.0	0.2
Std	0.48	0.35	0.36	0.45	0.42	0.33	0.42	0.32	0.29	0.34	0.28	0.28	0.17
Min	5.0	6.0	6.5	5.6	5.8	6.5	6.4	6.3	6.2	6.3	6.3	-0.6	0.0
Max	7.3	7.8	8.3	7.8	8.1	8.2	8.4	7.8	7.6	7.8	7.7	0.8	0.8

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
1a	48.85	46.85	48.76	47.68	48.69	46.17	47.93	49.40	50.41	49.23	48.4	0.37	0.21
1b	48.05	46.09	47.80	47.27	48.69	45.62	47.45	48.78	50.11	49.01	47.9	-0.14	0.20
2	48.92	46.44	48.65	48.11	48.84	45.64	47.78	48.78	50.22	49.76	48.3	0.29	0.34
4a	47.79	45.89	48.76	47.45	48.41	45.71	47.08	49.24	50.23	48.73	47.9	-0.09	0.27
4b	48.36	45.77	48.10	47.68	48.34	45.17	47.29	48.42	49.99	48.62	47.8	-0.25	0.25
5	48.78	46.37	48.49	48.00	48.65	45.53	47.60	49.10	50.16	49.35	48.2	0.18	0.23
8a	47.65	46.40	48.39	47.58	48.61	45.51	48.07	48.91	49.73	48.88	48.0	-0.05	0.30
8b	48.23	46.27	48.29	47.23	48.62	45.29	47.33	49.05	50.18	48.76	47.9	-0.10	0.13
11a	48.17	46.01	48.19	47.68	48.63	45.72	47.68	48.95	50.25	49.05	48.0	0.01	0.14
11b	47.95	46.38	48.46	47.36	48.62	45.54	47.65	49.17	50.19	48.84	48.0	-0.01	0.13
11e	49.10	46.44	48.64	47.42	48.60	45.67	47.83	48.78	50.40	48.77	48.2	0.14	0.34
12	47.54	46.01	48.28	47.44	48.44	45.67	47.23	49.31	49.99	48.76	47.9	-0.16	0.23
15a	48.35	46.27	48.47	47.76	48.90	45.33	47.30	49.26	50.32	48.93	48.1	0.07	0.17
15b	48.40	46.75	48.36	47.42	48.62	45.32	47.89	49.37	50.30	49.64	48.2	0.18	0.30
17	48.27	45.89	48.21	47.27	48.97	45.84	47.28	49.02	50.19	48.97	48.0	-0.03	0.22
18	48.37	46.22	47.91	47.45	48.52	45.43	47.67	49.09	49.95	48.77	47.9	-0.08	0.19
19	48.23	46.55	48.89	47.70	49.11	45.81	48.20	49.12	50.06	49.16	48.3	0.26	0.24
24	48.44	46.09	48.80	47.54	49.08	45.46	46.91	49.11	50.29	49.02	48.1	0.05	0.30
31	48.10	46.23	48.17	47.54	48.87	45.23	47.16	49.09	49.79	48.81	47.9	-0.12	0.20
33	47.46	46.38	48.69	47.23	47.77	46.53	48.00	49.02	50.42	48.85	48.0	0.01	0.55
35a	48.14	45.92	47.94	47.24	48.65	45.77	47.41	48.91	49.76	48.85	47.9	-0.17	0.20
35b	48.16	46.35	48.07	47.19	49.11	45.06	47.45	48.89	50.17	48.64	47.9	-0.11	0.28
35c	48.45	46.22	48.26	47.75	48.66	45.42	47.70	48.98	50.33	48.96	48.1	0.05	0.15
35d	47.77	46.12	47.76	47.51	48.54	45.31	47.52	48.71	49.79	48.49	47.8	-0.27	0.20
56	48.33	46.25	48.50	47.48	48.65	45.54	48.08	48.92	50.36	49.04	48.1	0.09	0.20
64	48.40	46.19	48.51	47.50	48.77	45.73	47.26	49.06	49.99	48.65	48.0	-0.01	0.17
68	47.36	45.71	48.36	47.67	48.38	46.05	47.26	49.11	49.77	48.34	47.8	-0.22	0.38

79a	48.39	46.98	48.96	48.28	49.36	45.74	48.11	49.89	50.49	49.27	48.5	0.52	0.24
79b	47.54	46.08	48.40	47.23	48.59	45.16	47.48	48.59	50.27	49.08	47.8	-0.18	0.27
79c	47.81	45.70	48.18	47.47	48.51	45.71	47.35	49.12	50.26	48.67	47.9	-0.15	0.21
80	48.73	46.47	48.70	47.45	48.87	45.13	46.96	48.94	50.21	49.11	48.1	0.03	0.34
82	47.98	45.98	48.23	47.55	48.41	45.74	47.47	48.95	50.10	48.78	47.9	-0.10	0.13
85	47.59	45.82	48.40	47.42	48.49	45.78	46.55	49.75	50.66	48.70	47.9	-0.11	0.49
94a	48.26	46.42	48.47	47.76	48.37	45.09	47.53	48.91	50.20	49.19	48.0	0.00	0.24
94b	48.10	46.51	48.34	47.63	48.59	45.86	47.42	49.44	50.34	48.83	48.1	0.08	0.18
Average	48.2	46.2	48.4	47.5	48.7	45.6	47.5	49.1	50.2	48.9	48.0	0.0	0.2
Std	0.42	0.31	0.30	0.25	0.28	0.32	0.37	0.29	0.22	0.29	0.18	0.18	0.09
Min	47.4	45.7	47.8	47.2	47.8	45.1	46.5	48.4	49.7	48.3	47.8	-0.3	0.1
Max	49.1	47.0	49.0	48.3	49.4	46.5	48.2	49.9	50.7	49.8	48.5	0.5	0.5

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

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb/March 2022

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1a	6.28	6.31	7.79	6.32	6.27	7.61	7.61	7.35	7.00	7.09	7.0	0.07	0.14
1b	5.89	6.33	7.71	6.28	6.29	7.81	7.49	7.41	6.87	6.85	6.9	0.00	0.11
2	6.11	6.34	7.63	6.33	6.15	7.83	7.67	7.10	6.72	6.87	6.9	-0.02	0.14
4a	5.60	6.36	7.50	6.25	6.19	7.19	7.62	7.08	6.85	6.94	6.8	-0.14	0.15
4b	5.87	6.39	7.52	6.25	6.27	7.87	7.33	7.34	6.86	6.59	6.8	-0.07	0.16
5	6.04	6.40	7.67	6.31	6.36	7.79	7.60	7.30	6.91	6.86	6.9	0.03	0.07
8a	6.68	6.74	7.85	6.60	6.65	7.72	7.92	7.35	7.25	7.43	7.2	0.32	0.19
8b	6.09	6.50	7.77	6.23	6.24	7.73	7.62	7.18	7.00	6.93	6.9	0.03	0.09
11a	5.89	6.53	7.77	6.30	6.24	7.59	7.66	7.23	6.98	7.03	6.9	0.02	0.08
11b	5.95	6.56	7.83	6.51	6.59	7.68	7.80	7.46	7.08	7.17	7.1	0.17	0.08
11e	5.86	6.08	7.17	6.28	6.11	7.56	7.20	6.99	6.74	6.66	6.7	-0.23	0.15
12	5.35	6.42	7.70	5.96	6.24	7.33	7.65	7.10	6.58	6.96	6.7	-0.17	0.21
15a	5.93	6.27	7.54	6.20	6.28	7.58	7.52	7.25	6.83	6.81	6.8	-0.08	0.06
15b	6.20	6.30	7.83	6.54	6.37	7.93	7.77	7.36	6.80	6.85	7.0	0.10	0.16
17	5.65	6.45	7.73	6.29	6.37	7.57	7.69	7.20	6.89	7.03	6.9	-0.01	0.11
18	6.06	6.32	7.26	6.27	6.18	7.68	7.53	7.32	6.79	6.76	6.8	-0.08	0.15
19	5.81	6.65	7.71	6.32	6.31	7.65	7.65	7.17	7.08	7.24	7.0	0.06	0.14
24	6.09	6.45	7.62	6.40	6.37	7.78	7.44	7.15	6.80	6.88	6.9	0.00	0.10
31	6.02	6.40	7.66	6.28	6.33	7.67	7.46	7.20	6.88	6.78	6.9	-0.03	0.07
33	6.19	6.72	7.93	6.57	6.72	7.59	7.79	7.35	7.25	7.28	7.1	0.24	0.13
35a	5.65	6.47	7.57	6.28	6.45	7.48	7.41	7.20	7.00	6.77	6.8	-0.07	0.13
35b	6.02	6.23	7.53	6.25	6.28	7.69	7.61	7.28	6.77	6.84	6.8	-0.05	0.09
35c	6.03	6.26	7.61	6.33	6.16	7.63	7.36	7.12	6.71	6.93	6.8	-0.08	0.11
35d	5.86	6.44	7.65	6.40	6.48	7.60	7.64	7.32	6.88	6.91	6.9	0.02	0.07
56	5.98	6.35	7.75	6.28	6.19	7.81	7.56	7.30	6.73	6.93	6.9	-0.01	0.11
64	5.95	6.48	7.66	6.29	6.36	7.48	7.54	7.15	7.07	7.00	6.9	0.00	0.09
68	6.12	6.91	8.10	6.52	6.62	7.85	7.94	7.50	7.21	7.54	7.2	0.33	0.14

79a	6.11	6.51	7.50	6.51	6.41	7.88	7.47	7.53	6.74	6.67	6.9	0.04	0.20
79b	5.69	6.43	7.32	6.21	6.29	7.43	7.36	7.07	6.79	6.80	6.7	-0.16	0.10
79c	5.60	6.44	7.76	6.21	6.38	7.34	7.53	7.06	6.84	6.90	6.8	-0.09	0.14
80	6.02	6.38	7.67	6.41	6.27	7.88	7.58	7.17	6.85	6.99	6.9	0.03	0.10
82	5.58	6.50	7.54	6.25	6.47	7.57	7.59	7.12	6.73	6.95	6.8	-0.07	0.13
85	5.76	6.57	7.55	6.31	6.39	7.62	7.71	7.04	6.84	6.86	6.9	-0.03	0.11
94a	6.03	6.51	7.78	6.35	6.33	7.68	7.63	7.27	6.88	6.91	6.9	0.04	0.05
94b	5.42	6.34	7.54	6.23	6.41	7.45	7.57	7.09	6.88	6.93	6.8	-0.11	0.16
Average	5.9	6.4	7.6	6.3	6.3	7.6	7.6	7.2	6.9	6.9	6.9	0.0	0.1
Std	0.26	0.16	0.18	0.13	0.14	0.17	0.16	0.14	0.16	0.20	0.12	0.12	0.04
Min	5.3	6.1	7.2	6.0	6.1	7.2	7.2	7.0	6.6	6.6	6.7	-0.2	0.1
Max	6.7	6.9	8.1	6.6	6.7	7.9	7.9	7.5	7.3	7.5	7.2	0.3	0.2

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