

# **World Grain Network Ring Test**

**Results of the worldwide inter-laboratory study  
conducted in February-April 2023**

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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 2022 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 2023 all samples (2022 harvest)	Ref. methods	Local models	FOSS ANN
<b>Protein, range</b>	<b>9.2 % - 15.0 %</b>		
<b>Mean (%)</b>	<b>11.49</b>	<b>11.56</b>	<b>11.49</b>
<b>deviation from mean</b>		<b>0.07</b>	<b>0.00</b>
<b>SD reproducibility</b>	<b>0.17</b>	<b>0.20</b>	<b>0.11</b>
<b>RSD reproducibility</b>	<b>1.5</b>	<b>1.8</b>	<b>0.9</b>
<b>Moisture, range</b>	<b>10.8 % - 15.0 %</b>		
<b>Mean (%)</b>	<b>12.83</b>	<b>12.76</b>	<b>12.73</b>
<b>deviation from mean</b>		<b>-0.07</b>	<b>-0.10</b>
<b>SD reproducibility</b>	<b>0.18</b>	<b>0.25</b>	<b>0.06</b>
<b>RSD reproducibility</b>	<b>1.4</b>	<b>1.9</b>	<b>0.5</b>

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\* 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.

<b>WGN 2023 all samples (2022 harvest)</b>	<b>Ref. methods</b>	<b>Local models</b>	<b>FOSS ANN</b>
<b>Oil, range</b>	<b>46.2 % - 51.7 %</b>		
<b>Mean (%)</b>	<b>48.98</b>	<b>48.95</b>	<b>49.37</b>
<b>deviation from mean</b>		<b>-0.03</b>	<b>0.39</b>
<b>SD reproducibility</b>	<b>1.04</b>	<b>1.07</b>	<b>0.29</b>
<b>RSD reproducibility</b>	<b>2.1</b>	<b>2.2</b>	<b>0.6</b>
<b>Moisture, range</b>	<b>4.4 % - 6.7 %</b>		
<b>Mean (%)</b>	<b>5.48</b>	<b>5.59</b>	<b>5.57</b>
<b>deviation from mean</b>		<b>0.11</b>	<b>0.09</b>
<b>SD reproducibility</b>	<b>0.15</b>	<b>0.31</b>	<b>0.18</b>
<b>RSD reproducibility</b>	<b>2.9</b>	<b>5.7</b>	<b>3.4</b>

Fifty laboratories from twenty-three 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 hectoliter*
- *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 a record number of participants and nearly record number of countries: fifty participants as compared to forty-eight last year; and twenty-three with two new countries (South Korea and USA) as compared to twenty-one countries last year (twenty-four is the record so far).

This multi sample and multi parameter inter-laboratory study was organized by FOSS Analytical (Denmark) in February-April 2023 with Dr. T. Nilsson as project leader. The preliminary results of the study were presented on the FOSS World Grain Network Ring test Webinar 2 May 2023.

## 2 Participants

Fifty participants from twenty-three countries submitted results:

Argentina	BCR
Australia	CBH
Australia	GrainCorp
Austria	RWA
Belgium	CRA-W
Canada	Canadian Grain Commission
Canada	SGS
Czech Republic	Agro 2000
Czech Republic	Agrovykup
Czech Republic	Plzensky Prazdroj (Pilsner Urquel)
Denmark	DAKOFO
Denmark	FOSS Analytical
Denmark	Viking Malt
Estonia	Centre of Estonian Rural Research and Knowledge
Estonia	Scandagra Eesti AS
Estonia	Scanola Baltic
Finland	Finnish Food Authority
France	Agroreso (Arvalis)
France	Laborargo - InVivo
Germany	Max Rubner Institute, Detmold
Hungary	Mertcontrol
Hungary	SGS
Italy	CREA-QCE, Rome
Latvia	Eira Lab
Latvia	Incolab Services

Latvia	Laboratory of Grain Technology and Agrochemistry
Lithuania	The State Plant Service under the Ministry of Agriculture Plant Products Quality Testing Laboratory
Malaysia	Prestasi Flour Mill
The Netherlands	Agrifirm Plant
Poland	Cargill
Poland	Centralne Laboratorium Badawcze Uniwersytetu Przyrodniczego, Lublin
Poland	Hamilton
Poland	Bureau Veritas, Gdansk
Poland	SGS
South Africa	Bester Feeds
South Africa	BKB
South Africa	GWK
South Africa	Kaap Agri
South Africa	Overberg Agri
South Africa	OVK
South Africa	Rhine Ruhr
South Africa	SAGL
South Africa	Senwes
South Africa	SSK
South Korea	National Institute of Chemical Safety
Sweden	Eurofins
Sweden	Lantmännen
United Kingdom	Sciantec Analytical Services
United Kingdom	Sharnbrook Grain
USA	Cotecna

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.

<b>Wheat &amp; Barley</b>		
<b>Parameter</b>	<b>Code</b>	<b>Method</b>
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
	G02	ICC 137/1
Gluten	G03	ISO 21415-1 (manual)
	G04	ISO 21415-2 (mechanical)
	G05	other
	S01	ICC 122/1 (polarimetric, CaCl2)
Starch	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 hectoliter)
Weight	T02	EEC 71/347 (mass per hectoliter)
	T03	other
Falling	F01	ICC 107/1
Number	F02	ISO 3093
Hardness	H01	SKCS (single kernel characterization system)
	H02	ICC 129 (vitreousness of durum wheat)
	H03	other

<b>Rapeseed</b>		
<b>Parameter</b>	<b>Code</b>	<b>Method</b>
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 analyzed by the reference methods given above. A summary is given in table 3.3.2.

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

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
<b>Moisture</b>	<b>75</b>	<b>0.14</b>	<b>1.12%</b>	<b>23.70%</b>	<b>0.999</b>
<b>Protein (d.m.)</b>	<b>67</b>	<b>0.16</b>	<b>9.70%</b>	<b>16.30%</b>	<b>0.991</b>

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	"Sobbel" Winter Wheat	Hungary
W2	"Servus" Spring Wheat	Latvia
W3	Winter Wheat	Lithuania
W4	"Skagen" Winter Wheat	Lithuania
W5	Winter Wheat	Germany
W6	"Kapitol" Winter Wheat	Denmark
W7	"Lavz" Winter Wheat	France
W8	"Dawsum" Winter Wheat	UK
W9	Winter Wheat	Poland
W10	Starch Wheat	Sweden

Table 4.1.1: 2022 harvest wheat samples selected for the study (W10 from 2021).  
All samples belong to "Triticum Aestivum".

Barley samples		
Marking	Specification	Country
B1	"Runner" Spring Barley	Latvia
B2	"Planet" Spring Barley	Denmark
B3	"Jallon" Winter Barley	Hungary
B4	"Barke" Malting Spring Barley	Finland
B5	"Accordine" Spring Barley	Germany
B6	"Feedway" Spring Barley	Lithuania
B7	Barley	France
B8	"Laureate" Spring Barley	UK
B9	Winter Barley	Poland
B10	"Planet" Malting Spring Barley	Sweden

Table 4.1.2: 2022 harvest barley samples selected for the study.  
All samples belong to "Hordeum Vulgare".

Rapeseed samples		
Marking	Specification	Country
R1	Rapeseed	UK
R2	Rapeseed	Finland
R3	Winter Rapeseed	Denmark
R4	Winter Rapeseed	Latvia
R5	Rapeseed	Poland
R6	"KWS Umberto" Winter Rapeseed	Hungary
R7	Rapeseed	France
R8	Rapeseed	UK
R9	Spring Rapeseed	Finland
R10	"Explicit" Winter Rapeseed	Sweden

Table 4.1.3: 2022 harvest rapeseed samples selected for the study.  
All samples 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 50 laboratories from 23 countries participated in this study.

All wheat and barley samples had to be analyzed at least for the **moisture** and **protein** contents by the reference methods used and/or for the moisture and protein contents predicted by the local prediction models used in the respective networks. In a similar way, oil and moisture in rapeseed had to be analyzed. In addition, scans from the respective master instruments were supplied to be analyzed by FOSS using the ANN calibration model WB003034 and RA002635.

On a voluntary basis, participants could also submit data for the reference analysis of other parameters, for the mass per hectoliter using the Infratec TWM and for results obtained by NIR prediction models for other parameters.

## 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 <sub>R</sub> (%)	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<sub>R</sub> 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-nine labs reported reference data on basis of reference methods for Protein.

Labcode	Method code	Standard
1	P04	ICC 105/2 (Kjeldahl)
2	P02	EN ISO 16634 (Dumas combustion)
4	P01	EN ISO 20483 (KJELDAHL, Cu/Ti)
5	P01	EN ISO 20483 (KJELDAHL, Cu/Ti)
8	P04	ICC 105/2 (Kjeldahl)
10	P02	EN ISO 16634 (Dumas combustion)
12	P02	EN ISO 16634 (Dumas combustion)
15	P02	EN ISO 16634 (Dumas combustion)
17	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
18	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
19	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
26	P06	AOAC 990.03 (Dumas)
27	P06	AACCI 46-30.01 (Dumas)
30	P06	AACCI 46-30.01 (Dumas)
32	P06	Analytica EBC 3.3.1 (Kjeldahl)
33	P02	EN ISO 16634 (Dumas combustion)
35	P06	AACCI 46-30.01 (Dumas)
36	P02	EN ISO 16634 (Dumas combustion)
61	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
68	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
68	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
73	P06	AOAC 2001.11:2005 (Kjeldahl)
77a	P06	AOAC 2001.11:2005 (Kjeldahl)
80	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)
84	P03	EN ISO 5983-2 (Kjeldahl, Cu)
85	P03	EN ISO 5983-2 (Kjeldahl, Cu)
94	P02	EN ISO 16634 (Dumas combustion)
98	P01	EN ISO 20483 (Kjeldahl, Cu/Ti)

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

Thirty-four 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
27	M03	AACC 44-15.02	130° C, 1 h
30a	M01	ICC 110/1 (Wheat)	130° C, 2 h
30a	M03	Analytica EBC 3.2 (Barley)	130° C, 2 h
32	M03	Analytica EBC 3.2	130° C, 2 h
33	M01	ISO 712:2009	130° C, 2 h
35	M03	AACC 44-15.02	130° C, 1 h
36	M03	AACC 44-15.02	130° C, 1 h
61	M01	ISO 712:2009	130° C, 2 h
64	M01	ISO 712:2009	130° C, 2 h
68	M01	ISO 712:2009	130° C, 2 h
73	M03	AACC 44-15.02	130° C, 1 h
77a	M01	ISO 712:2009	130° C, 2 h
80	M01	ISO 712:2009	130° C, 2 h
82	M01	ISO 712:2009	130° C, 2 h
84	M03	AACC 44-15.02	130° C, 1 h
91	M01	ISO 712:2009	130° C, 2 h
94	M01	ISO 712:2009	130° C, 2 h
98	M01	ISO 712:2009	130° C, 2 h
99	M01	ISO 712:2009	130° C, 2 h
100	M03	National	130° C, 2 h
101	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

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb-Apr 2023

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	12.22	12.52	10.72	13.12	12.69	10.81	10.86	10.78	14.96	10.93	11.96	0.03	0.12
2	12.07	12.63	10.84	13.14	12.63	11.07	11.04	10.93	15.17	10.91	12.04	0.12	0.07
4	12.33	12.62	11.00	13.24	12.74	11.16	11.11	10.83	15.18	11.09	12.13	0.20	0.09
5	12.10	12.60	10.80	13.20	12.80	11.00	11.10	11.00	15.00	10.90	12.05	0.12	0.07
8	12.10	12.70	10.90	13.20	12.60	11.10	11.10	11.00	15.00	11.00	12.07	0.14	0.06
10	12.22	12.67	10.79	13.31	12.66	11.04	11.17	11.01	14.80	11.06	12.07	0.15	0.11
12	11.90	12.40	10.40	12.80	12.20	10.80	10.70	10.60	14.70	10.60	11.71	-0.22	0.11
15	11.99	12.35	10.73	12.96	12.38	11.05	11.11	10.84	14.96	11.10	11.95	0.02	0.12
17	12.00	12.40	10.90	13.00	12.50	10.80	11.00	10.80	14.90	10.90	11.92	-0.01	0.08
18	12.17	12.49	10.65	13.31	12.73	11.10	10.95	11.00	N/A	11.12	11.72	-0.20	0.12
19	12.07	12.54	10.82	13.18	12.77	11.13	11.18	10.83	15.21	10.99	12.07	0.14	0.08
26	11.96	12.50	10.65	12.95	12.59	11.03	10.75	11.15	14.82	11.10	11.95	0.02	0.08
27	11.94	12.27	10.44	12.78	12.65	10.67	10.93	10.38	14.56	10.26	11.69	-0.24	0.21
30	12.08	12.63	10.87	13.21	12.71	11.03	11.08	10.93	14.99	10.91	12.04	0.12	0.05
33	12.10	12.41	10.59	12.81	12.52	10.96	10.92	10.72	14.94	11.05	11.90	-0.03	0.12
35	12.22	12.70	10.94	13.28	12.81	11.11	11.19	11.05	15.21	11.08	12.16	0.23	0.04
36	12.02	12.45	10.96	13.28	12.71	11.06	11.13	10.93	15.00	10.98	12.05	0.13	0.07
61	11.80	12.70	10.60	13.00	12.50	10.70	10.80	10.80	14.80	10.60	11.83	-0.10	0.15
64	11.90	12.40	10.70	12.90	12.50	10.90	11.00	10.90	14.90	10.90	11.90	-0.03	0.07
68	12.02	12.35	10.71	13.11	12.43	10.90	11.06	10.77	14.99	10.88	11.92	-0.01	0.08
73	11.28	11.70	10.01	12.32	12.19	10.27	10.40	10.23	13.69	10.14	11.22	-0.70	0.08
77a	10.30	12.30	10.80	12.90	12.60	11.00	11.10	9.80	15.00	11.00	11.68	-0.25	0.60
80	12.22	12.44	10.89	13.14	12.50	11.14	10.80	11.10	14.97	11.02	12.02	0.09	0.15
85	11.90	12.40	10.89	13.12	12.60	10.90	10.95	11.20	14.97	11.14	12.01	0.08	0.15
94	12.00	12.60	11.15	13.35	12.60	11.32	11.10	10.85	15.18	11.04	12.12	0.19	0.14
98	12.10	12.40	10.80	13.00	12.50	11.00	11.00	10.80	14.70	10.90	11.92	-0.01	0.09
Average	12.0	12.5	10.8	13.1	12.6	11.0	11.0	10.8	14.9	10.9	11.9	0.0	0.1
Std	0.39	0.20	0.22	0.23	0.16	0.21	0.18	0.30	0.30	0.25	0.20	0.20	0.10

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb-Apr 2023

<b>Min</b>	10.3	11.7	10.0	12.3	12.2	10.3	10.4	9.8	13.7	10.1	11.2	-0.7	0.0
<b>Max</b>	12.3	12.7	11.2	13.4	12.8	11.3	11.2	11.2	15.2	11.1	12.2	0.2	0.6

*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-Apr 2023

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	10.40	9.19	12.10	11.10	9.20	11.66	12.60	11.90	11.57	9.82	10.95	-0.04	0.18
	10.03	8.98	11.78	11.21	8.94	11.56	12.25	11.56	11.22	9.83	10.74	-0.26	0.15
4	10.66	9.22	11.91	11.38	9.24	11.98	12.53	11.96	11.55	9.97	11.04	0.04	0.10
5	10.70	9.40	12.00	11.40	9.20	11.90	12.61	11.90	11.60	10.00	11.07	0.08	0.06
8	10.70	9.30	11.90	11.30	9.20	11.90	12.50	11.90	11.60	10.00	11.03	0.03	0.06
10	10.52	9.60	12.20	11.41	9.28	12.13	12.57	11.83	11.38	10.25	11.12	0.12	0.17
12	10.60	9.30	11.60	11.40	9.40	11.90	11.80	11.40	11.10	9.70	10.82	-0.18	0.26
15	10.53	9.41	11.69	11.32	9.19	12.21	12.41	11.92	11.55	9.96	11.02	0.02	0.16
17	10.80	9.80	11.70	11.30	9.20	11.70	12.10	11.70	11.60	9.90	10.98	-0.02	0.20
19	10.69	9.27	11.84	11.35	9.15	11.98	12.48	11.84	11.59	10.02	11.02	0.03	0.08
26	11.13	9.47	12.63	11.43	8.92	11.74	12.30	11.25	12.09	9.92	11.09	0.09	0.08
27	10.72	9.61	11.96	11.34	9.37	11.94	12.22	11.50	11.46	9.82	10.99	0.00	0.16
30	10.49	9.00	11.75	11.21	9.10	11.69	12.29	11.61	11.56	9.92	10.86	-0.13	0.10
32	10.30	9.10	12.10	11.30	9.10	11.60	12.50	11.90	11.40	9.80	10.91	-0.09	0.18
33	10.56	8.94	11.87	11.05	9.25	11.61	12.19	11.72	11.43	9.93	10.86	-0.14	0.14
35	10.71	9.33	12.04	11.46	9.20	11.89	12.54	11.79	11.56	10.07	11.06	0.06	0.06
36	10.70	9.36	11.90	11.71	9.35	11.97	12.61	11.84	11.49	10.11	11.10	0.11	0.13
61	10.70	9.50	12.40	11.60	9.30	12.30	12.80	11.90	12.60	10.20	11.33	0.33	0.29
64	10.70	9.30	11.90	11.20	9.10	11.70	12.30	11.70	11.40	9.80	10.91	-0.09	0.07
68	10.62	9.40	11.78	11.35	9.32	11.82	12.35	11.85	11.61	10.01	11.01	0.02	0.07
77a	10.50	9.10	12.00	11.40	9.20	11.70	12.60	11.80	11.40	10.00	10.97	-0.03	0.14
80	10.48	9.29	11.93	11.21	9.09	11.95	12.40	12.06	11.81	9.79	11.00	0.01	0.17
84	11.00	9.69	11.77	11.43	9.46	11.49	N/A	12.04	11.28	10.85	11.00	0.01	0.38
85	11.10	10.00	11.70	11.46	9.20	11.98	12.31	11.76	11.80	10.20	11.15	0.16	0.25
94	10.60	9.30	11.80	11.30	9.20	11.80	12.30	11.80	11.60	10.00	10.97	-0.03	0.05
98	11.00	9.60	11.80	11.20	9.00	11.60	12.10	11.50	11.30	9.60	10.87	-0.13	0.24
Average	10.7	9.4	11.9	11.3	9.2	11.8	12.4	11.8	11.6	10.0	11.0	0.0	0.2

<b>Std</b>	0.24	0.25	0.23	0.14	0.13	0.20	0.21	0.20	0.29	0.23	0.12	0.12	0.08
<b>Min</b>	10.0	8.9	11.6	11.1	8.9	11.5	11.8	11.3	11.1	9.6	10.7	-0.3	0.1
<b>Max</b>	11.1	10.0	12.6	11.7	9.5	12.3	12.8	12.1	12.6	10.9	11.3	0.3	0.4

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-Apr 2023

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1	10.98	13.11	13.79	12.96	11.26	14.66	11.70	15.17	13.74	13.24	13.1	0.32	0.06
2	11.05	13.18	13.67	12.89	11.29	14.52	11.76	15.19	N/A	13.75	13.0	0.29	0.17
4	10.82	13.12	13.66	12.89	11.19	14.57	11.61	15.19	13.77	13.20	13.0	0.26	0.08
5	10.87	13.08	13.59	12.91	11.23	14.22	11.32	14.77	13.46	12.90	12.8	0.09	0.20
8	10.70	12.90	13.50	12.70	11.00	14.20	11.30	14.70	13.40	12.80	12.7	-0.02	0.14
10	10.27	12.42	13.24	12.30	10.50	13.89	11.14	14.45	13.27	12.74	12.4	-0.32	0.12
12	11.00	13.30	13.80	12.90	11.30	14.80	11.60	15.20	13.80	13.20	13.1	0.35	0.12
15	10.86	13.06	13.50	12.75	11.10	14.23	11.53	15.24	13.46	12.98	12.9	0.13	0.14
17	10.84	12.97	13.64	12.79	11.01	14.38	11.59	15.07	13.68	13.15	12.9	0.17	0.08
18	10.68	12.96	13.65	12.60	11.16	14.26	11.51	14.85	13.51	12.93	12.8	0.07	0.13
19	10.95	13.19	13.75	12.96	11.26	14.63	11.72	15.23	13.76	13.33	13.1	0.34	0.07
25	11.10	12.70	13.30	12.50	10.90	14.40	11.30	15.20	13.30	12.90	12.8	0.02	0.18
26	10.55	12.48	13.51	12.65	10.73	14.42	11.31	14.95	13.64	12.92	12.7	-0.03	0.18
27	10.72	12.84	13.65	12.60	10.95	14.53	11.41	14.88	13.59	12.90	12.8	0.06	0.12
30a	10.58	12.18	12.72	11.98	10.64	13.20	10.85	13.48	12.55	12.04	12.0	-0.72	0.39
33	11.04	13.19	13.82	12.97	11.36	14.60	11.80	15.21	13.77	13.24	13.1	0.36	0.08
35	10.70	12.90	13.60	12.70	11.00	14.50	11.50	15.00	13.60	13.10	12.9	0.12	0.07
36	10.67	12.90	13.59	12.66	11.00	14.48	11.45	15.00	13.54	12.97	12.8	0.08	0.08
61	10.88	13.07	13.66	12.91	11.24	14.52	11.71	15.22	13.78	13.13	13.0	0.27	0.07
64	11.01	13.19	13.70	12.94	11.34	14.63	11.78	15.24	13.79	13.26	13.1	0.35	0.06
68	10.70	12.92	13.59	12.74	10.97	14.52	11.49	14.98	13.62	13.05	12.9	0.12	0.08
73	10.28	12.41	13.07	12.34	10.78	13.72	11.48	14.69	12.96	12.42	12.4	-0.33	0.08
77a	11.06	13.50	13.44	12.80	11.20	14.53	11.74	15.15	13.52	13.12	13.0	0.26	0.21
80	9.55	9.77	11.59	11.22	9.98	14.58	10.53	15.24	13.74	13.21	11.9	-0.80	1.08
82	9.70	10.17	11.63	11.36	10.07	14.57	10.63	15.17	13.69	13.20	12.0	-0.72	1.08
91	10.80	12.88	13.48	12.78	11.09	14.37	11.52	14.98	13.60	13.08	12.9	0.12	0.05

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb-Apr 2023

<b>94</b>	10.83	12.98	13.61	12.81	11.09	14.53	11.56	15.13	13.61	13.10	12.9	0.18	0.06
<b>98</b>	10.50	12.70	13.40	12.50	10.70	14.20	11.30	14.80	13.50	13.10	12.7	-0.07	0.06
<b>99</b>	9.94	11.71	12.47	11.65	10.42	12.74	10.79	12.97	11.55	11.20	11.5	-1.20	0.55
<b>100</b>	10.80	13.10	13.00	12.20	11.10	14.40	11.20	15.20	13.00	13.30	12.7	-0.01	0.32
<b>101</b>	11.00	13.00	13.70	12.90	11.30	14.60	11.70	15.10	13.70	13.10	13.0	0.27	0.07
<b>Average</b>	10.7	12.7	13.4	12.6	11.0	14.3	11.4	14.9	13.5	13.0	12.7	0.0	0.2
<b>Std</b>	0.38	0.81	0.56	0.46	0.35	0.43	0.33	0.50	0.46	0.44	0.38	0.38	0.26
<b>Min</b>	9.6	9.8	11.6	11.2	10.0	12.7	10.5	13.0	11.6	11.2	11.5	-1.2	0.0
<b>Max</b>	11.1	13.5	13.8	13.0	11.4	14.8	11.8	15.2	13.8	13.8	13.1	0.4	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-Apr 2023

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1	14.02	14.56	11.87	12.33	11.97	12.65	11.67	13.36	13.17	12.99	12.9	0.17	0.05
2	13.87	14.44	11.88	12.26	12.00	12.64	11.74	13.39	13.27	13.04	12.9	0.17	0.07
4	13.92	14.59	11.92	12.32	12.03	12.69	11.75	13.51	13.36	13.10	12.9	0.23	0.07
5	13.82	14.48	11.70	12.29	11.95	12.65	11.61	13.36	13.25	12.88	12.8	0.11	0.06
8	13.80	14.40	11.60	12.10	11.80	12.30	11.30	13.00	12.80	12.60	12.6	-0.12	0.11
10	13.03	13.99	11.23	11.66	11.36	11.88	11.13	12.58	12.71	12.36	12.2	-0.49	0.13
12	14.00	14.60	12.00	12.30	12.10	12.90	11.80	13.70	13.40	13.10	13.0	0.30	0.10
15	13.83	14.31	11.48	12.05	11.60	12.36	11.76	13.01	12.90	12.55	12.6	-0.10	0.15
17	13.66	14.11	11.68	12.07	11.77	12.47	11.43	13.17	13.13	12.69	12.6	-0.07	0.10
19	13.97	14.68	11.92	12.36	12.03	12.77	11.76	13.48	13.38	13.12	12.9	0.26	0.07
25	13.80	14.50	11.60	12.20	12.00	12.60	11.70	13.80	13.20	13.00	12.8	0.15	0.18
26	13.95	14.66	11.79	12.29	12.08	12.81	11.49	13.26	12.58	12.44	12.7	0.05	0.18
27	13.80	14.47	11.79	12.15	11.88	12.54	11.54	13.24	13.11	12.83	12.7	0.05	0.05
30a	13.57	14.24	11.75	12.12	11.79	12.48	11.50	13.09	12.97	12.77	12.6	-0.06	0.06
32	13.70	14.40	11.70	12.10	11.80	12.50	11.50	13.20	13.00	12.80	12.7	-0.02	0.03
33	13.92	14.45	12.07	12.47	12.14	12.81	11.84	13.57	13.39	13.09	13.0	0.29	0.09
35	13.80	14.40	11.60	12.10	11.80	12.50	11.50	13.20	13.00	12.80	12.7	-0.02	0.05
36	13.83	14.44	11.65	12.14	11.89	12.50	11.49	13.23	13.16	12.82	12.7	0.03	0.07
61	13.92	14.58	11.97	12.35	12.09	12.70	11.70	13.44	13.38	13.12	12.9	0.24	0.08
64	13.97	14.58	11.97	12.40	12.01	12.72	11.76	13.43	13.34	13.04	12.9	0.24	0.05
68	13.93	14.61	11.86	12.29	11.97	12.73	11.75	13.41	13.36	13.09	12.9	0.21	0.08
77a	13.70	14.63	12.17	12.30	11.94	12.52	11.74	13.33	13.10	12.90	12.8	0.15	0.14
80	13.85	14.51	11.78	12.29	11.98	12.60	11.75	13.33	13.05	13.07	12.8	0.14	0.07
82	13.89	14.52	11.94	12.32	11.97	12.72	11.80	13.42	13.30	13.06	12.9	0.21	0.07
84	13.60	14.20	11.30	12.00	11.50	12.40	N/A	13.30	13.00	11.90	12.6	-0.11	0.28
91	13.78	14.47	11.64	12.24	11.90	12.60	11.60	13.25	13.07	12.96	12.8	0.07	0.06

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb-Apr 2023

94	13.70	14.54	11.80	12.18	11.88	12.56	11.51	13.31	13.17	12.82	12.7	0.06	0.07
98	13.90	14.60	11.70	12.40	12.00	12.50	11.40	13.20	12.90	12.80	12.7	0.05	0.07
99	11.10	12.10	9.40	10.48	10.00	10.87	9.66	10.47	9.13	10.63	10.4	-2.30	0.66
101	13.80	14.20	11.90	12.20	12.00	12.60	11.70	13.30	13.10	12.80	12.8	0.07	0.10
<b>Average</b>	13.7	14.4	11.7	12.2	11.8	12.5	11.5	13.2	13.0	12.8	12.7	0.0	0.1
<b>Std</b>	0.53	0.46	0.48	0.35	0.39	0.36	0.40	0.56	0.76	0.49	0.46	0.46	0.12
<b>Min</b>	11.1	12.1	9.4	10.5	10.0	10.9	9.7	10.5	9.1	10.6	10.4	-2.3	0.0
<b>Max</b>	14.0	14.7	12.2	12.5	12.1	12.9	11.8	13.8	13.4	13.1	13.0	0.3	0.7

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 WGN2023.

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-eight 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 WGN2023.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.06	12.50	10.78	13.09	12.58	10.99	11.01	10.91	14.95	11.00
3	0.13	0.13	0.17	0.17	0.16	0.15	0.14	0.14	0.17	0.09
4	1.06	1.06	1.57	1.31	1.27	1.38	1.26	1.32	1.12	0.77

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	10.65	9.36	11.90	11.34	9.20	11.83	12.39	11.77	11.52	9.94
3	0.24	0.25	0.18	0.14	0.13	0.20	0.21	0.20	0.20	0.16
4	2.23	2.69	1.51	1.26	1.42	1.72	1.73	1.66	1.76	1.56

**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 for most labs. However, lab 73 has a systematic shift which could be that the reported values are in a different moisture base than the expected dry matter. There are a few labs with more random deviations: lab 27 has red-marked sample W10 (and yellow-marked samples W8-W9), and lab 77a has red-marked samples W1 and W8. These should be re-analyzed to confirm if there were a random error or if there are some problems with the sample processing.

For barley, there are no labs with a systematic deviation. However, four labs have one red-marked sample each: lab 2 (B1), lab 26 (B3), lab 61 (B9), and 84 (B9). A few yellow-marked results, where those with highest z score belong to labs 12, 26 and 61. The latter two also have red-marked results hence should investigate the reasons for the deviations.

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.8	0.1	-0.3	0.1	0.5	-0.9	-0.7	-0.6	0.0	-0.4
2	0.1	0.7	0.3	0.2	0.2	0.4	0.2	0.1	1.1	-0.5
4	1.4	0.6	1.1	0.7	0.8	0.8	0.5	-0.4	1.1	0.4
5	0.2	0.5	0.1	0.5	1.1	0.0	0.5	0.5	0.2	-0.5
8	0.2	1.0	0.6	0.5	0.1	0.5	0.5	0.5	0.2	0.0
10	0.8	0.9	0.0	1.1	0.4	0.2	0.8	0.5	-0.8	0.3
12	-0.8	-0.5	-1.9	-1.5	-1.9	-1.0	-1.5	-1.5	-1.3	-2.0
15	-0.3	-0.7	-0.3	-0.7	-1.0	0.3	0.5	-0.3	0.0	0.5
17	-0.3	-0.5	0.6	-0.5	-0.4	-1.0	0.0	-0.5	-0.3	-0.5
18	0.6	0.0	-0.7	1.1	0.7	0.5	-0.3	0.5	N/A	0.6
19	0.1	0.2	0.2	0.4	0.9	0.7	0.9	-0.4	1.3	-0.1
26	-0.5	0.0	-0.7	-0.7	0.0	0.2	-1.3	1.2	-0.7	0.5
27	-0.6	-1.1	-1.7	-1.6	0.4	-1.6	-0.4	-2.6	-2.0	-3.7
30	0.1	0.7	0.4	0.6	0.6	0.2	0.4	0.1	0.2	-0.5
33	0.2	-0.4	-1.0	-1.4	-0.3	-0.2	-0.4	-0.9	-0.1	0.2
35	0.8	1.0	0.8	0.9	1.1	0.6	0.9	0.7	1.3	0.4
36	-0.2	-0.3	0.9	0.9	0.6	0.4	0.6	0.1	0.2	-0.1
61	-1.3	1.0	-0.9	-0.5	-0.4	-1.5	-1.0	-0.5	-0.8	-2.0
64	-0.8	-0.5	-0.4	-1.0	-0.4	-0.5	0.0	0.0	-0.3	-0.5
68	-0.2	-0.7	-0.4	0.1	-0.8	-0.5	0.3	-0.7	0.2	-0.6
73	-3.9	-4.0	-3.9	-3.9	-2.0	-3.6	-3.0	-3.4	-6.3	-4.3
77a	-8.8	-1.0	0.1	-1.0	0.1	0.0	0.5	-5.5	0.2	0.0
80	0.8	-0.3	0.5	0.2	-0.4	0.7	-1.0	1.0	0.1	0.1
85	-0.8	-0.5	0.5	0.1	0.1	-0.5	-0.3	1.5	0.1	0.7
94	-0.3	0.5	1.8	1.3	0.1	1.6	0.5	-0.3	1.1	0.2
98	0.2	-0.5	0.1	-0.5	-0.4	0.0	0.0	-0.5	-1.3	-0.5

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	-1.3	-0.9	1.0	-1.2	0.0	-0.9	1.1	0.7	0.3	-0.6
2	-3.1	-1.9	-0.6	-0.6	-1.3	-1.4	-0.7	-1.0	-1.5	-0.6
4	0.0	-0.7	0.1	0.2	0.2	0.7	0.7	1.0	0.2	0.1
5	0.2	0.2	0.5	0.3	0.0	0.3	1.1	0.7	0.4	0.3
8	0.2	-0.3	0.0	-0.2	0.0	0.3	0.6	0.7	0.4	0.3
10	-0.7	1.2	1.5	0.4	0.4	1.5	0.9	0.3	-0.7	1.5
12	-0.3	-0.3	-1.5	0.3	1.0	0.3	-2.9	-1.8	-2.1	-1.2
15	-0.6	0.2	-1.0	-0.1	0.0	1.9	0.1	0.8	0.2	0.1
17	0.7	2.2	-1.0	-0.2	0.0	-0.7	-1.4	-0.3	0.4	-0.2
19	0.2	-0.5	-0.3	0.1	-0.2	0.7	0.5	0.4	0.4	0.4
26	2.4	0.5	3.7	0.5	-1.4	-0.5	-0.4	-2.6	2.9	-0.1
27	0.3	1.2	0.3	0.0	0.9	0.5	-0.8	-1.3	-0.3	-0.6
30	-0.8	-1.8	-0.7	-0.6	-0.5	-0.7	-0.5	-0.8	0.2	-0.1
32	-1.8	-1.3	1.0	-0.2	-0.5	-1.2	0.6	0.7	-0.6	-0.7
33	-0.5	-2.1	-0.1	-1.4	0.3	-1.1	-1.0	-0.2	-0.4	-0.1
35	0.3	-0.2	0.7	0.6	0.0	0.3	0.8	0.1	0.2	0.6
36	0.2	0.0	0.0	1.9	0.8	0.7	1.1	0.3	-0.1	0.8
61	0.2	0.7	2.5	1.3	0.5	2.3	2.1	0.7	5.4	1.3
68	0.2	-0.3	0.0	-0.7	-0.5	-0.7	-0.4	-0.3	-0.6	-0.7
68	-0.2	0.2	-0.6	0.1	0.6	-0.1	-0.2	0.4	0.5	0.3
77a	-0.8	-1.3	0.5	0.3	0.0	-0.7	1.1	0.2	-0.6	0.3
80	-0.9	-0.4	0.2	-0.6	-0.5	0.6	0.1	1.5	1.5	-0.8
84	1.7	1.6	-0.6	0.5	1.3	-1.7	N/A	1.4	-1.2	4.5
85	2.2	3.2	-1.0	0.6	0.0	0.7	-0.4	0.0	1.4	1.3
94	-0.3	-0.3	-0.5	-0.2	0.0	-0.2	-0.4	0.2	0.4	0.3
98	1.7	1.2	-0.5	-0.7	-1.0	-1.2	-1.4	-1.3	-1.1	-1.7

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

Thirty-two 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 WGN2023.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	10.79	12.94	13.59	12.75	11.04	14.50	11.52	15.04	13.61	13.08
3	0.22	0.29	0.15	0.19	0.25	0.14	0.19	0.21	0.15	0.16
4	2.03	2.26	1.08	1.47	2.29	0.95	1.62	1.37	1.10	1.19

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	13.83	14.45	11.77	12.24	11.95	12.60	11.62	13.33	13.12	12.88
3	0.12	0.17	0.21	0.12	0.10	0.14	0.17	0.18	0.21	0.21
4	0.85	1.18	1.79	0.98	0.86	1.13	1.48	1.36	1.62	1.63

**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 % H<sub>2</sub>O), 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 four labs (10, 30a, 73 and 99). Moisture loss during milling is the most likely reason. There are more labs with re-marked results and reasons can be either systematic as in moisture loss during milling or random, which may depend on the moisture content how sever it is. Labs that seem to have more random errors are labs 2, 26, 77a, and 100. There are two labs (80 and 82) deviating significantly for samples W1-W5 and W7. These two labs received extra sample sets where it was found that moisture loss had occurred. It was determined from re-predictions that the moisture loss could be verified and if adjusted accordingly, the z scores would be fine. It means these two labs do not need to take any actions.

The moisture determination for barley looks in general very good, but lab 10 has red- and yellow-marked results and lab 99 have all results red-marked. All have negative sign, which means a systematic shift that should be investigated. Lab 26 has one red-marked sample (B9) and lab 84 also have one red-marked results (B10). These seems to be of more random nature, but lab 84 also had red-marked for protein on the same sample and hence could be a mistake in the sample processing step.

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	1.3	1.2	1.4	1.5	1.6	1.2	1.3	0.9	0.9	1.1
2	1.8	1.7	0.5	1.0	1.8	0.2	1.7	1.1	N/A	4.8
4	0.2	1.3	0.5	1.0	1.1	0.5	0.6	1.1	1.1	0.9
5	0.5	1.0	0.0	1.2	1.4	-2.0	-1.4	-1.9	-1.1	-1.3
8	-0.7	-0.3	-0.7	-0.3	-0.3	-2.1	-1.6	-2.4	-1.5	-2.0
10	-3.7	-3.7	-2.5	-3.2	-3.8	-4.3	-2.7	-4.2	-2.4	-2.4
12	1.5	2.6	1.5	1.1	1.9	2.2	0.6	1.1	1.4	0.9
15	0.5	0.9	-0.7	0.0	0.4	-1.9	0.1	1.4	-1.1	-0.7
17	0.3	0.2	0.3	0.3	-0.2	-0.8	0.5	0.2	0.5	0.5
18	-0.8	0.2	0.4	-1.1	0.9	-1.7	-0.1	-1.4	-0.7	-1.1
19	1.1	1.8	1.1	1.5	1.6	0.9	1.4	1.3	1.1	1.8
25	2.2	-1.7	-2.1	-1.8	-1.0	-0.7	-1.6	1.1	-2.2	-1.3
26	-1.7	-3.3	-0.6	-0.7	-2.2	-0.6	-1.5	-0.7	0.2	-1.1
27	-0.5	-0.7	0.4	-1.1	-0.6	0.2	-0.8	-1.2	-0.1	-1.3
30a	-1.5	-5.4	-6.2	-5.5	-2.8	-9.3	-4.8	-11.2	-7.6	-7.4
33	1.8	1.8	1.6	1.6	2.3	0.7	2.0	1.2	1.1	1.1
35	-0.7	-0.3	0.0	-0.3	-0.3	0.0	-0.1	-0.3	-0.1	0.1
36	-0.9	-0.3	0.0	-0.6	-0.3	-0.1	-0.5	-0.3	-0.5	-0.8
61	0.6	1.0	0.5	1.2	1.4	0.2	1.4	1.3	1.2	0.4
64	1.5	1.8	0.8	1.4	2.2	0.9	1.9	1.4	1.3	1.3
68	-0.7	-0.1	0.0	-0.1	-0.5	0.2	-0.2	-0.4	0.1	-0.2
73	-3.7	-3.8	-3.7	-2.9	-1.8	-5.6	-0.3	-2.5	-4.6	-4.7
77a	1.9	4.0	-1.1	0.4	1.2	0.2	1.6	0.8	-0.6	0.3
80	-8.9	-22.6	-14.3	-10.9	-7.6	0.6	-7.1	1.4	0.9	0.9
82	-7.8	-19.8	-14.0	-9.9	-6.9	0.5	-6.4	0.9	0.6	0.9
91	0.0	-0.4	-0.8	0.2	0.4	-0.9	0.0	-0.4	-0.1	0.0
94	0.3	0.3	0.1	0.4	0.4	0.2	0.3	0.6	0.0	0.1
98	-2.1	-1.7	-1.4	-1.8	-2.4	-2.1	-1.6	-1.7	-0.8	0.1
99	-6.1	-8.8	-8.0	-7.8	-4.4	-12.6	-5.2	-14.8	-14.7	-13.4
100	0.0	1.2	-4.2	-3.9	0.4	-0.7	-2.3	1.1	-4.4	1.6
101	1.5	0.5	0.8	1.1	1.9	0.7	1.3	0.4	0.6	0.1

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	1.1	0.6	0.6	0.6	0.1	0.3	0.3	0.2	0.3	0.6
2	0.2	-0.1	0.7	0.1	0.3	0.2	0.7	0.3	0.9	0.9
4	0.5	0.8	0.9	0.5	0.5	0.5	0.8	1.0	1.4	1.3
5	-0.1	0.2	-0.4	0.3	0.0	0.3	0.0	0.2	0.8	0.0
8	-0.2	-0.3	-1.0	-0.8	-0.9	-1.8	-1.9	-2.0	-1.9	-1.6
10	-4.7	-2.7	-3.2	-3.4	-3.5	-4.2	-2.9	-4.4	-2.4	-3.1
12	1.0	0.9	1.4	0.4	0.9	1.8	1.1	2.2	1.6	1.3
15	0.0	-0.8	-1.7	-1.1	-2.1	-1.4	0.9	-1.9	-1.3	-1.9
17	-1.0	-2.0	-0.5	-1.0	-1.1	-0.8	-1.1	-1.0	0.0	-1.1
19	0.8	1.3	0.9	0.7	0.5	1.0	0.9	0.9	1.5	1.4
25	-0.2	0.3	-1.0	-0.2	0.3	0.0	0.5	2.8	0.5	0.7
26	0.7	1.2	0.1	0.3	0.7	1.2	-0.7	-0.4	-3.2	-2.6
27	-0.2	0.1	0.1	-0.5	-0.4	-0.4	-0.4	-0.5	-0.1	-0.3
30a	-1.5	-1.3	-0.1	-0.7	-1.0	-0.7	-0.7	-1.4	-0.9	-0.6
32	-0.8	-0.3	-0.4	-0.8	-0.9	-0.6	-0.7	-0.8	-0.7	-0.5
33	0.5	0.0	1.8	1.4	1.1	1.2	1.3	1.4	1.6	1.2
35	-0.2	-0.3	-1.0	-0.8	-0.9	-0.6	-0.7	-0.8	-0.7	-0.5
36	0.0	-0.1	-0.7	-0.6	-0.4	-0.6	-0.7	-0.6	0.2	-0.4
61	0.5	0.7	1.2	0.7	0.8	0.6	0.5	0.6	1.5	1.4
64	0.8	0.7	1.2	1.0	0.3	0.7	0.9	0.6	1.3	0.9
68	0.6	0.9	0.5	0.3	0.1	0.8	0.8	0.5	1.4	1.2
77a	-0.8	1.0	2.4	0.4	-0.1	-0.5	0.7	0.0	-0.1	0.1
80	0.1	0.3	0.1	0.3	0.2	0.0	0.8	0.0	-0.4	1.1
82	0.3	0.4	1.0	0.5	0.1	0.7	1.1	0.5	1.0	1.1
84	-1.4	-1.5	-2.8	-1.4	-2.7	-1.2	N/A	-0.2	-0.7	-5.8
91	-0.3	0.1	-0.8	0.0	-0.3	0.0	-0.1	-0.5	-0.3	0.5
94	-0.8	0.5	0.2	-0.3	-0.4	-0.2	-0.6	-0.1	0.3	-0.4
98	0.4	0.9	-0.4	1.0	0.3	-0.6	-1.3	-0.8	-1.3	-0.5
99	-16.1	-13.8	-13.9	-10.3	-11.5	-10.2	-11.5	-16.8	-23.5	-13.2
101	-0.2	-1.5	0.8	-0.2	0.3	0.0	0.5	-0.2	-0.1	-0.5

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 WGN2023.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	12.10	12.60	10.91	13.16	12.62	11.07	11.05	11.05	15.01	11.01
3	0.04	0.10	0.13	0.07	0.03	0.08	0.05	0.15	0.05	0.01
4	0.17	0.18	0.19	0.19	0.16	0.20	0.19	0.19	0.20	0.22
5	1.43	1.43	1.77	1.42	1.24	1.76	1.71	1.69	1.35	2.03

**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	11.07	9.52	11.83	11.43	9.16	11.91	12.33	11.78	11.64	9.96
3	0.42	0.16	-0.06	0.09	-0.04	0.08	-0.06	0.01	0.12	0.01
4	0.23	0.27	0.18	0.17	0.18	0.23	0.20	0.21	0.19	0.22
5	2.12	2.86	1.54	1.48	2.00	1.92	1.60	1.78	1.67	2.25

**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. Two labs deviate significantly for most samples, but not all. Lab 73 has 9 red-marked results with negative sign, but W1 is good. The results should be double-checked. Lab 100 has 4 red-marked and two yellow-marked and the result should be double checked as well. There is another instrument (lab 56) that deviate with both one red with positive sign and nine yellow marked Z-scores of negative sign. The red-marked might be an outlier warning giving rise to the deviation, but the yellow marked indicate a tendency for a systematic shift that should be investigated. Lab 85 also has several yellow-marked results with negative sign, which indicates an adjustment might be needed. For most other labs, it looks good with only few yellow marked wheat results (labs 10, 12, 26, 30h, 30k, 35a, 61 and 94b).

For barley, there are also red marked results and a few more compared to wheat, which is normal due to the nature of inhomogeneity in barley. Three labs show two red-marked results each (labs 26, 35a and 56). The first two labs have positive signs and the third has negative signs, but since several results are good it is only indications of a systematic shift. Lab 27a has one red-

marked and several yellow-marked results all with positive sign indicating a systematic shift. Lab 35d has one red-marked result that seems to be more random, possibly due to outlier warning. 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	-0.5	0.0	-0.5	-0.8	-1.1	-0.9	-0.8	-0.3	0.0	-0.6
2	-0.7	-0.1	-0.3	0.2	-0.8	-0.1	-0.6	-0.7	-0.5	-0.4
4a	-0.1	-0.3	-0.2	-0.2	-0.5	0.0	0.0	-0.4	0.1	0.0
4b	1.0	0.6	0.6	-0.1	-0.3	0.3	0.5	-0.1	0.1	0.2
5	0.5	0.5	0.5	0.2	0.4	-0.4	0.2	-0.3	0.5	-0.1
8a	0.0	0.0	0.0	-0.3	0.4	0.1	-0.3	0.2	0.5	0.9
8b	0.0	0.5	0.0	0.2	-0.1	0.6	0.2	0.2	1.0	0.9
10	0.0	-1.0	0.7	-1.0	-0.1	-1.1	1.0	0.2	-2.0	-0.1
11a	-0.1	-0.3	-0.6	-0.3	-0.3	-0.1	0.3	-0.9	0.3	-0.6
11b	-0.6	0.0	0.1	-0.5	-0.4	0.3	0.2	0.3	0.3	-0.4
12	-1.0	-1.0	-1.5	-0.8	-1.6	-0.9	-2.3	-1.8	-1.0	-1.1
15	0.6	0.4	-0.4	0.7	0.3	-0.1	0.4	0.3	0.7	0.6
17a	0.0	0.2	0.0	0.2	-0.8	-0.1	-0.5	-0.3	-0.5	0.2
17b	0.8	0.0	0.0	0.2	-0.1	-0.4	0.0	-0.3	0.0	0.4
18	-0.5	0.5	0.0	0.2	-0.1	0.1	0.7	-0.3	0.0	0.9
19	0.1	-0.2	-0.7	-0.7	-0.8	-0.8	-0.9	-0.3	-0.9	-0.8
25	-1.0	-0.5	-1.5	-0.3	-0.6	0.1	-0.8	0.2	0.5	-0.6
26	1.5	2.0	0.5	1.7	0.9	1.6	1.7	1.2	2.0	1.4
27a	0.5	1.4	1.3	0.3	1.1	0.7	1.3	1.4	1.5	0.1
27b	0.9	0.7	1.3	1.1	0.6	1.3	1.0	1.1	0.5	-0.1
30a	1.2	0.7	1.0	1.0	0.5	0.5	0.3	0.0	0.4	0.4
30b	0.8	1.1	1.3	1.4	1.5	1.2	1.7	1.5	0.9	1.6
30c	1.0	0.4	0.6	0.8	0.3	1.1	0.7	0.8	1.4	1.5
30d	0.6	1.0	1.3	0.9	0.7	1.0	0.9	0.9	0.9	1.2
30e	0.3	1.1	0.1	1.2	0.5	0.9	0.7	0.5	1.2	1.1
30f	-0.2	0.8	0.5	0.3	0.1	1.1	0.2	0.8	-0.1	1.5
30h	1.5	0.6	2.3	0.7	1.1	1.4	1.5	2.1	1.1	1.7
30i	0.4	0.7	0.8	0.4	0.5	0.9	1.0	0.2	1.2	0.6
30k	0.2	0.6	1.2	0.9	1.1	0.9	0.0	1.1	0.9	2.2
30l	0.1	0.6	0.3	1.1	0.9	0.8	1.3	0.9	1.3	1.2
33	0.0	0.0	-0.5	-0.3	-0.1	0.1	-0.3	-0.3	-0.5	0.4
35a	1.5	1.5	0.5	1.7	0.9	1.1	1.2	1.2	2.0	1.4
35b	1.5	1.0	1.0	1.7	0.9	1.1	0.7	1.2	0.5	1.4
35c	1.0	1.0	1.5	1.2	0.9	1.1	1.2	1.2	1.5	0.9
35d	1.5	1.0	1.5	1.2	1.4	1.1	1.2	0.7	0.5	0.4
36	-0.9	-1.2	-1.2	-0.1	-0.2	-1.4	-0.2	-1.9	-0.3	-1.7
56	-2.0	-2.0	4.0	-2.8	-2.6	-2.4	-2.3	-2.3	-2.0	-2.6
61	-1.0	-1.5	-2.0	-1.3	-2.6	-1.9	-0.8	-0.8	-2.5	-0.6

64	-0.5	-0.5	-0.5	-0.8	-0.6	-0.4	-0.3	-1.3	-0.5	-0.1
66	-0.5	-1.0	0.0	-0.3	-1.1	0.1	-0.3	-0.3	0.0	0.4
67	-0.5	-0.5	0.0	-0.8	-0.6	0.6	-0.3	0.7	-0.5	-0.6
68	-1.0	0.0	-0.5	0.2	0.4	0.6	-0.8	-0.8	0.5	-0.6
73	0.3	-4.0	-3.7	-4.1	-3.8	-3.5	-3.3	-4.0	-4.9	-3.5
77a	0.0	0.5	0.5	0.1	-0.1	-0.4	0.2	0.2	-0.5	-0.1
79a	-0.5	0.0	0.5	-0.3	-0.1	-0.4	0.2	-0.3	-0.5	-0.1
79b	-0.5	-1.0	-1.0	-0.8	-1.1	-1.4	-0.8	0.2	-1.0	-1.1
79c	-0.5	-1.0	-0.5	-0.3	-0.1	-0.4	-0.3	0.2	-1.0	0.4
80	-0.1	-1.0	-0.7	-1.0	-0.2	-0.3	-0.8	-0.6	-0.2	-0.5
82	0.0	-0.7	-0.7	-0.3	-1.1	-1.0	-1.3	-0.9	-0.4	-0.7
85	-2.5	-2.5	-2.5	-1.8	-2.6	-2.4	-1.8	-1.8	-1.0	-2.1
91a	0.5	0.5	-1.0	-0.8	-0.6	-0.9	-0.8	-0.3	0.0	-1.1
91b	0.5	0.0	0.0	-0.3	-0.1	-0.9	-0.8	-0.8	-0.5	-0.1
94a	-0.5	-0.5	-0.5	-0.3	-0.6	-0.9	-0.8	-0.3	0.0	-0.6
94b	-1.5	-1.0	-2.0	-1.8	-1.6	-1.9	-1.3	-1.8	-1.0	-1.1
98	0.0	-0.5	0.0	0.2	-1.1	0.1	-0.8	-0.3	-1.0	-0.6
100	-1.3	-0.7	0.8	-3.7	1.4	-4.2	-4.0	-3.5	-2.4	-2.2
101	0.0	-1.0	0.0	-1.3	-0.6	0.1	-0.8	-0.3	-0.5	-0.1

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	0.2	0.9	-0.7	-0.1	-0.3	-0.1	-0.7	0.1	-0.2	-0.3
2	-1.7	-2.7	-1.3	-2.1	-2.3	-2.7	-1.5	-2.6	-1.8	-1.3
4a	1.9	1.1	-1.3	0.4	-0.3	-0.7	-1.5	-0.3	0.4	-1.2
4b	-0.3	0.2	0.2	-0.2	0.5	0.2	0.1	0.2	0.1	-0.8
5	-1.3	-0.1	0.8	0.9	0.7	0.9	0.8	-0.4	0.3	0.7
8a	0.2	0.4	-1.2	-0.6	-0.8	-0.6	-0.2	-0.4	-0.7	0.2
8b	-0.8	0.4	-0.7	-0.6	0.2	-0.1	-1.2	-0.4	-0.2	-0.3
10	-0.8	0.9	-0.9	-1.1	0.2	-2.8	-1.2	-1.7	-0.9	-0.3
11a	0.5	-0.7	0.3	-0.8	-0.2	0.2	-0.5	0.3	-0.6	1.0
11b	2.9	0.1	0.2	0.7	-0.2	-0.4	-0.3	-0.6	-0.3	-0.5
12	-0.8	-0.6	-0.7	-0.6	-0.3	-0.1	-0.7	-0.4	-1.2	-2.3
15	1.2	2.7	0.5	1.0	1.1	1.4	0.5	0.5	0.6	0.9
17a	0.2	-0.1	0.1	-1.6	-0.8	-0.6	-0.4	-1.2	-0.2	-1.0
17b	0.7	-1.1	-0.2	0.4	0.5	-0.1	0.1	-0.2	-0.4	-0.5
18	-0.3	-0.6	0.3	-0.1	0.2	-0.6	0.8	0.1	0.3	0.2
19	-1.7	-0.7	-0.2	-0.6	-0.2	0.0	0.2	-0.4	-0.1	-0.5
25	-1.3	-0.6	0.8	-0.1	-0.8	-0.6	-1.2	0.6	-0.7	-1.3
26	3.2	3.4	0.8	0.9	2.2	1.4	0.8	0.1	1.3	1.2
27a	2.9	1.6	2.1	2.6	2.1	2.0	2.3	3.2	2.0	2.3
27b	1.1	0.4	1.4	2.0	1.2	2.0	0.8	1.3	1.4	2.2
30a	1.8	0.8	1.3	-0.7	0.8	0.1	1.6	0.5	1.5	1.2
30b	-0.3	-0.1	0.8	0.4	-0.8	-0.8	-0.4	1.1	0.9	0.9

<b>30c</b>	0.9	0.8	0.8	1.0	0.8	1.1	0.2	0.8	0.9	<b>2.1</b>
<b>30d</b>	-0.9	-1.1	-1.0	-0.9	0.2	0.4	-0.1	-0.5	0.3	0.5
<b>30e</b>	-0.9	-0.1	-0.7	-0.9	-0.5	-0.2	1.1	0.1	0.3	-0.1
<b>30f</b>	0.6	-0.1	0.8	0.7	-0.5	-1.1	-0.4	0.5	1.5	1.5
<b>30h</b>	0.3	1.4	-0.1	0.1	-0.1	-0.8	0.8	1.1	0.0	-0.7
<b>30i</b>	0.3	0.2	1.1	1.0	0.8	-0.2	0.5	0.8	1.5	1.2
<b>30k</b>	-0.9	0.5	0.2	-0.2	-0.1	-0.2	0.5	-0.2	0.6	-0.1
<b>30l</b>	-1.3	0.5	-0.7	-0.2	-0.5	-0.2	-0.4	-0.2	0.0	-0.7
<b>32</b>	-1.3	<b>-2.1</b>	-1.2	<b>-2.1</b>	-1.3	-1.6	-1.7	-1.9	<b>-2.2</b>	-1.8
<b>33</b>	1.2	-0.1	-0.2	0.4	<b>2.2</b>	0.9	1.3	0.6	0.3	0.7
<b>35a</b>	<b>2.7</b>	<b>2.9</b>	0.8	0.9	<b>3.7</b>	<b>1.9</b>	<b>5.8</b>	1.6	1.3	<b>2.2</b>
<b>35b</b>	0.7	1.4	1.3	0.4	0.7	0.4	-0.2	0.6	1.3	1.2
<b>35c</b>	<b>2.2</b>	1.9	1.3	1.4	1.7	<b>2.4</b>	1.8	0.1	1.3	0.7
<b>35d</b>	<b>3.2</b>	1.9	0.8	0.9	0.7	<b>1.9</b>	0.8	1.1	0.3	0.7
<b>36</b>	0.2	1.4	-0.2	0.4	0.7	0.9	0.3	2.1	0.8	0.2
<b>56</b>	<b>-4.3</b>	<b>-3.6</b>	-1.7	<b>-2.1</b>	-1.3	-1.6	-1.2	-1.4	<b>-2.7</b>	<b>-2.8</b>
<b>61</b>	-0.8	-0.6	-1.7	-0.6	-1.3	-1.6	-0.7	-1.4	-1.7	-1.8
<b>64</b>	-0.8	-0.1	-0.2	-1.1	0.2	-1.1	-0.2	0.6	-0.2	-0.8
<b>68</b>	0.4	-1.5	0.3	-0.3	0.1	1.6	0.0	-0.2	-0.7	-0.5
<b>77a</b>	0.2	1.4	<b>-2.7</b>	-0.1	0.2	-0.6	<b>-2.7</b>	-0.9	-0.8	-0.1
<b>79a</b>	-0.3	<b>-2.6</b>	<b>-2.7</b>	-0.6	-1.3	-1.1	<b>N/A</b>	-0.9	-0.2	0.7
<b>79c</b>	-1.3	-1.1	-1.7	-0.1	-0.8	-0.6	<b>N/A</b>	<b>2.6</b>	-0.7	-0.8
<b>80</b>	-1.6	-0.7	0.1	-0.6	-0.1	0.4	-0.5	-0.5	0.4	0.8
<b>82</b>	-0.8	-1.1	-1.2	-0.6	-0.5	-0.3	-0.4	-0.2	0.3	-0.5
<b>84</b>	-0.3	-1.6	-0.7	<b>-2.1</b>	-0.8	<b>-2.1</b>	<b>N/A</b>	-0.9	-0.2	-0.8
<b>85</b>	0.7	-0.1	-0.7	-0.6	-1.3	0.9	-0.7	-0.4	-0.2	0.2
<b>91a</b>	-0.3	-0.1	0.3	-0.9	-0.3	-0.1	0.1	-0.2	-0.7	0.2
<b>91b</b>	-0.8	-1.0	-0.5	-0.8	-0.5	-0.3	0.8	-0.9	-0.5	-0.8
<b>94a</b>	-0.3	-0.6	0.8	-0.1	-0.3	0.4	-0.7	-0.4	-1.2	-0.8
<b>94b</b>	-0.3	-1.6	-0.2	0.9	0.2	0.9	0.3	0.1	0.3	0.7
<b>98</b>	-0.3	0.4	0.8	-0.6	0.2	0.4	1.8	-0.9	-0.7	-0.8
<b>101</b>	0.2	-0.1	0.0	-0.1	0.2	-0.6	-0.2	-0.4	-0.2	-0.3

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 WGN2023.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	10.66	12.91	13.46	12.63	10.94	14.31	11.36	14.77	13.40	12.93
3	-0.13	-0.02	-0.14	-0.11	-0.10	-0.19	-0.16	-0.27	-0.21	-0.15
4	0.25	0.27	0.27	0.27	0.24	0.26	0.45	0.28	0.26	0.27
5	2.35	2.12	2.00	2.15	2.22	1.84	3.95	1.89	1.92	2.07

**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	13.99	14.49	11.79	12.11	11.89	12.63	11.62	13.25	13.13	12.93
3	0.16	0.04	0.02	-0.12	-0.06	0.03	0.01	-0.08	0.01	0.05
4	0.31	0.23	0.16	0.21	0.20	0.21	0.21	0.19	0.22	0.16
5	2.19	1.60	1.34	1.73	1.67	1.67	1.80	1.42	1.69	1.21

**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 % H<sub>2</sub>O), 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 labs 68 and 98 with all results red or yellow marked. It means a clear bias that should be checked if it needs to be adjusted. There are several labs with tendency of systemic shifts (red and /or yellow with positive or negative sign), that should check if they are aligned with their reference. These labs are 2, 10, 30a-30l, 33, 36, 61, 64 and 91. Lab 100 has several red-marked with both positive and negative sign indicating some sever problem that should be checked. There are labs (66, 79a-79c, 80, 82, 85) in the same category as described for reference where extra sample sets were used having a moisture loss for W1-W5 and W7. This has been confirmed to be ok when corrected in the same manner as for reference correction hence no need to take actions for these labs.

For barley, several labs (30c, 30e, 30f, 30k, 79a, 79c, and 84) show several red and yellow-marked results with negative sig indicating incorrect alignment. A few labs (35a, 36, 68, and 91b) have one or a couple of red-marked results that seem to be random errors, possibly due to outlier warning. The reason for 79a, 79c and 84 is due to extra sample sets in a similar way as for wheat, which is confirmed from the re-prediction in section 5.2.6 and no need to take any actions for these labs.

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb-Apr 2023

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	0.9	1.1	1.3	1.3	0.7	1.4	1.5	1.0	1.6	1.3
2	2.7	2.8	2.7	2.6	2.8	2.8	3.3	3.0	2.6	2.7
4a	-0.1	2.0	2.4	1.7	0.6	3.4	1.6	4.1	2.8	2.4
4b	0.8	1.4	1.5	1.2	0.9	1.9	1.7	2.3	1.6	1.2
5	1.0	1.0	1.0	1.2	1.1	0.7	1.7	0.9	0.7	0.5
8a	1.0	0.6	1.0	0.5	0.4	0.7	1.7	0.9	0.7	0.5
8b	0.3	-0.1	0.3	0.5	0.4	-0.1	1.0	0.2	0.7	-0.2
10	-2.6	-2.2	-2.6	-2.4	-2.4	-2.9	-1.9	-3.3	-2.5	-1.6
11a	-0.5	0.3	0.3	-0.3	-0.5	0.5	0.2	0.1	0.2	0.3
11b	-0.6	0.1	0.1	-0.3	-0.5	0.2	0.0	-0.2	0.2	0.0
12	1.0	1.3	1.0	1.2	1.1	1.4	1.7	1.7	0.7	1.2
15	1.7	2.0	1.7	1.9	1.9	1.4	2.4	1.7	0.7	1.2
17a	1.0	2.0	1.0	1.2	1.1	1.4	2.1	0.6	1.4	1.9
17b	1.0	1.3	1.0	1.2	1.1	0.7	2.1	0.2	1.4	1.9
18	-1.1	-1.5	-1.1	-1.7	-1.7	-1.5	-1.2	-1.9	-2.2	-1.6
19	1.7	1.8	1.7	1.7	1.7	1.9	2.3	1.9	1.7	1.2
25	-0.4	-0.1	0.3	-0.2	-0.3	-0.1	0.3	0.2	0.0	-0.2
26	1.0	2.0	1.7	1.2	1.1	2.1	2.4	3.1	1.4	2.7
27a	-0.1	-1.1	-0.9	-0.7	0.1	-0.6	0.4	-0.8	-0.9	-1.1
27b	0.4	-0.8	-0.8	-0.2	0.4	-1.0	0.6	-1.1	-0.9	-1.1
30a	-2.6	-1.5	-1.8	-1.7	-2.4	-2.2	6.7	-2.6	-2.2	-1.6
30b	-1.7	-1.7	-1.8	-1.8	-1.4	-2.0	-1.2	-1.9	-1.7	-2.3
30c	-1.6	-2.0	-2.1	-2.2	-1.6	-2.3	-1.4	-2.2	-1.9	-2.6
30d	-2.4	-2.5	-2.3	-2.5	-2.3	-2.4	-1.7	-2.5	-2.2	-2.7
30e	-2.5	-2.6	-2.6	-2.4	-2.4	-2.4	-2.1	-2.7	-2.6	-2.9
30f	-2.6	-2.7	-2.7	-2.8	-2.3	-2.8	-2.0	-2.6	-2.7	-3.1
30h	-2.0	-2.5	-2.3	-2.4	-2.0	-2.6	-1.7	-2.5	-2.1	-2.8
30i	-2.6	-2.8	-2.7	-3.0	-2.5	-2.8	-1.9	-2.8	-2.6	-2.8
30k	-2.6	-2.6	-3.1	-2.8	-2.4	-2.8	-1.8	-2.8	-2.7	-3.0
30l	-1.4	-1.9	-2.1	-2.0	-1.4	-2.3	-1.0	-2.3	-2.1	-2.6
33	2.4	2.8	2.4	2.6	1.9	2.1	2.4	1.7	2.1	1.9
35a	1.0	1.3	1.0	1.9	1.1	0.7	2.4	0.9	1.4	1.9
35b	1.7	1.3	1.0	1.2	1.1	0.7	2.4	0.2	1.4	1.9
35c	1.7	1.3	1.0	1.2	1.1	0.7	2.4	0.2	1.4	1.9
35d	1.0	1.3	0.3	1.2	1.1	0.7	1.0	0.9	1.4	1.9
36	-0.4	-2.2	-3.3	-3.1	-1.7	-2.9	-1.2	-4.1	-2.9	-1.6
56	1.7	1.3	1.7	1.2	1.9	1.4	1.7	1.7	0.7	1.2
61	1.7	2.0	2.4	1.9	1.9	2.1	2.4	2.4	2.1	1.9
64	2.4	1.6	1.9	1.8	2.6	2.0	2.7	1.4	1.6	1.8
66	-9.0	-22.2	-16.1	-12.4	-8.1	-0.1	-7.6	0.2	0.0	-0.9
67	-0.4	-0.1	0.3	-0.2	-0.3	-0.1	1.0	-0.5	0.0	-0.2
68	-3.3	-3.7	-4.0	-3.1	-3.1	-3.6	-2.6	-2.6	-3.6	-3.1
73	1.2	1.3	1.4	1.5	0.4	1.0	1.7	0.2	2.1	1.9
77a	1.7	1.3	1.0	1.2	0.4	-0.1	3.1	-0.5	1.4	1.2
79a	-9.0	-22.2	-16.8	-12.4	-8.1	0.7	-6.9	0.9	0.0	-0.2
79b	-9.7	-23.0	-17.6	-12.4	-8.9	-0.8	-6.9	-0.5	-0.7	-0.9

<b>79c</b>	-9.7	-23.0	-17.6	-12.4	-8.9	-0.1	-7.6	0.2	0.0	-0.2
<b>80</b>	-7.5	-21.0	-13.1	-10.4	-6.3	2.0	-5.2	2.1	1.5	1.3
<b>82</b>	-8.3	-20.1	-13.1	-9.5	-6.7	2.1	-5.4	1.9	1.4	1.7
<b>85</b>	-9.7	-21.5	-17.6	-11.7	-8.9	-0.8	-6.9	-0.5	-0.7	-0.2
<b>91a</b>	1.7	2.0	1.7	1.9	1.9	2.1	2.4	2.4	2.1	1.9
<b>91b</b>	1.7	2.0	2.4	1.9	1.9	2.1	2.4	2.4	2.1	1.9
<b>94a</b>	0.3	0.6	0.3	0.5	0.4	0.7	1.0	0.9	0.7	0.5
<b>94b</b>	-0.4	-0.1	0.3	-0.2	0.4	0.7	1.0	0.9	0.0	-1.6
<b>98</b>	-4.7	-5.1	-4.0	-5.2	-4.6	-4.3	-4.0	-4.8	-5.0	-5.2
<b>100</b>	10.3	-2.2	-7.6	2.6	10.4	-16.5	6.0	-19.1	-1.4	0.5
<b>101</b>	2.0	1.9	1.7	1.7	2.1	1.6	2.3	1.8	1.3	1.2

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	2.7	0.2	0.6	0.4	0.4	-0.1	0.7	1.0	0.6
2	1.2	0.5	-0.1	0.3	0.0	0.1	0.3	0.6	0.4	-0.2
4a	1.1	0.6	0.8	1.8	1.1	2.7	1.8	1.2	1.3	1.7
4b	0.4	-0.2	0.4	0.4	0.4	0.1	0.1	0.3	0.3	0.9
5	2.1	1.2	0.7	0.8	0.7	0.1	0.2	0.6	0.4	0.1
8a	-0.6	0.6	0.1	0.5	0.1	-0.2	-0.1	-0.3	0.4	-0.1
8b	0.0	0.0	-0.5	0.5	0.1	-0.2	-0.7	0.3	0.4	-0.1
10	-2.3	-1.4	1.2	1.7	0.7	0.4	1.1	0.9	1.0	0.4
11a	-1.4	0.2	-0.2	0.2	0.1	-0.4	-0.1	0.3	0.5	0.5
11b	-1.5	0.3	-0.5	-0.1	-0.2	-0.8	-0.6	0.2	0.4	0.1
12	0.0	0.6	0.1	0.5	0.1	-0.2	-0.1	0.9	0.4	0.4
15	0.6	1.2	0.7	1.1	0.7	1.0	1.1	0.9	0.4	0.4
17a	0.9	0.3	0.4	0.2	0.1	0.4	0.2	0.3	0.4	0.1
17b	1.8	-0.5	0.1	-0.1	0.7	1.0	-0.1	-0.3	0.1	-0.1
18	0.6	1.2	0.1	-0.1	-0.5	1.0	-0.1	-0.3	-0.2	-0.7
19	0.3	1.2	0.5	1.1	0.4	0.5	0.7	0.9	1.4	0.6
25	0.0	-0.5	0.1	1.1	0.1	0.4	-0.1	-0.3	-0.2	-0.7
26	0.0	0.6	0.7	0.5	0.1	-0.2	-0.1	0.3	1.0	0.4
27a	-1.4	-0.7	-0.9	-0.6	-0.2	-0.3	-0.8	-0.6	-0.4	-0.7
27b	-1.1	0.0	-0.5	-0.2	0.1	-0.3	0.7	-0.4	0.2	0.4
30a	0.6	-0.5	0.1	-0.1	0.1	-0.2	-0.1	0.9	0.4	-0.1
30b	0.1	0.6	0.9	1.2	1.2	0.7	0.7	1.0	0.9	0.7
30c	-2.4	-1.4	-2.2	-2.1	-2.0	-2.0	-1.2	-2.1	-2.1	-2.1
30d	-1.6	-1.3	-1.8	-1.5	-1.8	-1.7	-1.9	-1.8	-1.8	-1.6
30e	-3.7	-3.2	-3.5	-2.7	-3.2	-3.0	-3.5	-2.8	-2.7	-3.1
30f	-3.2	-2.5	-2.7	-2.1	-2.3	-2.3	-2.7	-2.4	-2.4	-2.4
30h	2.9	-0.1	-0.4	-0.5	-0.4	0.0	-0.6	-0.1	0.2	-0.1
30i	-2.4	-2.2	-2.1	-1.7	-2.0	-1.9	-1.9	-1.9	-1.7	-2.2
30k	-3.4	-2.7	-3.5	-2.7	-3.1	-3.5	-2.9	-3.3	-3.4	-3.4
30l	2.2	2.5	-0.4	0.0	0.0	-0.4	-0.2	-0.5	-0.3	-0.4
32	0.6	0.0	0.1	-0.1	-0.5	-0.2	-0.1	0.3	-0.2	-0.1
33	1.8	0.6	1.2	0.5	0.7	1.0	0.5	0.9	1.0	0.4
35a	1.8	1.8	1.8	1.7	3.6	2.2	3.4	1.5	2.2	1.6
35b	0.6	0.0	0.7	1.1	1.2	1.6	2.2	0.9	1.6	1.0
35c	0.0	0.6	1.2	1.1	1.2	0.4	0.5	0.9	1.0	1.0
35d	1.8	1.2	1.2	1.7	1.2	2.8	1.6	1.5	1.6	1.0
36	-5.3	-3.5	-0.5	-0.7	-1.1	-1.9	-1.3	-2.1	-0.8	-1.3
56	1.2	0.6	0.1	0.5	0.1	1.0	0.5	0.3	0.4	0.4
61	-1.1	0.0	0.1	-0.1	0.1	-0.2	-0.1	0.3	0.4	-0.1
64	-0.5	0.7	-0.2	0.0	0.0	0.0	-0.2	0.2	-0.1	-0.1
68	4.2	-1.1	-0.5	-0.7	-0.5	-0.7	-0.1	-0.3	-0.8	-1.3
77a	-0.6	-0.5	0.1	0.5	0.7	-0.2	1.1	-0.3	0.4	0.4
79a	-24.1	-1.1	-14.1	-2.4	-7.6	-8.4	N/A	-5.0	-2.6	-6.6
79c	-21.7	-1.7	-14.6	-2.4	-8.2	-9.0	N/A	-9.1	-3.1	-9.0
80	0.9	2.3	0.6	1.3	0.3	1.3	1.0	0.9	1.0	0.3

<b>82</b>	1.1	0.9	0.9	1.4	0.7	1.0	1.6	1.2	1.3	1.0
<b>84</b>	-25.8	-1.7	-14.6	-3.0	-8.2	-8.4	N/A	-5.6	-2.6	-8.4
<b>85</b>	-0.6	-0.5	-1.1	-0.7	0.1	-0.7	1.1	-0.3	-0.2	-0.1
<b>91a</b>	0.3	1.2	0.1	0.5	1.8	0.1	0.2	0.6	1.6	1.0
<b>91b</b>	3.4	2.2	0.9	1.3	0.8	1.0	0.6	1.2	1.3	0.8
<b>94a</b>	0.6	0.0	-1.1	-0.7	-0.5	-0.2	-0.7	-0.9	-0.8	-1.3
<b>94b</b>	0.0	0.6	-0.5	-0.1	-0.5	-0.2	-0.7	-0.3	-0.2	-0.1
<b>98</b>	-1.1	-0.5	-0.5	-0.1	-0.5	-0.2	-0.1	0.3	1.0	-0.1
<b>101</b>	0.6	0.6	0.8	0.8	0.4	0.3	0.6	0.6	0.5	0.2

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 62 different set of scans submitted by 46 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 WGN2023.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	11.98	12.50	10.79	13.06	12.52	11.04	11.00	10.92	14.98	10.99
3	-0.08	0.00	0.01	-0.03	-0.06	0.04	0.00	0.01	0.02	-0.01
4	0.08	0.09	0.11	0.07	0.08	0.09	0.09	0.10	0.11	0.09
5	0.65	0.10	0.99	0.56	0.62	0.79	0.80	0.89	0.70	0.85

**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	10.99	9.46	11.73	11.41	9.08	11.88	12.29	11.77	11.50	9.90
3	0.34	0.10	-0.16	0.07	-0.12	0.05	-0.10	0.01	-0.02	-0.04
4	0.20	0.14	0.13	0.11	0.10	0.13	0.12	0.10	0.09	0.12
5	1.84	1.49	1.15	1.00	1.13	1.10	0.96	0.83	0.78	1.19

**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 labs 56, 73 and 100 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 is only one red marked (lab 11b) and four yellow marked results from three labs (labs 15a, 27a, and 30d). This means that the larger number of red and yellow marked results for the local models originates from other versions, being adjusted differently, or reported in the wrong moisture base.

World Grain Network Ring Test: Results of the inter-laboratory study conducted in Feb-Apr 2023

<b>Lab</b>	<b>W1</b>	<b>W2</b>	<b>W3</b>	<b>W4</b>	<b>W5</b>	<b>W6</b>	<b>W7</b>	<b>W8</b>	<b>W9</b>	<b>W10</b>
<b>1a</b>	0.3	0.4	0.7	0.0	0.0	0.4	0.0	1.1	0.7	0.5
<b>1b</b>	0.2	0.4	-0.3	-0.4	0.2	0.0	-0.5	0.1	0.6	0.3
<b>2</b>	0.1	0.2	0.1	0.4	0.0	0.2	-0.1	-0.1	-0.3	-0.1
<b>4a</b>	0.0	-0.3	0.1	-0.2	-0.2	0.2	0.0	0.1	-0.1	-0.2
<b>4b</b>	0.6	0.3	0.4	-0.2	-0.5	0.1	0.5	-0.3	-0.3	-0.1
<b>5</b>	0.3	0.1	0.7	0.1	0.4	-0.1	0.2	-0.3	-0.2	0.1
<b>8a</b>	0.1	-0.1	-0.4	-0.6	0.3	0.0	-0.4	0.2	0.0	0.3
<b>8b</b>	0.0	0.0	0.0	0.1	0.2	0.5	0.1	0.0	0.5	0.3
<b>10</b>	0.7	0.8	-0.1	0.3	-0.3	-0.2	0.0	-0.2	-0.3	-0.3
<b>11a</b>	0.5	0.2	0.0	0.1	0.2	0.1	0.5	-0.2	0.5	-0.5
<b>11b</b>	-0.1	0.6	0.7	0.0	0.1	0.5	0.5	0.9	0.5	-0.3
<b>11d</b>	-0.2	-0.4	0.3	0.3	0.1	-0.2	-0.3	-0.1	0.6	-0.7
<b>11e</b>	-0.3	0.0	0.5	-0.3	-0.1	-0.4	0.1	-0.2	0.3	0.1
<b>12</b>	-0.4	0.2	-0.3	0.5	-0.4	0.2	-0.9	-0.3	-0.3	-0.3
<b>15a</b>	0.0	-0.1	-0.1	0.4	0.2	-0.2	0.2	-0.3	0.0	0.6
<b>17a</b>	-0.1	0.4	-0.1	0.3	-0.6	0.3	-0.6	-0.3	-0.4	-0.1
<b>17b</b>	0.6	0.5	0.1	0.3	0.1	0.4	-0.2	0.2	-0.3	0.1
<b>18</b>	0.3	0.0	0.0	-0.1	-0.5	0.1	-0.1	-0.5	0.3	0.3
<b>19</b>	0.0	-0.1	-0.3	-0.1	0.1	-0.4	-0.4	0.0	-0.4	-0.2
<b>25</b>	-0.5	0.1	-0.9	0.0	0.0	1.0	-0.9	1.1	0.6	-0.4
<b>26</b>	0.0	0.5	-0.5	0.2	0.0	0.3	0.5	-0.2	0.7	0.2
<b>27a</b>	0.2	0.8	1.1	0.0	0.7	-0.3	0.7	0.5	0.9	-0.5
<b>27b</b>	0.6	0.0	0.7	0.6	0.2	0.2	0.3	0.2	-0.1	-1.0
<b>30a</b>	0.0	0.5	0.5	0.2	0.1	0.4	0.0	0.1	0.0	0.7
<b>30b</b>	-0.3	-0.5	-0.2	0.0	0.3	-0.8	0.5	-0.3	-0.7	0.0
<b>30c</b>	0.5	-0.5	-0.2	-0.1	-0.1	0.0	0.2	0.0	0.4	0.5
<b>30d</b>	-0.3	-0.4	0.1	-0.2	0.0	-0.7	-0.1	-0.6	-0.3	-0.3
<b>30e</b>	-0.3	0.2	-0.9	0.1	0.1	-0.4	0.2	-0.5	0.4	0.2
<b>30f</b>	-0.2	0.2	0.0	-0.2	0.0	0.3	0.2	0.2	-0.7	0.9
<b>30h</b>	0.5	-0.7	1.0	-0.8	0.4	-0.2	0.5	0.3	-0.7	0.3
<b>30i</b>	0.1	-0.1	0.0	-0.3	0.2	-0.2	0.6	-0.7	0.4	-0.4
<b>30k</b>	0.0	-0.1	0.7	0.3	0.8	0.1	-0.4	0.4	0.0	1.5
<b>30l</b>	-0.2	-0.2	-0.5	0.4	0.6	-0.2	0.6	0.3	0.4	0.2
<b>33</b>	0.4	0.2	-0.3	0.0	0.0	-0.1	0.0	0.1	-0.4	0.5
<b>35a</b>	-0.2	0.5	-0.4	0.7	-0.1	0.4	0.3	0.2	0.8	0.7
<b>35b</b>	-0.2	0.0	0.1	0.3	0.0	-0.2	-0.1	-0.1	-0.3	0.4
<b>35a</b>	-0.1	-0.1	0.4	0.2	0.0	0.2	0.2	-0.1	0.3	0.0
<b>35d</b>	0.2	0.2	0.9	0.1	0.3	0.3	0.0	0.1	-0.4	-0.2
<b>36</b>	0.0	0.1	-0.7	0.3	0.3	0.0	0.8	-0.3	0.2	-0.5
<b>56</b>	0.0	-0.1	-0.3	-0.5	-0.3	0.1	-0.1	-0.2	-0.5	0.0
<b>61</b>	0.0	0.0	-0.6	0.0	-1.2	-0.7	0.2	-0.1	-1.8	0.2
<b>64</b>	0.1	0.4	0.3	0.0	0.3	0.5	0.4	0.2	0.0	0.2
<b>66</b>	-0.3	-1.0	-0.2	-0.6	-0.8	0.0	-0.2	-0.8	-0.6	0.0
<b>67</b>	0.1	-0.1	0.0	0.5	0.2	-0.6	0.9	0.0	0.2	-0.7
<b>68</b>	-0.9	0.1	-0.8	-0.2	0.5	0.1	-1.1	-1.0	-0.1	-0.9
<b>73</b>	-0.1	0.2	0.6	0.2	-0.3	1.0	-0.4	0.6	0.2	0.0

<b>77a</b>	0.3	0.1	0.4	0.6	0.0	0.4	-0.8	0.1	1.2	-0.2
<b>79a</b>	-0.1	0.5	1.1	-0.2	0.4	-0.2	0.4	0.2	-0.5	-0.3
<b>79b</b>	-0.2	-0.9	-0.5	-0.4	-0.7	0.0	-0.6	1.0	-0.7	-0.8
<b>79c</b>	-0.1	-0.6	-0.5	-0.2	0.3	0.4	-0.1	0.4	-1.1	0.1
<b>80</b>	-0.8	-1.3	-0.7	-0.9	-0.2	-0.4	-0.4	-0.4	0.0	-0.2
<b>82</b>	-0.3	-0.8	-0.4	-0.2	-0.8	-0.3	-1.0	-0.3	-0.1	-0.1
<b>85</b>	-0.9	-1.0	-0.8	-0.5	-0.6	-1.2	0.0	-0.5	0.4	-0.6
<b>91a</b>	0.5	0.3	-1.0	-0.3	-0.2	-0.7	-0.2	-0.1	0.2	-0.4
<b>91b</b>	-0.1	-0.1	0.1	0.2	0.0	-0.2	-0.3	-0.4	0.1	0.3
<b>94a</b>	-0.3	0.0	0.4	0.0	0.0	-0.5	-0.2	-0.2	0.2	0.2
<b>94b</b>	-1.0	0.8	-0.5	0.1	0.1	0.5	0.2	-0.6	0.1	-0.5
<b>98</b>	0.2	0.2	-0.5	0.5	-0.5	-0.7	0.4	-0.3	-0.5	-0.2
<b>100</b>	0.7	0.2	0.7	-1.0	0.6	0.6	0.3	1.7	0.5	1.0
<b>101</b>	0.5	-0.4	0.4	-0.2	0.5	0.6	-0.1	0.0	0.1	0.5

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

<b>Lab</b>	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>B4</b>	<b>B5</b>	<b>B6</b>	<b>B7</b>	<b>B8</b>	<b>B9</b>	<b>B10</b>
1a	0.1	0.3	-0.1	0.2	-0.3	0.9	0.1	0.1	0.3	-0.2
1b	-1.2	0.6	0.2	0.6	0.7	0.6	0.6	0.5	0.2	0.2
2	0.1	-0.3	0.6	-0.2	0.0	-0.6	0.7	-0.7	-0.3	0.6
4a	1.2	1.3	-0.9	0.9	0.0	-0.9	-1.1	0.0	0.3	-0.8
4b	-0.1	0.4	0.6	0.3	0.2	0.8	0.5	0.4	0.3	-0.9
5	-0.2	-0.2	0.0	-0.2	-0.2	-0.1	-0.2	-0.8	-0.2	0.1
8a	0.5	0.0	-0.3	-0.5	-0.3	0.2	0.1	-0.3	-0.3	0.0
8b	0.2	0.7	-0.3	-0.1	0.6	-0.3	0.2	0.3	-0.2	-0.2
10	0.4	-0.7	0.8	-0.1	0.1	-0.7	0.7	-0.6	0.7	-0.6
11a	0.9	-0.4	0.8	-0.8	0.2	0.4	-0.3	0.3	0.1	1.3
11b	3.3	0.4	0.7	0.7	0.2	-0.2	-0.1	-0.6	0.4	-0.2
11d	-1.5	-0.6	-0.4	0.2	-0.3	-0.4	0.3	-0.2	0.1	-0.3
11e	1.0	0.5	0.4	0.1	0.7	-0.3	0.0	0.4	-0.1	0.0
12	-0.5	-0.2	-0.6	-0.6	0.1	0.2	-0.6	-0.5	-1.0	-1.1
15a	2.0	1.4	-0.6	0.3	0.0	0.9	-0.1	-0.8	0.5	0.5
17a	0.1	-0.5	0.5	-0.9	-0.4	-0.4	0.2	-0.5	-0.1	-0.7
17b	-0.7	-1.0	0.0	0.5	-0.6	0.4	0.5	0.5	-0.4	-0.2
18	-0.4	0.9	0.4	0.4	0.9	0.0	0.6	0.0	0.0	0.3
19	-1.4	-0.5	0.0	-0.3	0.0	1.0	0.1	-0.2	-0.1	0.1
25	-0.5	-0.8	0.9	0.3	-0.4	-0.3	-0.5	0.8	-0.3	-1.0
26	0.4	0.7	-0.2	0.1	0.7	0.2	-0.4	-0.7	0.3	0.2
27a	2.3	0.1	0.8	0.7	0.5	0.4	1.1	1.5	0.8	-2.9
27b	1.6	0.0	0.9	1.4	0.6	1.4	0.2	0.5	1.1	0.0
30a	1.0	0.5	0.1	-0.6	-0.3	0.2	0.0	0.2	0.0	-0.1
30b	-0.6	-0.4	0.4	0.0	-1.0	-1.1	-0.9	0.3	-0.2	0.2
30c	-0.1	0.4	0.2	0.2	0.0	0.5	-0.6	0.0	-0.3	1.1
30d	-0.8	-0.6	-2.1	0.8	0.3	0.1	-0.1	-0.7	-0.1	0.7
30e	-0.9	0.2	-0.6	-0.8	-0.1	-0.3	1.0	-0.1	-0.2	0.1
30f	0.6	0.2	0.9	0.9	-0.2	-1.3	0.1	0.5	1.4	1.5
30h	0.4	1.4	0.3	0.2	0.2	-0.7	0.8	1.0	-0.1	-0.6
30i	-0.4	-0.2	0.7	0.5	0.3	-0.8	0.1	0.4	0.5	0.6
30k	-0.6	0.9	0.2	-0.1	0.2	-0.2	0.7	-0.1	0.5	0.4
30l	-0.8	0.3	-0.2	0.2	0.4	-0.4	-0.3	0.1	0.1	-0.3
32	0.9	-0.2	0.2	-0.4	0.1	0.5	0.3	-0.6	-0.1	0.4
33	0.1	-0.1	-0.9	-0.3	1.6	0.2	0.2	0.0	0.0	0.1
35a	0.2	0.4	-0.4	-0.6	0.0	-0.5	-1.4	-0.2	-0.8	0.1
35b	-1.2	0.2	0.7	-0.4	-0.1	-0.4	-1.1	-0.1	0.1	0.4
35a	-0.1	0.3	0.3	0.4	-0.1	0.8	0.7	0.0	0.3	-0.1
35d	1.0	0.0	0.2	0.0	-0.2	0.6	0.0	0.3	-0.4	-0.1
36	-1.3	0.6	0.0	-0.2	0.0	0.1	-0.3	1.0	0.8	-0.6
56	-1.4	-1.4	0.4	-0.1	0.2	0.1	0.6	0.3	-0.1	-0.4
61	0.6	0.1	-0.4	0.1	-0.3	-0.5	0.6	-0.6	-0.6	-1.0
64	-0.2	-0.4	-0.1	-0.5	0.2	-1.0	0.0	0.5	-0.2	0.0
68	1.1	-1.3	0.0	-0.9	-1.4	1.3	-0.9	-0.3	-0.6	-1.5
77a	1.4	1.5	-1.7	1.6	0.1	1.1	-0.7	0.7	-0.4	0.0
79a	0.0	-1.5	-1.6	0.1	-0.4	-0.2	-0.3	-0.2	0.2	0.6

<b>79c</b>	-1.8	-0.7	-1.0	0.5	-0.2	-0.1	-0.3	-0.2	-0.8	0.0
<b>80</b>	-1.0	0.5	0.3	-0.2	0.3	0.7	0.1	-0.3	0.2	1.1
<b>82</b>	-0.9	-0.9	-1.4	-0.7	-0.5	-0.7	-0.6	-0.4	-0.1	-0.7
<b>84</b>	0.2	0.3	0.2	-1.2	-0.5	-1.4	-0.3	-0.1	0.5	0.0
<b>85</b>	0.3	0.8	-0.7	-0.1	-0.8	0.8	-0.5	-0.1	-0.4	0.8
<b>91a</b>	0.0	0.0	0.4	-0.7	-0.4	-0.3	0.1	-0.1	-0.3	0.1
<b>91b</b>	-0.6	-1.0	-0.2	-0.4	0.0	0.0	1.2	-0.4	-0.3	-0.3
<b>94a</b>	-0.4	-0.3	0.5	0.3	0.1	0.5	-0.1	-0.1	-0.3	-0.1
<b>94b</b>	-1.9	-1.2	0.0	0.1	0.0	0.1	0.2	0.0	0.2	-0.2
<b>98</b>	-0.1	-0.4	0.4	-0.8	-1.3	-1.0	-1.4	-0.1	-0.4	0.4
<b>101</b>	0.1	-0.3	0.4	0.1	0.8	0.0	0.5	-0.2	-0.3	0.4

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

### 5.2.6 Moisture content by the ANN model WB003034

There are 62 sets of scans from 46 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 WGN2023.

1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
2	10.63	12.89	13.42	12.58	10.90	14.28	11.41	14.70	13.35	12.90
3	-0.16	-0.04	-0.17	-0.17	-0.14	-0.22	-0.11	-0.34	-0.26	-0.18
4	0.05	0.06	0.07	0.05	0.04	0.06	0.03	0.07	0.05	0.07
5	0.45	0.45	0.50	0.37	0.39	0.45	0.29	0.49	0.37	0.53

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	13.85	14.48	11.72	12.12	11.88	12.54	11.54	13.25	13.18	12.92
3	0.02	0.03	-0.05	-0.12	-0.07	-0.06	-0.08	-0.08	0.06	0.04
4	0.11	0.09	0.05	0.05	0.04	0.06	0.05	0.06	0.06	0.06
5	0.78	0.61	0.40	0.41	0.34	0.49	0.44	0.47	0.42	0.45

**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 % H<sub>2</sub>O), 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 for most labs. The problem with extra sample sets having moisture loss for W1-W5 and W7 is clear from the re-predicted values shown here where labs 66, 79a-79c, 80, 82 ad 85 are all red-marked with negative sign. It could of course have been caused by mixing up samples, but since protein results were all fine, it verifies the suspicion with moisture loss. Lab 67 has 4 red-marked results (W6, W8-W10) and it is unclear what the reason is. Their protein results were fine, so it could be moisture loss causing this, but since local moisture results were all fine it seems to be something different.

For barley, three sets of data (79a, 79c and 84) show several red-marked samples with negative sign. The reason is due to extra sample sets where moisture loss has been observed in a similar way as for the wheat extra sets. The good protein results confirm the moisture change and no need to take any actions for these labs. All other labs are in good alignment.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1a	-0.3	-0.2	0.1	0.1	-0.4	0.2	-0.4	0.1	0.4	0.1
1b	0.3	-0.2	0.2	0.2	0.1	0.0	0.1	0.0	-0.1	0.1
2	0.4	0.4	0.5	0.4	0.4	0.5	0.4	0.6	0.4	0.6
4a	-0.5	-0.1	0.1	-0.1	-0.3	0.3	-0.1	0.5	0.4	0.4
4b	0.1	0.2	0.0	0.0	-0.1	0.1	0.2	0.3	0.2	0.1
5	0.1	-0.1	0.2	0.1	0.0	-0.2	-0.2	-0.1	-0.1	-0.1
8a	0.3	0.2	0.5	0.3	0.0	0.1	0.2	0.2	0.2	0.2
8b	0.0	-0.1	0.0	-0.1	-0.2	-0.4	-0.2	-0.2	0.2	-0.2
10	0.7	1.1	1.1	1.1	0.9	1.1	1.2	1.2	0.9	1.5
11a	-0.2	0.4	0.6	0.1	-0.2	0.8	-0.1	0.6	0.6	0.5
11b	-0.4	0.2	0.4	0.0	-0.3	0.5	-0.3	0.3	0.5	0.2
11d	-0.1	-0.1	-0.5	-0.5	-0.2	-0.6	-0.2	-9.7	-0.6	-1.0
11e	-0.3	-0.2	-0.8	-0.4	-0.4	-0.8	-0.4	-1.5	-0.6	-0.9
12	0.4	0.8	0.8	0.7	0.5	1.0	0.4	1.1	0.4	0.9
15	0.4	0.7	0.5	0.4	0.4	0.1	0.4	0.1	-0.3	0.5
17a	-0.2	0.2	0.1	-0.1	-0.1	0.3	-0.2	-0.1	0.2	0.2
17b	-0.3	-0.3	-0.3	-0.4	-0.3	-0.3	-0.2	-0.6	-0.5	-0.3
18	0.3	0.2	0.5	0.0	0.2	0.2	0.2	0.0	0.3	-0.1
19	0.2	0.3	0.2	0.3	0.1	0.3	0.1	0.3	0.2	0.1
25	0.1	0.4	0.7	0.4	0.1	0.2	0.2	0.5	0.5	0.4
26	0.2	0.2	0.2	0.2	0.1	0.3	0.0	0.1	0.0	0.0
27a	0.2	-0.7	-0.6	-0.3	0.3	-0.2	0.1	-0.6	-0.4	-0.7
27b	0.7	-0.6	-0.4	0.1	0.5	-0.9	0.3	-0.9	-0.6	-0.6
30a	0.1	0.3	0.4	0.3	0.3	0.4	0.4	0.3	0.2	0.5
30b	0.1	0.1	-0.1	0.0	0.1	-0.4	0.0	-0.3	0.0	-0.4
30c	0.0	-0.1	-0.2	-0.2	0.0	-0.7	-0.1	-0.6	-0.1	-0.4
30d	0.1	0.1	0.3	0.0	0.2	-0.1	0.1	-0.1	0.1	-0.2
30e	0.0	-0.1	-0.2	-0.1	-0.1	0.0	-0.3	-0.3	-0.1	-0.2
30f	0.0	-0.1	-0.2	-0.1	0.0	-0.4	-0.1	-0.2	-0.2	-0.3
30h	-0.3	-0.8	-0.6	-0.5	-0.4	-1.0	-0.5	-0.8	-0.4	-0.8
30i	-0.1	-0.3	-0.2	-0.3	-0.1	-0.5	0.0	-0.4	0.0	-0.2
30k	0.0	-0.1	-0.5	-0.2	0.0	-0.3	0.1	-0.4	-0.2	-0.2
30l	0.3	-0.1	-0.3	-0.2	0.2	-0.6	0.1	-0.7	-0.4	-0.5
33	-0.1	0.2	0.4	0.2	0.0	0.5	0.1	0.2	0.0	0.2
35a	0.0	0.0	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
35b	-0.1	-0.2	-0.3	-0.2	0.0	-0.4	-0.1	-0.3	-0.3	-0.3
35a	-0.2	-0.4	-0.6	-0.4	-0.2	-0.6	-0.4	-0.5	-0.5	-0.6
35d	-0.4	-0.3	-0.7	-0.6	-0.2	-0.6	-0.3	-0.3	-0.4	-0.4
36	0.4	0.1	0.0	-0.1	0.0	-0.2	0.3	-0.8	0.1	0.2
56	0.6	0.8	0.5	0.4	0.5	0.4	0.5	0.4	-0.1	0.4
61	0.0	0.1	0.3	0.4	0.1	0.5	0.2	0.4	0.1	0.6
64	0.1	-0.5	-0.4	-0.4	0.1	-0.2	-0.1	-0.9	-0.5	-0.3
66	-9.1	-22.1	-15.9	-12.3	-7.9	0.1	-7.7	0.5	0.1	0.0
67	-0.7	-2.3	-1.0	-2.4	-0.9	-22.2	-2.0	-5.2	-3.1	-2.5
68	-0.8	-0.6	-0.6	-0.4	-0.6	-0.6	-0.1	0.3	-0.7	0.2
73	-0.4	-0.1	0.2	0.1	-0.3	0.1	-0.2	-0.1	0.5	0.0

<b>77a</b>	-0.9	-1.3	-1.5	-0.6	-0.1	-1.9	-0.3	<b>-2.4</b>	-1.8	-1.4
<b>79a</b>	<b>-8.7</b>	<b>-22.2</b>	<b>-16.9</b>	<b>-11.9</b>	<b>-8.4</b>	0.8	<b>-7.1</b>	0.8	0.7	0.7
<b>79b</b>	<b>-9.2</b>	<b>-22.7</b>	<b>-17.4</b>	<b>-12.4</b>	<b>-8.6</b>	-0.3	<b>-7.3</b>	-0.2	-0.1	0.1
<b>79c</b>	<b>-9.6</b>	<b>-22.9</b>	<b>-17.3</b>	<b>-12.3</b>	<b>-9.1</b>	0.3	<b>-7.8</b>	0.7	0.2	0.5
<b>80</b>	<b>-9.5</b>	<b>-23.2</b>	<b>-15.0</b>	<b>-12.2</b>	<b>-8.5</b>	0.2	<b>-7.7</b>	0.2	-0.1	-0.2
<b>82</b>	<b>-9.6</b>	<b>-21.7</b>	<b>-14.6</b>	<b>-11.2</b>	<b>-8.6</b>	0.6	<b>-7.8</b>	0.4	0.2	0.4
<b>85</b>	<b>-9.2</b>	<b>-21.8</b>	<b>-17.3</b>	<b>-11.3</b>	<b>-9.1</b>	0.0	<b>-7.1</b>	0.0	-0.3	0.3
<b>91a</b>	0.2	0.2	0.3	0.4	0.2	0.3	0.3	0.3	0.1	0.4
<b>91b</b>	-0.1	0.1	0.2	0.1	0.0	0.1	0.1	0.2	0.0	0.2
<b>94a</b>	0.0	0.2	0.3	0.1	0.1	0.1	0.0	0.3	0.3	0.1
<b>94b</b>	0.0	0.0	-0.1	-0.2	0.0	0.0	0.0	0.2	0.0	0.2
<b>98</b>	-0.4	-0.4	0.4	-0.2	-0.3	0.3	-0.2	0.3	-0.4	0.0
<b>100</b>	0.3	0.1	0.1	0.0	-0.1	-0.4	-0.2	-0.5	0.3	-0.1
<b>101</b>	0.4	0.4	0.2	0.3	0.5	0.1	0.2	0.1	0.0	-0.1

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

<b>Lab</b>	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>B4</b>	<b>B5</b>	<b>B6</b>	<b>B7</b>	<b>B8</b>	<b>B9</b>	<b>B10</b>
1a	-0.4	1.2	0.0	0.0	-0.3	0.1	-0.3	0.0	0.1	0.0
1b	0.5	0.2	0.1	0.1	0.0	0.0	0.1	0.3	0.3	0.5
2	0.4	0.4	0.3	0.3	0.2	0.1	0.2	0.5	0.4	0.1
4a	-0.8	-0.3	-0.4	0.0	-0.2	0.1	-0.3	0.0	0.0	0.3
4b	0.0	0.0	0.0	-0.1	-0.1	0.0	-0.4	0.3	0.2	0.6
5	0.3	0.1	-0.2	0.0	0.1	0.0	-0.1	-0.1	-0.1	-0.2
8a	0.5	0.5	0.2	0.1	0.0	0.2	0.1	0.2	0.4	0.1
8b	0.4	0.2	0.2	0.1	0.0	0.0	-0.1	0.0	0.5	0.0
10	-0.1	0.3	0.5	0.5	0.5	0.6	0.2	0.5	0.6	0.5
11a	-0.6	0.3	0.2	0.2	0.1	0.2	0.4	0.3	0.2	0.5
11b	-0.7	0.4	-0.1	-0.1	-0.2	-0.3	-0.2	0.2	0.2	0.2
11d	-0.9	-0.4	-0.4	-0.3	-0.2	-0.4	-0.3	-0.4	-0.3	-0.2
11e	-0.6	-0.1	-0.3	-0.2	-0.2	-0.3	-0.6	-0.6	-0.1	-0.4
12	0.2	0.3	0.6	0.4	0.3	0.3	0.2	0.6	0.5	0.9
15	0.3	0.3	0.3	0.4	0.2	0.4	0.2	0.4	0.1	-0.1
17a	-0.5	-0.1	0.0	-0.1	-0.2	-0.4	-0.4	0.0	-0.1	0.0
17b	-0.6	-0.8	-0.3	-0.4	-0.4	-0.3	-0.7	-0.5	-0.5	-0.3
18	0.9	0.7	0.2	0.2	0.2	0.2	0.1	-0.1	-0.1	-0.2
19	0.3	0.7	0.2	0.3	0.0	0.4	0.3	0.3	0.4	0.4
25	-0.4	-0.1	0.1	0.3	0.2	0.4	0.2	0.2	0.2	-0.1
26	-0.1	0.1	0.0	0.1	0.1	0.0	0.0	-0.1	0.1	0.2
27a	-0.3	-0.7	-0.3	-0.4	-0.2	0.0	0.2	-0.6	-0.6	-0.1
27b	0.6	-0.3	0.0	-0.3	0.2	0.0	0.7	-0.4	0.0	0.1
30a	-0.4	-0.4	0.0	-0.1	-0.1	-0.4	-0.2	0.0	-0.1	0.0
30b	-0.4	-0.4	0.1	0.0	0.2	-0.4	-0.1	-0.1	-0.2	-0.2
30c	0.3	0.3	-0.1	-0.2	0.2	0.0	0.6	-0.1	-0.3	-0.1
30d	0.4	0.5	2.5	-2.0	0.2	0.3	0.2	0.1	0.1	0.4
30e	0.0	0.0	0.0	0.2	0.1	0.4	-0.1	0.2	0.2	0.2
30f	0.4	0.2	0.1	0.3	0.3	0.5	0.1	0.1	0.0	0.2
30h	0.2	0.2	-0.1	-0.3	-0.1	0.3	-0.2	-0.1	-0.1	0.1
30i	-0.1	-0.2	0.1	0.1	0.0	0.2	0.2	0.0	0.0	-0.1
30k	-0.2	0.5	-0.2	0.2	0.1	-0.1	0.2	-0.1	-0.3	-0.1
30l	0.1	0.3	-0.1	0.0	0.1	-0.2	0.1	-0.3	-0.2	-0.2
32	1.4	0.0	0.1	0.0	0.0	0.3	-0.1	0.0	-0.1	0.1
33	0.0	-0.2	0.1	-0.1	0.0	0.1	-0.3	0.1	0.0	0.0
35a	-0.3	-0.5	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.1	-0.4
35b	-0.7	-0.6	-0.3	-0.1	-0.2	-0.2	0.4	-0.5	-0.1	-0.4
35a	-0.6	-0.6	-0.4	-0.3	-0.3	-0.5	-0.4	-0.6	-0.6	-0.6
35d	-1.0	-0.8	-0.5	-0.5	-0.5	-0.3	-0.4	-0.6	-0.5	-0.8
36	-0.4	0.0	0.3	0.2	0.3	0.1	0.1	0.1	-0.1	-0.1
56	0.9	0.6	0.4	0.5	0.5	0.6	0.4	0.7	0.5	0.6
61	-0.9	0.2	0.2	0.0	0.1	0.0	-0.1	0.5	0.0	0.0
64	0.3	0.3	0.2	0.1	0.3	0.3	0.0	0.2	-0.1	0.1
68	1.8	-1.0	-0.5	-0.8	-0.6	-1.2	-0.3	-0.7	-0.6	-1.0
77a	-1.5	-1.7	-0.7	-0.8	-0.3	-0.7	-0.3	-1.1	-1.0	-0.5
79a	-23.5	-1.1	-14.3	-2.5	-7.8	-8.4	0.4	-5.2	-2.6	-8.1

<b>79c</b>	-22.2	-2.1	-14.8	-2.8	-8.3	-9.1	0.4	-5.8	-3.2	-8.7
<b>80</b>	0.6	0.7	0.2	0.4	-0.2	0.7	0.2	0.3	0.3	0.0
<b>82</b>	0.2	0.0	0.0	0.3	-0.1	0.1	0.1	0.2	0.3	0.3
<b>84</b>	-24.3	-1.7	-14.6	-2.7	-8.2	-8.8	0.4	-5.5	-2.5	-8.3
<b>85</b>	-0.1	-0.5	-0.3	-0.5	-0.1	-0.6	-0.3	-0.1	-0.2	-0.1
<b>91a</b>	0.0	0.2	0.0	0.1	0.2	-0.2	-0.2	0.1	0.4	0.0
<b>91b</b>	1.0	0.4	0.3	0.2	0.1	0.1	0.0	0.2	0.1	0.1
<b>94a</b>	0.8	0.6	0.0	0.2	0.0	0.1	0.0	0.1	0.2	0.0
<b>94b</b>	-0.1	-0.1	0.0	-0.2	-0.2	-0.3	-0.3	-0.1	-0.1	-0.2
<b>98</b>	-0.7	-0.1	-0.4	0.0	-0.3	-0.5	0.1	-0.2	0.2	-0.2
<b>101</b>	0.8	0.2	0.4	0.2	0.2	0.4	0.2	0.4	0.1	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 2023 all samples (2022 harvest)	Ref. methods	Local models	FOSS ANN
<b>Protein, range</b>	<b>9.2 % - 15.0 %</b>		
Mean (%)	<b>11.49</b>	<b>11.56</b>	<b>11.49</b>
deviation from mean		<b>0.07</b>	<b>0.00</b>
SD reproducibility	<b>0.17</b>	<b>0.20</b>	<b>0.11</b>
RSD reproducibility	<b>1.5</b>	<b>1.8</b>	<b>0.9</b>
<b>Moisture, range</b>	<b>10.8 % - 15.0 %</b>		
Mean (%)	<b>12.83</b>	<b>12.76</b>	<b>12.73</b>
deviation from mean		<b>-0.07</b>	<b>-0.10</b>
SD reproducibility	<b>0.18</b>	<b>0.25</b>	<b>0.06</b>
RSD reproducibility	<b>1.4</b>	<b>1.9</b>	<b>0.5</b>

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

WGN 2023 Wheat (2022 samples)	Ref. methods	Local models	FOSS ANN
<b>Protein, range</b>	<b>10.8% - 15.0 %</b>		
Mean (%)	<b>11.99</b>	<b>12.06</b>	<b>11.98</b>
deviation from mean		<b>0.07</b>	<b>-0.01</b>
SD reproducibility	<b>0.14</b>	<b>0.19</b>	<b>0.09</b>
RSD reproducibility	<b>1.2</b>	<b>1.6</b>	<b>0.7</b>
<b>Moisture, range</b>	<b>10.8 % - 15.0 %</b>		
Mean (%)	<b>12.89</b>	<b>12.74</b>	<b>12.71</b>
deviation from mean		<b>-0.15</b>	<b>-0.18</b>
SD reproducibility	<b>0.19</b>	<b>0.28</b>	<b>0.06</b>
RSD reproducibility	<b>1.5</b>	<b>2.3</b>	<b>0.4</b>

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

WGN 2023 Barley (2022 samples)	Ref. methods	Local models	FOSS ANN
<b>Protein, range</b>	<b>9.2 % - 12.4 %</b>		
Mean (%)	<b>10.99</b>	<b>11.06</b>	<b>11.00</b>
deviation from mean		<b>0.07</b>	<b>0.01</b>
SD reproducibility	<b>0.19</b>	<b>0.21</b>	<b>0.13</b>
RSD reproducibility	<b>1.8</b>	<b>1.9</b>	<b>1.1</b>
<b>Moisture, range</b>	<b>11.6 % - 14.5 %</b>		
Mean (%)	<b>12.78</b>	<b>12.78</b>	<b>12.75</b>
deviation from mean		<b>0.00</b>	<b>-0.03</b>
SD reproducibility	<b>0.16</b>	<b>0.21</b>	<b>0.06</b>
RSD reproducibility	<b>1.3</b>	<b>1.7</b>	<b>0.5</b>

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

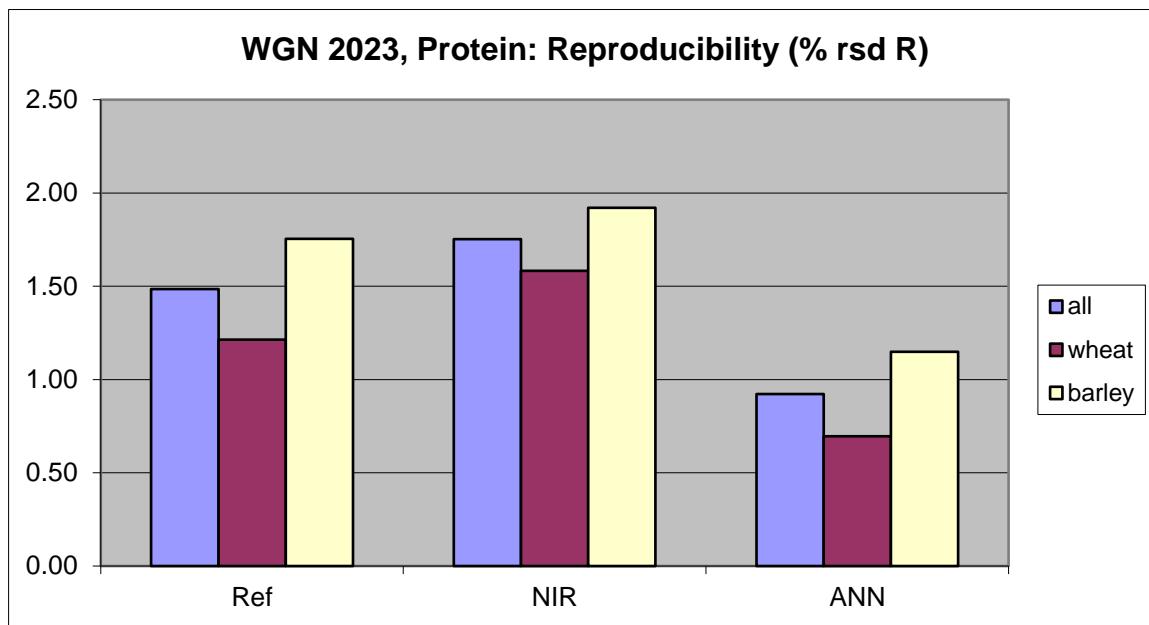


Fig. 5.3.1a: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model WB003034 (ANN) for the determination of **protein**.

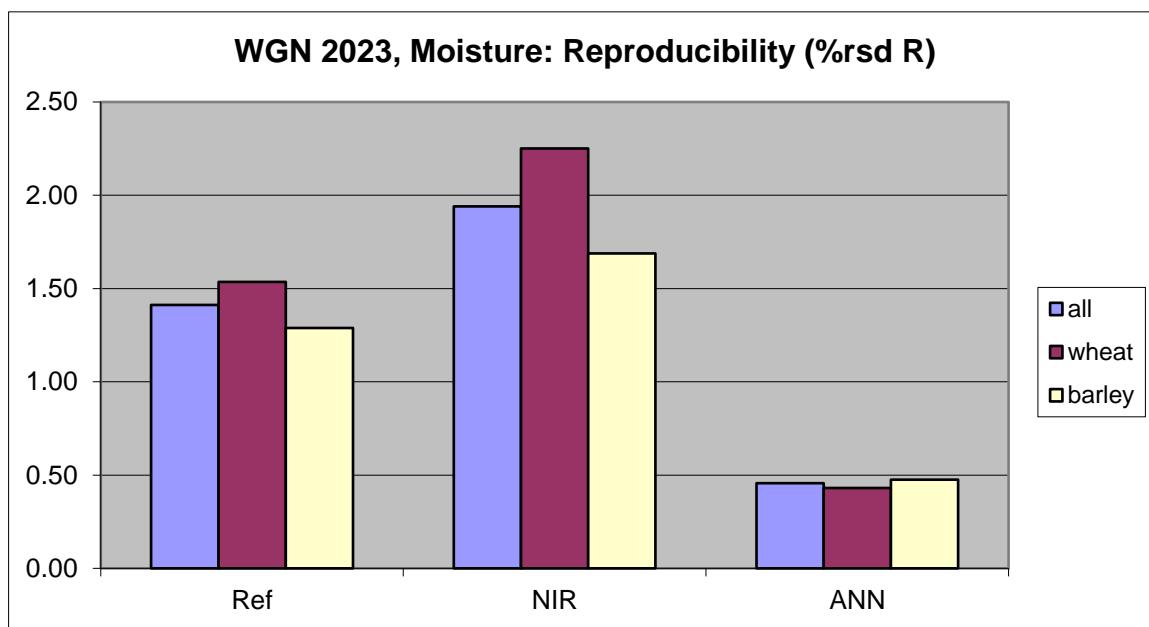


Fig. 5.3.1b: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model WB003034 (ANN) for the determination of **moisture**.

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

(0.07%) and for moisture (-0.07%) than the best estimates of the reference values. The performance in terms of reproducibility for the local prediction models are slightly worse than the reference methods on average. For protein it was somewhat worse than the reference methods for wheat and barley. For moisture, the reproducibility is better for the reference method compared to local prediction models for both wheat and barley. This indicate a larger spread of adjustments for the local prediction models applied to wheat and 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 (0.00%) and for moisture (-0.10%). The unadjusted ANN model has somewhat larger deviation for moisture in wheat (-0.18%) than the local models (-0.15%). WB003034 showed an improved reproducibility versus both the reference methods and the locally used/adopted prediction models (see table and figures above). The prediction model ANN WB003034 was not bias-corrected and the study shows that the model can be used without losses in accuracy compared to the presently used models and the reference methods for protein and moisture.

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

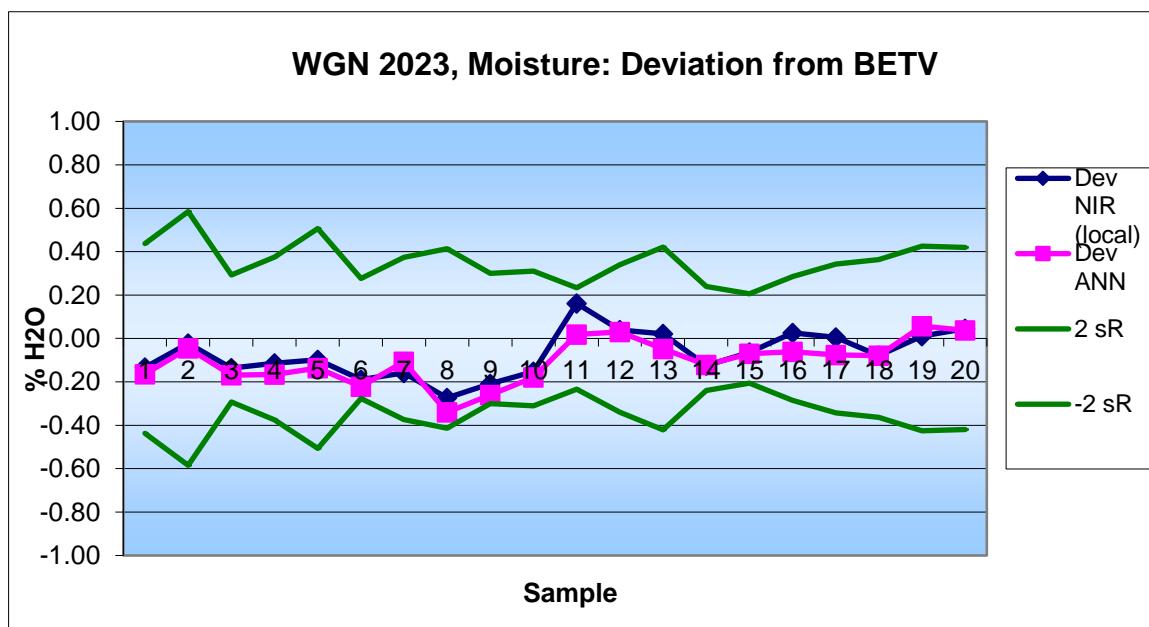


Fig. 5.3.2a: Deviations between predicted **moisture** values and the best estimate of the true value

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 B1 that is just within the reference reproducibility limits.

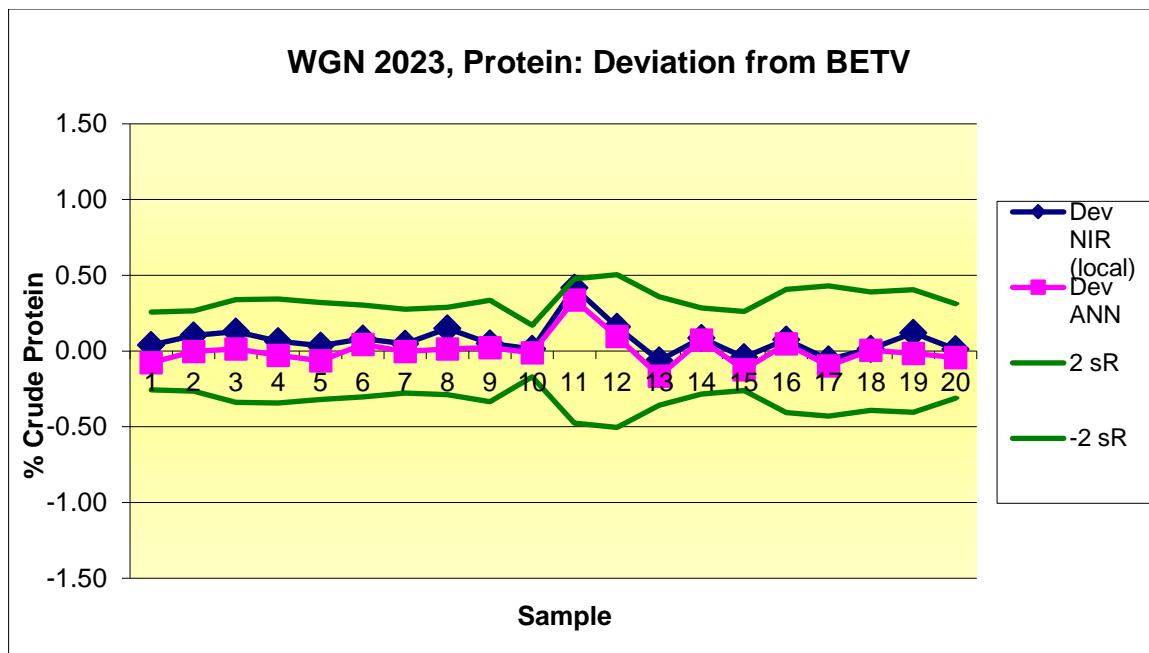


Fig. 5.3.2b: Deviations between predicted **protein** values and the best estimate of the true value

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

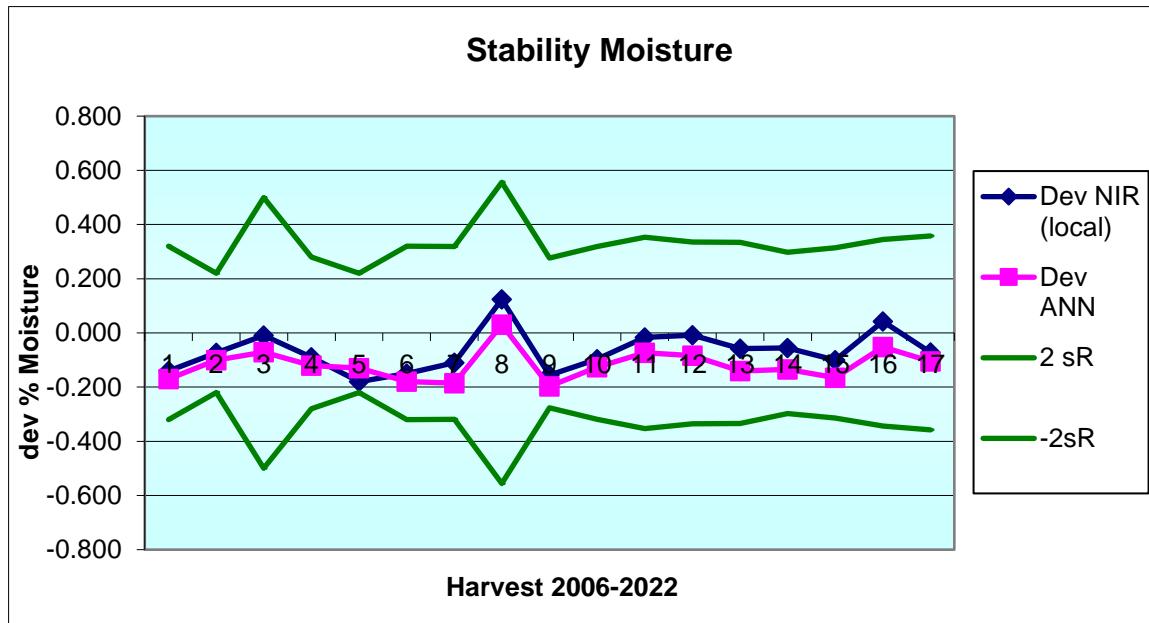


Figure 5.3.3 a: Average deviations of predicted moisture results from the best estimate of the true value during the past thirteen years. Blue = Local and Pink = ANN.

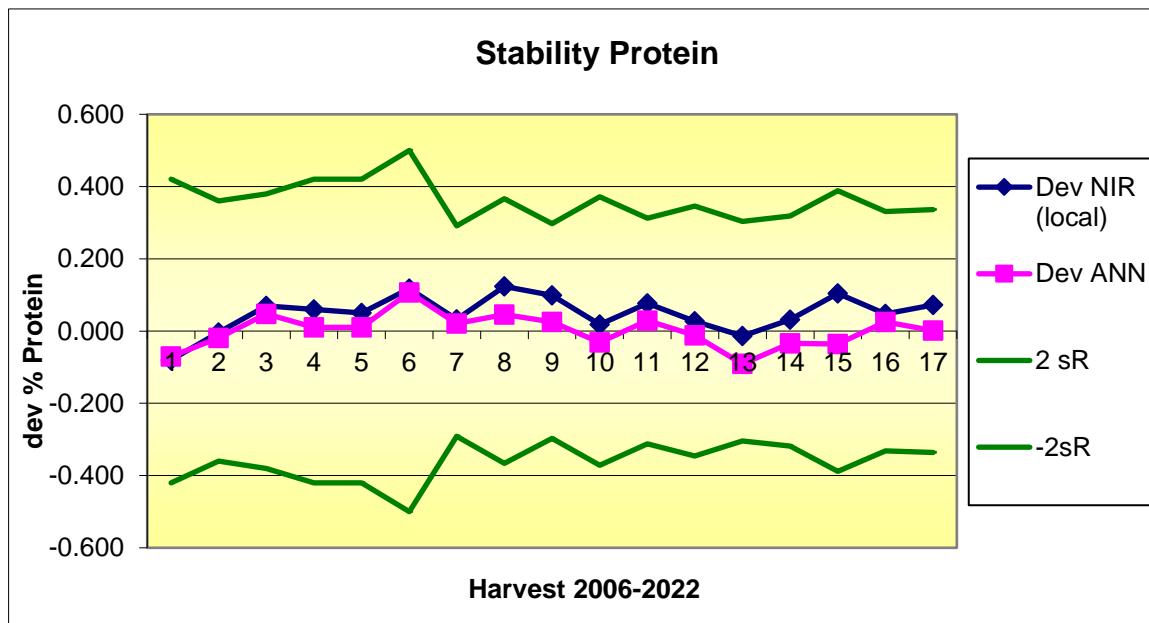


Figure 5.3.3 b: Average deviations of predicted protein results from the best estimate of the true value during the past thirteen years. Blue = Local and Pink = ANN.

## 6 Results for oil and moisture in Rapeseed

### 6.1 Collation of results

#### 6.1.1 Oil content by reference methods

Twenty-three sets of reference data were reported:

Labcode	Method code	Standard
2	O3	National Nr. 152/2009
4	O3	Foss Analytical ASN 3134
8	O1	ISO 659:2009
12	O4	ISO 10565:1998 (NMR)
15a	O1	ISO 659:2009
15b	O4	ISO 10565:1998 (NMR)
17	O1	ISO 659:2009
18	O1	ISO 659:2010
19	O1	ISO 659:2009
26	O4	ISO 10565:1998 (NMR), Bruker minispec mq10 AACCI method 30-25.01. In-House validated Method 024, Petroleum ether extraction, Soxhlet
30a	O3	
33	O1	ISO 659:2009
35	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
36	O1	ISO 659:2009
61	O1	ISO 659:2009
68	O1	ISO 659:2009
77a	O1	ISO 659:2009
80	O1	ISO 659:2009
85	O1	ISO 659:2009
91	O3	Foss Analytical ASN 3134
94	O4	ISO 10565:1998 (NMR), Bruker minispec mq10
98	O1	ISO 659:2009
99	O1	ISO 659:2009

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

Thirty sets of reference values 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	M2	ISO 10565:1998 (NMR)	NMR
17	M1	ISO 665:2000	103° C, 1 h, whole seed
18	M1	ISO 665:2020-09	103° C, 1 h, whole seed
19	M1	ISO 665:2000	103° C, 1 h, whole seed
25	M1	ISO 665:2000	103° C, 1 h, whole seed
26	M1	ISO 665:2000	103° C, 1 h, whole seed
27	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
36	M3	National Nr. 4-1.5	130° C, 1 h, whole seed
61	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
77a	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
85	M1	ISO 665:2000	103° C, 1 h, whole seed
91	M1	ISO 665:2000	103° C, 1 h, whole seed
94	M1	ISO 665:2000	103° C, 1 h, whole seed
98	M1	ISO 665:2000	103° C, 1 h, whole seed
99	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	49.51	47.93	51.51	48.59	49.71	46.21	49.85	47.57	48.74	49.03	48.9	0.01	0.50
4	49.34	47.92	52.56	50.93	50.49	46.96	49.91	48.40	49.63	51.07	49.7	0.86	0.65
8	49.70	48.40	52.30	49.00	50.40	46.20	49.60	48.50	48.80	49.90	49.3	0.42	0.46
12	49.40	49.00	52.20	49.50	50.50	46.50	50.70	48.70	49.60	50.30	49.6	0.78	0.23
15a	43.19	46.92	48.90	46.37	45.05	42.64	47.69	48.46	47.80	45.82	46.3	-2.57	1.71
15b	49.13	47.98	51.73	48.65	49.57	45.39	49.67	47.13	48.56	49.65	48.7	-0.11	0.47
17	48.90	48.40	51.70	50.50	51.40	46.80	49.60	49.80	49.50	49.60	49.6	0.76	0.70
18	47.80	47.80	51.30	48.90	49.70	45.60	49.60	48.30	48.30	49.20	48.7	-0.21	0.29
19	48.86	48.80	51.83	48.94	50.28	46.68	50.20	48.51	49.99	50.16	49.4	0.57	0.31
26	50.21	49.34	53.71	50.74	51.32	47.44	51.80	49.38	50.47	51.35	50.6	1.72	0.29
30a	46.65	46.81	50.11	47.88	48.49	42.64	47.57	44.73	46.54	46.79	46.8	-2.04	0.81
33	48.49	48.59	52.44	49.25	50.05	46.26	49.39	47.59	48.76	49.53	49.0	0.18	0.37
35	48.70	48.60	52.00	48.80	49.90	46.00	50.20	47.70	49.20	49.50	49.1	0.20	0.27
36	46.05	46.62	49.31	46.70	47.34	44.00	48.05	45.43	47.39	47.53	46.8	-2.02	0.40
61	50.33	48.51	53.23	50.01	51.66	46.90	49.79	49.13	50.02	50.70	50.0	1.17	0.58
68	48.63	47.11	51.43	47.91	49.91	45.75	49.22	47.72	48.12	49.16	48.5	-0.36	0.45
77a	47.64	48.78	51.06	48.26	49.37	45.74	49.71	47.71	49.18	49.29	48.7	-0.18	0.45
80	48.91	47.47	51.29	48.19	49.70	45.19	49.62	47.78	48.72	49.37	48.6	-0.23	0.40
85	46.24	46.61	50.07	47.42	48.40	45.65	48.89	46.68	48.24	47.13	47.5	-1.32	0.60
91	48.90	47.60	53.80	49.40	50.30	46.00	49.80	48.60	49.40	49.50	49.3	0.47	0.64
94	49.63	48.69	52.44	49.35	50.33	46.33	50.45	48.12	49.23	49.98	49.5	0.60	0.34
98	49.60	48.50	52.70	49.60	50.60	46.60	50.30	48.50	49.10	50.00	49.6	0.69	0.34
99	44.03	47.70	52.18	49.92	51.16	47.48	51.13	48.60	51.95	50.58	49.5	0.62	1.90
Average	48.3	48.0	51.7	48.9	49.8	45.9	49.7	48.0	49.0	49.4	48.9	0.0	0.6
Std	1.86	0.79	1.25	1.17	1.44	1.27	0.98	1.15	1.10	1.36	1.07	1.07	0.42
Min	43.2	46.6	48.9	46.4	45.1	42.6	47.6	44.7	46.5	45.8	46.3	-2.6	0.2
Max	50.3	49.3	53.8	50.9	51.7	47.5	51.8	49.8	52.0	51.4	50.6	1.7	1.9

Deviation = Mean Value - Average Value

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

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

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	6.66	4.50	5.81	5.35	6.44	5.39	4.66	6.46	4.40	5.46	5.5	0.03	0.06
2	6.24	4.61	5.46	5.14	6.01	5.11	4.60	6.29	4.46	5.30	5.3	-0.16	0.15
4	6.73	4.42	5.73	5.31	6.35	5.31	4.55	6.40	4.37	5.45	5.5	-0.02	0.07
5	6.70	4.50	5.70	5.30	6.30	5.00	4.50	5.90	4.20	5.10	5.3	-0.16	0.18
8	6.80	4.60	5.80	5.30	6.40	5.40	4.60	6.50	4.40	5.50	5.5	0.05	0.08
12	6.70	4.40	5.70	5.30	6.30	5.30	4.60	6.40	4.20	5.40	5.4	-0.05	0.09
15a	6.73	4.49	5.76	5.32	6.38	5.33	4.61	6.37	4.40	5.49	5.5	0.00	0.05
15b	6.43	4.89	5.85	5.65	6.25	5.33	5.03	6.23	4.80	5.66	5.6	0.13	0.22
17	6.50	4.50	5.70	5.30	6.30	5.30	4.70	6.30	4.30	5.20	5.4	-0.07	0.08
18	6.50	4.40	5.50	5.20	6.10	5.20	4.50	6.10	4.30	5.30	5.3	-0.17	0.05
19	6.78	4.50	5.75	5.34	6.42	5.38	4.63	6.46	4.38	5.50	5.5	0.03	0.07
25	6.40	4.10	5.50	5.00	6.40	5.20	4.20	6.10	4.00	5.10	5.2	-0.28	0.17
26	6.58	4.51	5.72	5.27	6.30	5.36	4.66	6.29	4.38	5.42	5.4	-0.04	0.17
27	6.75	5.06	6.00	5.57	6.41	5.76	5.21	6.61	5.53	5.77	5.9	0.38	0.28
30	6.71	4.84	5.78	5.50	6.41	5.57	4.88	6.47	4.82	5.62	5.7	0.18	0.10
33	6.87	4.70	5.79	5.48	6.46	5.47	4.73	6.58	4.67	5.60	5.6	0.15	0.06
35	6.70	4.60	5.80	5.40	6.40	5.50	4.70	6.50	4.50	5.40	5.6	0.07	0.06
36	6.97	4.73	5.88	5.52	6.42	5.49	4.93	6.51	4.72	5.66	5.7	0.20	0.07
61	6.80	4.40	5.70	5.30	6.40	5.30	4.60	6.40	4.40	5.50	5.5	0.00	0.09
64	6.60	4.40	5.60	5.30	6.30	5.30	4.60	6.40	4.30	5.40	5.4	-0.06	0.06
68	6.51	4.28	5.55	5.16	6.20	5.16	4.48	6.20	4.22	5.25	5.3	-0.18	0.04
77a	6.87	5.13	6.15	5.74	6.82	5.89	5.15	6.85	4.98	5.97	6.0	0.47	0.10
80	6.81	4.41	5.88	5.30	6.47	5.35	4.58	6.41	4.47	5.50	5.5	0.03	0.10
82	6.66	4.42	5.69	5.28	6.29	5.28	4.64	6.31	4.36	5.42	5.4	-0.05	0.04
85	5.56	4.17	5.34	4.78	5.60	5.11	4.52	6.35	4.34	5.37	5.1	-0.37	0.33
91	6.70	4.50	5.70	5.30	6.40	5.30	4.70	6.40	4.40	5.40	5.5	0.00	0.05
94	6.76	4.51	5.79	5.36	6.44	5.38	4.64	6.48	4.45	5.52	5.5	0.05	0.06
98	6.80	4.50	5.80	5.40	6.40	5.30	4.60	6.40	4.40	5.50	5.5	0.03	0.06
99	6.61	4.44	5.56	5.19	6.13	5.23	4.58	6.17	4.33	5.30	5.4	-0.13	0.05
Average	6.6	4.5	5.7	5.3	6.3	5.3	4.7	6.4	4.5	5.5	5.5	0.0	0.1
Std	0.26	0.23	0.16	0.18	0.20	0.18	0.20	0.18	0.29	0.19	0.18	0.18	0.07
Min	5.6	4.1	5.3	4.8	5.6	5.0	4.2	5.9	4.0	5.1	5.1	-0.4	0.0
Max	7.0	5.1	6.2	5.7	6.8	5.9	5.2	6.9	5.5	6.0	6.0	0.5	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 WGN2023.

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-three 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 WGN2023.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	48.70	48.00	51.73	48.90	50.03	46.18	49.68	48.23	49.01	49.35
3	1.20	0.79	1.25	1.17	1.02	0.80	0.98	0.74	1.10	1.36
4	2.46	1.65	2.41	2.40	2.04	1.73	1.98	1.53	2.24	2.75

**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 with negative sign for five labs (15a, 30a, 36, 61 and 85). In addition, lab 26 have several red- and yellow-marked results with positive sign. Lab 99 has red- and yellow-marked results of both positive and negative sign. Labs 4, 17 and 91 has 1-2 red-marked results that seems to be of more random nature.

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 the other uses extraction (labs 15a, 30a, 36, 61 and 85). In addition, we have another four labs using NMR with good performance (labs 12, 15b, 35 and 94).

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	1.5	-0.1	-0.4	-0.6	-0.6	0.1	0.3	-1.2	-0.5	-0.6
4	1.2	-0.2	1.5	3.7	0.8	1.4	0.4	0.3	1.1	3.1
8	1.8	0.7	1.0	0.2	0.7	0.0	-0.2	0.5	-0.4	1.0
12	1.3	1.8	0.9	1.1	0.9	0.6	1.8	0.8	1.1	1.7
15a	-10.0	-2.0	-5.1	-4.6	-9.0	-6.4	-3.6	0.4	-2.2	-6.4
15b	0.8	0.0	0.0	-0.5	-0.8	-1.4	0.0	-2.0	-0.8	0.5
17	0.4	0.7	-0.1	2.9	2.5	1.1	-0.2	2.8	0.9	0.4
18	-1.6	-0.4	-0.8	0.0	-0.6	-1.0	-0.2	0.1	-1.3	-0.3
19	0.3	1.4	0.2	0.1	0.5	0.9	0.9	0.5	1.8	1.5
26	2.8	2.4	3.6	3.3	2.4	2.3	3.8	2.1	2.7	3.6
30a	-3.7	-2.2	-2.9	-1.9	-2.8	-6.4	-3.8	-6.4	-4.5	-4.7
33	-0.4	1.1	1.3	0.6	0.0	0.2	-0.5	-1.2	-0.5	0.3
35	0.0	1.1	0.5	-0.2	-0.2	-0.3	0.9	-1.0	0.3	0.3
36	-4.8	-2.5	-4.4	-4.0	-4.9	-4.0	-3.0	-5.1	-2.9	-3.3
61	3.0	0.9	2.7	2.0	3.0	1.3	0.2	1.6	1.8	2.4
68	-0.1	-1.6	-0.5	-1.8	-0.2	-0.8	-0.8	-0.9	-1.6	-0.4
77a	-1.9	1.4	-1.2	-1.2	-1.2	-0.8	0.0	-1.0	0.3	-0.1
80	0.4	-1.0	-0.8	-1.3	-0.6	-1.8	-0.1	-0.8	-0.5	0.0
85	-4.5	-2.5	-3.0	-2.7	-3.0	-1.0	-1.4	-2.8	-1.4	-4.0
91	0.4	-0.7	3.8	0.9	0.5	-0.3	0.2	0.7	0.7	0.3
94	1.7	1.2	1.3	0.8	0.6	0.3	1.4	-0.2	0.4	1.1
98	1.6	0.9	1.8	1.3	1.0	0.8	1.1	0.5	0.2	1.2
99	-8.5	-0.6	0.8	1.8	2.1	2.4	2.6	0.7	5.3	2.2

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-nine sets of results were submitted for 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 WGN2023.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	6.67	4.53	5.72	5.32	6.36	5.31	4.61	6.37	4.43	5.46
3	0.16	0.23	0.16	0.18	0.08	0.13	0.07	0.18	0.21	0.13
4	2.40	5.02	2.87	3.46	1.33	2.40	1.47	2.82	4.69	2.45

**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 % H<sub>2</sub>O), 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 85 where the first five samples are red- or yellow marked, whereas samples R6-R10 are good. This indicates a batch variation assuming samples R1-R5 and R6-R10 were analyzed in two different batches. This should be checked and verified. Lab 77a have several red- and yellow-marked results all with a positive sign indicating an adjustment is needed. Lab 5 has two red-marked results with negative sign, but otherwise fine. Lab 27 has three red-marked results with positive sign. These two labs should check and possibly re-analyze the samples to see if there are random errors or some systematic issue that needs to be taken care of.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-0.1	-0.2	0.5	0.2	0.5	0.5	0.3	0.5	-0.2	0.0
2	-2.7	0.5	-1.6	-1.1	-2.2	-1.2	0.0	-0.5	0.2	-1.0
4	0.4	-0.7	0.0	-0.1	-0.1	0.0	-0.4	0.2	-0.4	0.0
5	0.2	-0.2	-0.1	-0.1	-0.4	-1.9	-0.7	-3.0	-1.4	-2.2
8	0.8	0.4	0.5	-0.1	0.3	0.6	0.0	0.8	-0.2	0.3
12	0.2	-0.8	-0.1	-0.1	-0.4	-0.1	0.0	0.2	-1.4	-0.4
15a	0.4	-0.3	0.2	0.0	0.1	0.1	0.0	0.0	-0.2	0.2
15b	-1.5	2.2	0.8	2.0	-0.7	0.1	2.6	-0.9	2.3	1.3
17	-1.1	-0.2	-0.1	-0.1	-0.4	-0.1	0.6	-0.5	-0.8	-1.6
18	-1.1	-0.8	-1.4	-0.8	-1.6	-0.7	-0.7	-1.7	-0.8	-1.0
19	0.7	-0.2	0.2	0.1	0.4	0.4	0.1	0.5	-0.3	0.3
25	-1.7	-2.7	-1.4	-2.0	0.3	-0.7	-2.5	-1.7	-2.7	-2.2
26	-0.6	-0.2	0.0	-0.3	-0.4	0.3	0.3	-0.5	-0.3	-0.2
27	0.5	3.3	1.7	1.5	0.3	2.8	3.8	1.5	6.9	2.0
30	0.2	1.9	0.4	1.1	0.3	1.6	1.7	0.6	2.5	1.0
33	1.2	1.0	0.4	1.0	0.6	1.0	0.8	1.3	1.5	0.9
35	0.2	0.4	0.5	0.5	0.3	1.2	0.6	0.8	0.5	-0.4
36	1.9	1.2	1.0	1.2	0.4	1.1	2.0	0.9	1.8	1.3
61	0.8	-0.8	-0.1	-0.1	0.3	-0.1	0.0	0.2	-0.2	0.3
64	-0.5	-0.8	-0.8	-0.1	-0.4	-0.1	0.0	0.2	-0.8	-0.4
68	-1.0	-1.6	-1.1	-1.0	-1.0	-0.9	-0.8	-1.1	-1.3	-1.3
77a	1.2	3.7	2.7	2.6	2.9	3.6	3.4	3.0	3.5	3.2
80	0.9	-0.8	1.0	-0.1	0.7	0.3	-0.2	0.2	0.3	0.3
82	-0.1	-0.7	-0.2	-0.3	-0.4	-0.2	0.2	-0.4	-0.4	-0.2
85	-7.0	-2.3	-2.4	-3.4	-4.7	-1.2	-0.5	-0.1	-0.5	-0.5
91	0.2	-0.2	-0.1	-0.1	0.3	-0.1	0.6	0.2	-0.2	-0.4
94	0.5	-0.2	0.4	0.2	0.5	0.4	0.2	0.7	0.1	0.4
98	0.8	-0.2	0.5	0.5	0.3	-0.1	0.0	0.2	-0.2	0.3
99	-0.4	-0.6	-1.0	-0.8	-1.4	-0.5	-0.2	-1.3	-0.6	-1.0

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 WGN2023.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	48.29	48.35	51.03	49.24	50.35	46.39	48.96	48.69	48.85	49.31
3	-0.40	0.35	-0.70	0.33	0.32	0.22	-0.72	0.46	-0.16	-0.04
4	1.12	1.16	1.12	1.04	1.07	1.02	1.07	0.98	0.96	1.10
5	2.32	2.41	2.20	2.12	2.12	2.21	2.18	2.01	1.97	2.23

**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. Seven labs (30a-30k, 67 and 79c) have a significant systematic shift with all Z-scores of negative sign and many are red marked. These instruments should be adjusted accordingly. Two labs (31 and 33) have one or more red-marked results with positive sign, which could indicate a systematic shift. Other labs that have one or more red-marked results that should double-check if it is some systematic or random issue are labs 8a, 15b, 17a, 27a, 27b, 61, 79a, and 91c.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-0.7	-2.3	-1.0	-0.6	0.3	2.6	-0.3	0.6	-1.4	-0.8
2	-0.7	0.0	0.8	0.9	0.8	-0.2	0.6	1.2	0.0	-0.1
4a	1.1	0.8	-1.0	1.1	-0.8	2.7	0.8	0.7	0.8	0.5
4b	2.4	0.8	-0.8	0.7	0.3	2.2	1.0	1.1	0.8	0.7
5	1.3	1.5	0.1	0.8	0.8	0.6	1.0	0.9	0.8	1.2
8a	1.8	1.7	3.4	0.8	2.6	2.0	2.4	2.0	1.5	0.3
8b	2.0	2.4	2.1	0.7	2.6	1.8	1.0	1.7	1.9	0.9
11a	1.6	1.3	0.6	0.4	0.1	1.2	0.3	0.4	0.8	1.2
11b	1.4	1.4	0.0	1.2	0.2	0.4	0.5	0.1	1.7	1.1
12	2.0	1.9	1.0	1.2	0.3	0.7	1.3	1.1	1.2	2.7
15a	1.5	1.2	0.3	0.4	0.6	1.4	1.5	1.8	1.5	1.2
15b	1.7	1.4	0.8	1.2	0.1	8.0	-3.4	2.3	1.1	1.1
17a	1.4	3.0	1.9	3.4	2.6	1.5	1.2	2.1	2.7	0.5
17b	0.3	1.0	1.7	0.3	1.7	-0.9	-0.8	0.6	1.2	-0.2
18	-1.1	1.0	1.6	1.7	0.6	0.9	0.6	1.3	0.3	0.7
19	1.3	0.8	0.1	0.5	1.2	0.2	0.6	0.6	0.6	1.4
25	0.9	0.3	-0.2	-0.3	1.0	1.5	-0.8	0.9	-0.6	-0.2
27a	0.6	1.9	0.6	1.7	1.1	3.9	-0.2	0.9	1.8	0.6
27b	-1.1	3.2	2.1	3.1	1.6	1.5	0.5	1.0	1.8	-0.8
30a	-2.0	-1.7	-1.7	-2.8	-1.9	-3.1	-2.3	-2.3	-1.9	-4.0
30d	-2.1	-3.0	-2.0	-1.7	-1.9	-2.8	-1.9	-2.0	-3.1	-2.6
30e	-3.8	-4.0	-4.8	-4.7	-4.9	-5.3	-5.4	-4.3	-3.9	-4.9
30f	-3.5	-4.0	-4.4	-4.5	-4.6	-4.2	-4.8	-4.2	-3.0	-4.4
30k	-4.9	-4.8	-4.3	-5.0	-2.9	-2.9	-2.6	-2.3	-4.0	-4.0
31	2.6	0.6	3.5	1.0	2.8	-2.4	2.0	-0.2	0.3	1.7
33	2.9	1.5	4.5	2.5	3.4	-1.4	3.5	0.2	1.2	3.8
35a	0.2	-0.1	-1.9	0.1	-0.6	1.1	-0.8	0.0	-1.4	-0.6
35b	0.4	1.2	0.3	0.1	1.4	0.6	1.2	0.4	0.6	0.2
35c	1.3	1.4	-0.1	0.7	0.1	-0.3	0.6	0.7	0.8	0.3
35d	-0.5	-0.5	-2.2	-0.8	0.5	-0.2	-0.8	-0.7	-0.6	-1.3
35e	-0.4	0.1	1.6	-1.7	0.5	-0.7	1.2	-0.7	0.8	0.7
35f	0.6	1.0	1.0	-1.0	0.1	-0.9	1.7	-0.7	1.4	1.1
36	0.8	0.7	0.7	1.7	0.9	1.2	1.4	1.8	1.0	1.5
56	2.9	2.3	1.0	2.5	1.7	2.0	2.1	1.8	2.3	2.2
61	0.7	-1.5	2.0	2.3	3.0	1.7	1.4	1.9	1.6	1.7
64	-0.1	-0.1	0.3	1.2	0.1	0.8	0.6	0.8	-0.4	0.6
67	-5.4	-3.6	-5.1	-4.1	-5.4	-3.3	-3.6	-4.9	-3.9	-4.8
68	0.0	-0.7	0.1	-0.1	0.4	0.5	1.1	0.9	-0.6	1.3
77a	-1.7	1.4	-0.2	-1.0	-1.2	-0.3	1.4	-1.5	0.9	0.3
79a	-0.2	-1.2	0.5	-0.3	-15.2	0.2	N/A	0.7	-0.8	0.0
79b	0.4	-1.0	1.6	0.7	-0.3	-0.3	0.4	0.6	-0.6	1.1
79c	-2.8	-4.9	-3.1	-3.2	-3.6	-1.3	-3.6	-3.0	-4.2	-4.1
80	-2.6	-1.7	0.4	1.0	1.5	-0.6	-0.5	1.0	-0.8	-0.7

<b>82</b>	0.1	1.0	0.1	-0.2	-0.6	0.5	0.0	0.1	0.2	1.2
<b>85</b>	-1.6	-2.1	-1.1	-1.2	-2.4	-1.3	-1.9	-2.0	-1.3	-1.7
<b>91a</b>	1.1	0.8	0.7	1.2	1.7	1.8	1.5	2.4	0.6	0.7
<b>91b</b>	1.3	0.6	1.0	0.8	1.0	-0.2	-1.2	0.6	0.6	1.1
<b>91c</b>	1.8	2.3	2.1	0.8	-0.3	0.3	3.5	-1.6	2.4	2.5
<b>94a</b>	0.9	0.3	-0.2	-0.1	0.6	0.6	0.8	0.6	0.8	1.2
<b>94b</b>	1.3	1.7	0.3	0.8	-0.4	0.7	0.8	0.4	0.8	1.6
<b>98</b>	0.4	-1.4	0.3	0.8	-0.6	0.2	0.8	0.4	-0.5	0.5

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 WGN2023.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	6.55	4.57	5.92	5.46	6.65	5.53	4.72	6.54	4.59	5.41
3	-0.12	0.04	0.20	0.14	0.29	0.22	0.11	0.16	0.16	-0.05
4	0.21	0.29	0.33	0.35	0.33	0.38	0.35	0.27	0.32	0.26
5	3.15	6.35	5.61	6.47	4.94	6.81	7.32	4.15	7.06	4.82

**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 % H<sub>2</sub>O), 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 with z score of negative sign such as labs 1, 18, 35e, and 35f. Some labs deviate systematically with a positive sign such as 27a, 27b, 30k, 35a, and 35d. There are also labs with one or a few red marked results of more random character: 8b, 15b, 17b, 30a, 30e, 67, 68, 79b, 80, and 85. These labs should check and perhaps re-analyze the deviating samples to see if there are some systematics in it.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	-5.0	-1.0	-3.8	-1.5	0.2	-2.3	-3.2	-0.9	-3.0	-3.3
2	-0.4	-1.1	0.0	-0.2	0.3	1.3	-0.7	0.1	-1.0	-0.6
4a	-0.9	-2.2	-2.1	-1.1	0.7	1.3	-0.2	0.8	-1.1	-0.4
4b	0.9	1.2	0.7	-0.4	-0.4	-1.2	-0.6	0.6	0.2	-0.9
5	0.3	0.2	-0.8	0.3	-0.9	-0.8	1.1	-2.1	0.1	1.2
8a	-0.3	-0.5	-2.0	-1.0	-1.6	-2.7	-0.1	-0.2	-1.8	-0.7
8b	-0.3	-1.7	-3.9	-1.0	-1.6	-0.8	-1.4	-0.9	-1.8	-1.9
11a	1.6	-2.6	0.1	-1.4	0.4	-1.1	-0.2	0.0	-1.7	0.0
11b	1.2	-1.0	-0.4	-0.7	-1.1	-1.0	-0.6	-0.5	-1.4	1.3
12	-0.9	-1.1	1.1	-1.0	-2.2	-1.4	-1.4	-1.5	-0.5	-0.1
15a	0.3	0.8	-0.8	-0.4	-0.9	-0.8	0.5	-2.7	1.3	1.8
15b	-1.9	1.7	-0.1	0.3	-5.6	3.3	3.0	-9.6	0.7	0.9
17a	-0.9	-1.1	-0.5	-0.4	2.2	1.7	-0.1	2.0	0.4	-0.4
17b	-1.6	0.5	-1.1	-0.4	3.1	1.7	1.5	2.9	-0.5	-0.7
18	-2.2	-3.6	-3.3	-2.9	-1.6	-1.4	-3.2	-2.1	-2.4	-1.9
19	0.5	-0.1	-0.4	0.6	-1.1	-1.1	0.5	-0.6	-0.4	-0.4
25	-0.9	1.4	-2.0	-1.6	-0.9	-0.8	-2.0	-2.7	0.7	-0.7
27a	0.9	7.1	4.0	5.3	2.3	4.5	0.9	1.7	5.3	2.2
27b	1.2	6.2	4.0	4.6	0.6	4.5	2.5	1.4	4.7	1.6
30a	-2.2	1.4	-0.8	0.3	4.1	3.0	1.1	6.0	0.7	1.2
30d	-0.4	-1.1	0.1	1.0	0.2	1.2	0.5	2.6	-0.4	-0.6
30e	1.7	2.0	3.7	2.9	0.7	1.2	4.4	2.6	2.5	3.9
30f	0.9	-0.1	2.5	1.7	0.4	-0.7	2.8	-0.8	1.3	1.1
30k	3.0	4.2	4.5	6.1	4.6	5.3	1.8	3.7	2.4	1.9
33	0.3	2.0	-2.0	0.3	0.9	1.1	-1.4	-1.5	2.6	0.6
35a	2.2	5.2	3.6	2.8	4.7	4.2	4.9	4.8	3.8	1.8
35b	-0.3	0.8	2.4	-0.4	-0.9	-1.4	0.5	-0.2	0.7	0.6
35c	-0.9	0.8	-0.1	0.3	-0.3	-0.8	1.1	-1.5	0.1	-0.1
35d	2.8	4.5	4.9	4.0	5.9	6.1	5.5	5.4	4.5	3.7
35e	-4.7	-2.3	-8.3	-5.4	-7.2	-4.5	-3.9	-7.1	-1.8	-3.2
35f	-4.7	-3.0	-7.0	-6.0	-7.8	-5.2	-4.5	-7.1	-3.0	-3.2
36	1.0	2.3	2.7	1.6	-0.1	-1.4	1.5	-1.5	1.6	1.6
56	0.3	0.2	-0.1	-1.0	-2.2	-2.7	-0.1	-2.7	-0.5	0.6
61	-0.3	-0.5	-0.8	0.9	-2.2	-2.7	-1.4	-0.2	-1.8	-0.7
64	-0.9	-0.5	-0.8	-1.0	-0.9	0.5	-0.1	0.4	-0.5	-0.1
67	-0.3	-1.7	-0.8	-2.2	-1.6	-3.3	-2.6	-1.5	-3.7	-1.3
68	0.3	0.8	-0.8	0.3	0.3	1.1	-3.2	-0.2	1.3	0.6
79a	-0.9	0.2	-0.8	2.1	-0.3	-0.2	N/A	-0.2	-0.5	-1.9
79b	-3.4	-0.5	-0.1	-1.0	-1.6	-0.8	0.5	-2.1	-0.5	-2.6
79c	-0.3	-1.1	-0.8	-0.4	-0.3	-0.8	-0.7	-0.2	-2.4	-0.7
80	0.1	-1.9	0.2	-1.4	0.2	-0.4	-2.3	0.0	-3.7	-2.2
82	0.7	0.5	0.0	0.6	1.6	1.1	0.7	1.2	0.9	1.6
85	-6.6	-0.5	-2.0	-1.0	-2.2	0.5	-2.0	1.0	0.7	0.6
91a	-0.6	-1.1	-1.7	0.6	-0.9	-0.2	-0.1	1.3	-0.9	-0.7

<b>91b</b>	1.2	0.0	-0.1	-0.9	-0.9	-1.0	1.8	-0.3	-0.2	0.1
<b>91c</b>	0.9	0.8	-1.4	-0.1	-0.3	-0.8	-0.7	0.4	0.4	0.9
<b>94a</b>	0.3	0.2	-0.1	-1.0	-0.9	-0.8	0.5	-0.9	-0.5	1.8
<b>94b</b>	-0.3	0.2	0.5	0.9	0.3	0.5	1.1	0.4	0.7	-0.1
<b>98</b>	-0.9	-1.7	-0.8	-1.6	-0.3	-0.8	<b>-2.6</b>	0.4	-1.2	-1.9

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)

Fifty 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 WGN2023 for an example.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	49.06	48.91	51.26	49.56	50.60	46.80	49.23	49.05	49.41	49.81
3	0.37	0.90	-0.47	0.66	0.58	0.63	-0.45	0.82	0.40	0.46
4	0.37	0.35	0.28	0.28	0.23	0.21	0.35	0.28	0.30	0.28
5	0.76	0.71	0.54	0.57	0.45	0.45	0.70	0.57	0.61	0.56

**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. Only lab 30k has two yellow-marked results. This confirms very good quality of spectra and predictions with RAOI0035.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1a	0.0	-0.7	-0.3	-0.3	0.0	0.1	1.1	0.4	-0.1	0.5
1b	-1.0	-1.2	-0.7	-0.4	0.2	-0.2	-0.9	-0.2	-0.9	-0.2
2	-0.1	0.4	0.2	0.8	0.6	0.0	0.1	0.7	0.6	-0.6
4a	0.2	0.4	0.3	0.0	-0.2	0.0	0.1	-0.4	1.1	-0.1
4b	0.7	0.0	-0.7	-0.3	0.1	0.3	0.2	0.4	-0.2	-0.1
5	0.2	0.4	0.1	0.4	0.1	0.0	0.1	0.3	0.3	0.0
8a	-0.4	0.3	-0.6	0.4	-0.2	-0.1	0.2	0.3	-0.5	-0.8
8b	-0.8	-0.8	-0.1	-0.6	-0.1	0.1	-1.1	0.7	-0.6	-0.5
11a	0.2	0.2	0.2	-0.1	-0.3	0.5	-0.2	-0.3	-0.2	0.3
11b	0.0	0.4	-0.4	0.6	-0.3	-0.4	0.0	-0.5	0.6	0.2
11d	0.0	-0.1	0.0	-0.4	-0.1	-0.1	-0.4	-0.3	0.5	-0.5
11e	0.3	0.1	0.1	1.0	0.5	0.6	0.9	0.5	-0.2	0.1
12	0.1	0.7	0.5	0.3	0.3	-0.5	-0.3	0.1	-0.1	0.9
15a	-0.1	-0.5	-0.3	-0.6	0.1	0.5	0.1	0.7	-0.1	-0.8
15b	-0.1	0.3	0.1	0.0	-0.1	0.2	0.7	0.0	-0.3	0.0
17a	0.1	1.0	-0.1	0.9	-0.4	0.3	-0.4	0.4	0.4	-0.1
17b	1.1	1.3	1.3	0.2	0.2	-0.3	0.0	0.0	0.7	1.0
18	-0.9	0.3	0.5	-0.7	-0.5	-0.2	-1.5	0.0	0.5	-0.3
19	-0.7	0.1	-0.1	-0.4	0.2	-0.5	0.0	0.0	-0.6	-0.3
25	1.1	0.6	0.4	-0.1	0.3	-0.3	-0.9	0.1	-0.9	0.4
27a	-0.1	-1.1	-0.2	-1.2	-1.0	-1.2	-1.3	-1.6	-0.3	0.4
27b	-1.2	0.5	-1.0	-1.1	-0.9	-1.6	-0.1	0.6	0.7	-1.2
30a	1.2	0.3	0.9	0.2	0.3	0.0	1.0	-0.4	0.7	-0.2
30d	1.1	0.9	-0.2	-0.2	0.4	-0.1	1.2	0.4	0.2	0.1
30e	-0.7	-0.8	-0.5	-0.7	-0.4	-0.5	-1.0	-0.4	-0.1	-1.3
30f	-0.2	-0.4	0.1	-0.2	-0.2	0.5	-0.3	0.2	0.8	-0.5
30k	-1.6	-1.4	-2.3	-2.5	-0.3	-0.2	0.6	-0.3	-0.3	-0.4
31	0.1	-0.3	-0.1	0.0	0.2	-0.3	0.3	-0.6	0.0	-0.3
33	-0.6	-0.6	1.0	-0.3	-0.3	-0.8	0.3	-0.8	-1.4	0.5
35a	0.7	1.0	-0.5	0.5	-0.2	0.4	-0.3	-0.1	0.2	-0.3
35b	-0.5	0.0	-0.4	0.2	0.9	0.3	0.7	-0.5	-0.9	-0.2
35c	0.1	0.2	-0.6	0.1	-0.5	-0.1	0.3	0.1	-0.7	0.0
35d	-0.3	0.0	-0.4	-0.1	0.0	-0.4	0.3	0.2	-0.2	0.1
36	-1.0	-0.2	-0.2	0.1	-0.1	-0.2	0.3	0.7	-0.2	0.2
56	0.6	-0.1	0.3	1.2	-0.2	0.3	0.2	-0.1	0.1	0.2
61	1.2	-1.0	0.4	0.8	0.6	0.0	0.8	-0.9	1.1	0.5
64	-0.4	-0.1	0.5	0.3	-0.2	-0.1	-0.3	-0.6	0.2	0.4
67	1.0	0.6	0.2	0.5	0.1	1.1	0.8	-0.2	0.1	1.3
68	-0.8	-0.2	-0.1	0.0	-0.1	-0.4	0.4	0.4	-0.2	0.6
79a	1.2	0.0	0.8	-0.6	0.6	0.6	-0.2	-0.2	0.4	0.1
79b	0.2	0.1	1.0	-0.4	-0.1	-0.7	0.3	-0.2	0.0	0.7
79c	0.8	-1.1	0.0	0.0	0.1	-0.3	-0.1	0.9	0.1	-0.2
80	-0.3	-0.2	-0.3	0.5	0.4	0.4	-0.2	0.6	0.2	-0.1
82	-0.2	0.9	-0.3	-0.3	-0.6	0.1	-0.2	-0.6	0.3	0.6
85	0.4	0.7	0.1	-0.1	-0.7	0.3	-0.1	-0.7	0.8	0.0

<b>91a</b>	0.2	0.5	-0.4	0.2	0.5	0.3	0.4	0.5	0.0	-0.3
<b>91b</b>	0.1	-0.3	0.2	0.2	0.2	-0.5	-1.0	-0.1	-0.9	0.2
<b>94a</b>	-0.6	-0.8	-0.3	-0.7	0.2	0.1	0.1	0.7	-0.5	-0.3
<b>94b</b>	-0.9	0.4	-0.8	-0.1	0.8	-0.2	0.4	0.1	0.2	-0.1
<b>98</b>	0.2	-0.5	0.5	0.4	0.4	0.5	-1.0	-0.1	-0.3	0.2

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)

Fifty 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 WGN2023 for an example.

1	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	6.59	4.60	5.91	5.42	6.50	5.36	4.84	6.39	4.58	5.50
3	-0.09	0.06	0.18	0.10	0.14	0.05	0.24	0.01	0.16	0.04
4	0.18	0.21	0.20	0.22	0.18	0.13	0.21	0.19	0.18	0.12
5	2.7	4.7	3.4	4.1	2.8	2.5	4.4	3.0	3.9	2.3

**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 % H<sub>2</sub>O), 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 several red-marked results for labs (27a and 27b), all with positive sign. Four other labs (4a, 30d, 67, 68, 79b, and 85) have one red-marked results of a random nature.

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1a	-0.7	-1.4	-0.6	-0.1	0.3	-0.1	0.2	-0.5	-0.1	-0.6
1b	0.2	1.4	0.3	1.3	0.5	-0.6	1.5	-0.4	0.7	0.4
2	0.5	0.2	0.5	0.8	-0.3	0.2	0.7	-0.4	0.9	-1.6
4a	-2.0	-1.0	-3.1	-1.5	-1.4	-0.2	-1.5	0.2	-0.7	-1.6
4b	0.7	1.6	1.3	0.0	1.3	-0.3	-0.7	0.1	0.4	-0.9
5	0.2	0.2	0.1	1.2	0.1	-0.1	1.0	-1.2	0.1	0.7
8a	0.6	2.2	0.3	0.9	0.1	-0.5	1.9	1.4	0.2	0.6
8b	2.1	0.6	-0.7	2.4	1.8	2.1	-0.1	0.2	5.2	0.4
11a	1.4	-2.7	0.2	-1.1	1.3	0.0	-1.0	1.0	-1.6	-0.6
11b	0.9	-1.1	-0.3	-0.4	-0.2	0.0	-1.4	0.4	-1.4	0.8
11d	-2.5	1.3	-1.2	-0.2	-1.4	-1.0	-0.5	-1.9	-0.4	-0.4
11e	-2.7	0.5	-1.0	-1.0	-1.3	-1.4	-0.5	-2.3	0.7	-0.8
12	-1.1	-2.0	0.7	-1.2	-1.7	-0.9	-1.9	0.5	-1.9	-0.5
15a	-0.1	0.4	0.1	0.8	0.5	1.1	1.5	-1.8	1.7	1.3
15b	-0.2	2.0	1.1	1.8	-1.8	-0.3	2.2	-1.5	1.8	0.7
17a	-0.5	-2.9	0.3	-1.1	0.3	-0.5	-0.5	-0.3	-0.3	-0.9
17b	-0.2	-1.4	-0.8	0.0	0.0	-0.7	0.3	-0.8	-0.6	-0.5
18	1.0	0.4	0.2	1.4	-0.7	-0.4	1.8	0.8	-0.4	-0.8
19	0.5	0.0	0.0	1.0	0.5	0.1	-0.9	1.1	0.1	0.3
25	0.4	-0.5	-0.8	-0.6	1.0	1.1	-1.9	-1.5	-0.9	-0.3
27a	0.5	9.4	2.9	7.3	2.9	7.2	-0.3	3.6	4.6	-0.2
27b	0.3	8.0	5.2	6.1	1.6	6.9	3.6	1.6	6.3	0.9
30a	-0.7	-0.7	-0.9	-1.4	-1.2	-0.4	-0.9	0.7	-1.6	0.3
30d	-0.3	0.5	-0.9	0.8	-2.6	-3.3	2.4	-0.8	-0.9	-0.8
30e	0.1	0.9	1.9	1.3	0.0	-0.1	0.9	-0.4	2.0	1.0
30f	1.2	0.8	1.6	1.7	0.5	-0.6	0.6	-0.2	1.8	0.9
30k	0.1	2.3	1.8	2.2	-0.5	-0.1	0.1	-0.3	1.4	0.1
31	0.5	-0.2	0.6	1.2	-0.2	0.7	1.2	-0.5	0.2	-0.1
33	1.3	1.6	-0.7	-0.2	0.9	1.3	-1.1	0.0	0.1	-0.8
35a	-0.4	-1.4	-1.0	-1.1	-0.6	0.3	-0.9	0.5	-0.6	-0.6
35b	-0.5	1.1	0.8	-0.5	0.1	-0.3	-0.3	-0.1	1.1	0.8
35c	-1.0	1.3	0.1	0.0	0.0	-0.6	0.9	-2.2	0.5	-0.6
35d	1.2	1.0	1.1	0.8	0.9	1.4	0.6	0.2	1.6	0.8
36	0.9	2.1	2.4	2.1	0.9	-0.3	1.0	-0.7	1.8	1.2
56	1.3	0.3	1.2	0.7	1.0	0.5	0.7	0.2	1.3	0.8
61	0.5	-0.6	0.7	-0.5	0.4	0.1	-1.5	1.4	-1.0	-0.9
64	-0.9	0.4	-0.8	-1.8	-0.8	0.4	0.3	0.1	-0.4	-0.7
67	-0.4	0.0	-0.9	-3.1	-1.3	-2.2	0.7	-0.7	-1.0	-0.9
68	0.7	0.1	0.2	0.9	2.2	1.8	-2.6	3.0	1.0	1.4
79a	-0.6	0.7	0.1	1.9	0.1	-0.3	-1.0	-1.8	1.2	0.3
79b	-2.5	-1.4	-2.8	-2.2	-1.7	-1.2	-0.6	-2.1	-1.1	-3.0
79c	0.3	-1.2	-0.7	-1.0	-0.8	0.6	-1.5	0.6	-2.2	-0.3
80	1.0	1.6	1.7	0.9	0.2	0.2	0.7	-0.2	0.0	0.5
82	-0.3	-1.8	-1.3	-1.1	0.4	0.3	-1.9	0.8	-1.5	-0.4

<b>85</b>	-5.9	-2.9	-1.7	-2.8	-2.7	1.1	-1.3	1.7	-0.8	0.4
<b>91a</b>	0.2	0.5	-0.1	1.1	0.2	0.4	0.8	0.7	0.3	0.1
<b>91b</b>	1.7	-0.3	1.1	-0.1	0.6	0.2	2.0	0.7	0.9	0.2
<b>94a</b>	0.7	0.2	0.3	0.0	0.9	0.7	0.0	0.5	0.2	1.5
<b>94b</b>	-1.8	-0.7	-1.5	-1.3	-1.0	-0.6	-1.3	0.4	-1.3	-0.1
<b>98</b>	-1.7	-1.6	-2.4	-2.8	0.5	-0.9	-1.4	0.3	-1.4	-0.4

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 2023 all samples (2022 harvest)	Ref. methods	Local models	FOSS ANN
<b>Oil, range</b>	<b>46.2 % - 51.7 %</b>		
Mean (%)	<b>48.98</b>	<b>48.95</b>	<b>49.37</b>
deviation from mean		-0.03	0.39
SD reproducibility	<b>1.04</b>	<b>1.07</b>	<b>0.29</b>
RSD reproducibility	<b>2.1</b>	<b>2.2</b>	<b>0.6</b>
<b>Moisture, range</b>	<b>4.4 % - 6.7 %</b>		
Mean (%)	<b>5.48</b>	<b>5.59</b>	<b>5.57</b>
deviation from mean		0.11	0.09
SD reproducibility	<b>0.15</b>	<b>0.31</b>	<b>0.18</b>
RSD reproducibility	<b>2.9</b>	<b>5.7</b>	<b>3.4</b>

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

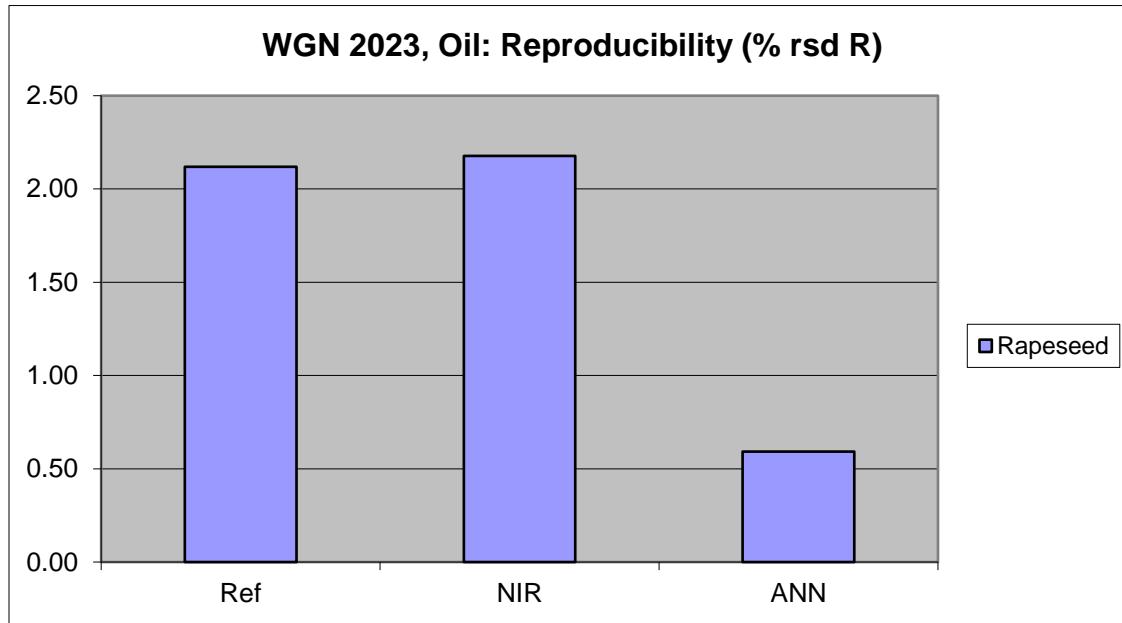


Fig. 6.3.1a: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model RA002635 (RAOI0035) (ANN) for the determination of oil in rapeseed.

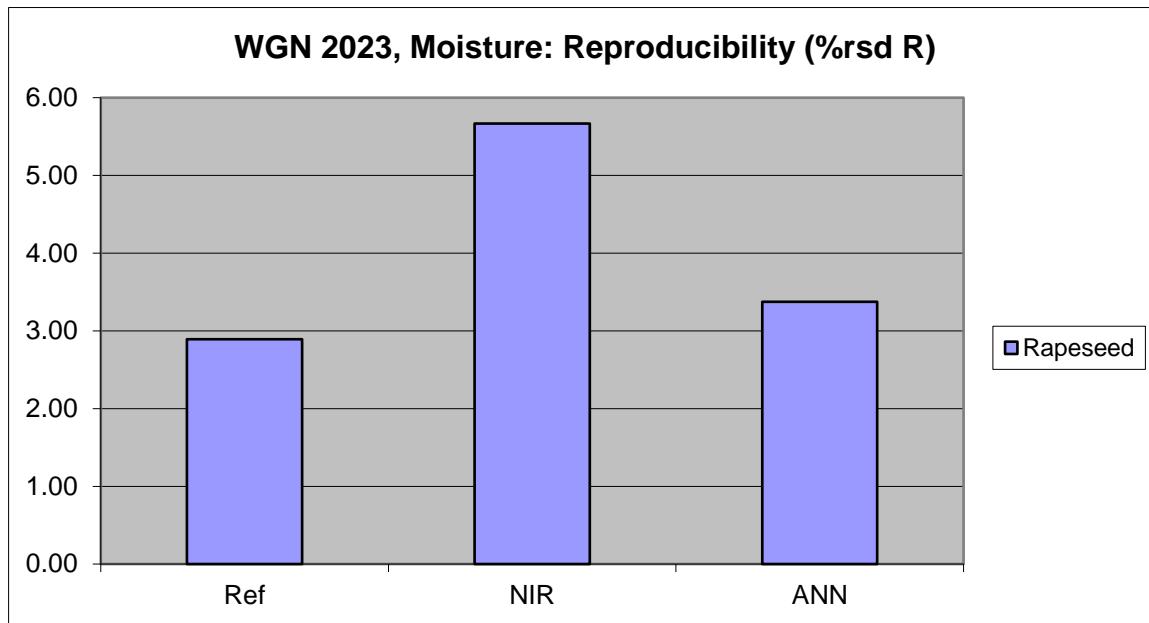


Fig. 6.3.1b: Relative standard deviations of the reproducibility (%) for reference methods (Ref), currently used prediction models (NIR) and Foss ANN model RA002635 (RAMO0026) (ANN) for the determination of **moisture in rapeseed**.

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 have 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 R5 deviate slightly for local NIR and sample R7 deviate slightly for the global unadjusted ANN model for moisture compared to the reference. For oil, local and global ANN compares very well to reference across all samples.

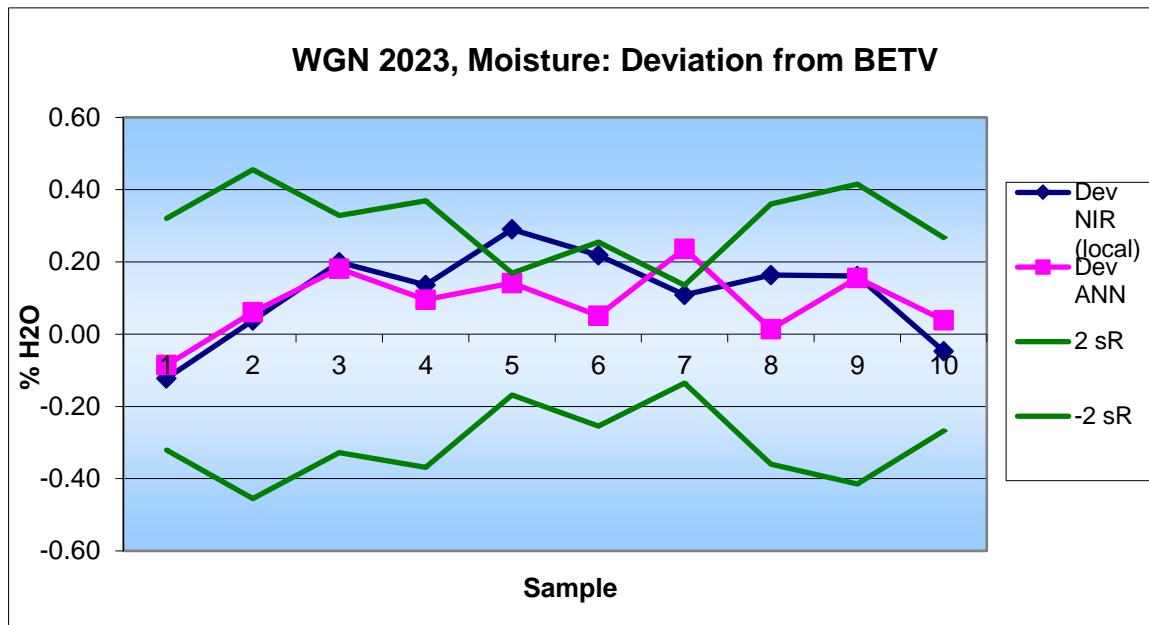


Fig. 6.3.2a: Deviations between predicted **moisture** values and the best estimate of the true value

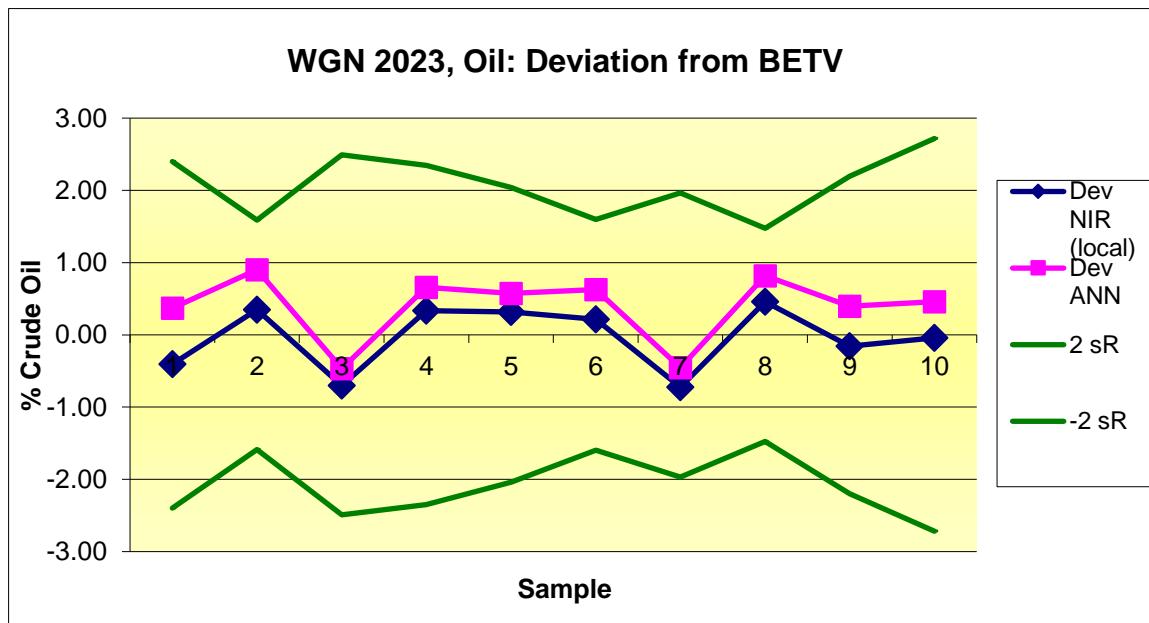


Fig. 6.3.2b: Deviations between predicted **oil** values and the best estimate of the true value

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.

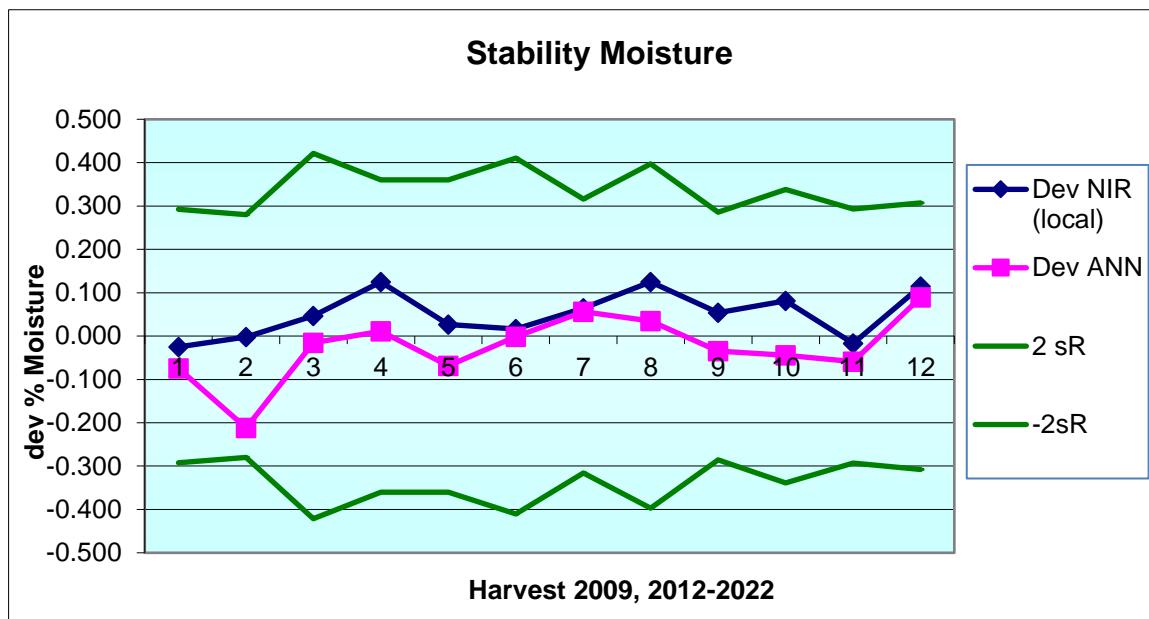


Figure 6.3.3 a: Average deviations of predicted moisture results from the best estimate of the true value for eight years of harvest (2009 and 2012-2022). Blue=Local and Pink = ANN.

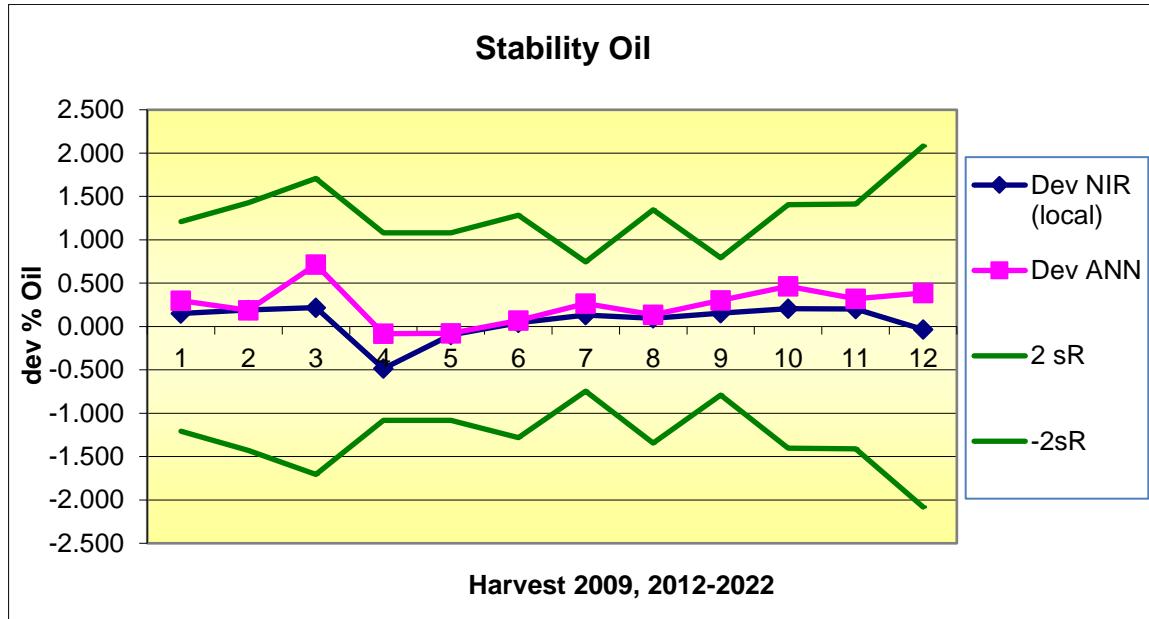


Figure 6.3.3 b: Average deviations of predicted oil results from the best estimate of the true value for eight years of harvest (2009 and 2012-2022). Blue=Local and Pink = ANN.

## 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 WGN2023 exercise. The interest for Starch in Barley and Hardness in Wheat is sparse and we may decide to omit those in future ring tests.

Parameter	# labs reporting (ref + pred)
TWM (Mass per hectoliter)	28 + 43
Falling number	23
Zeleny	6 + 30
Wet gluten	14 + 43
Starch in wheat	6 + 29
Starch in barley	3+9
Hardness	1 + 5

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 hectoliter

In total twenty-eight participants reported reference results for the test weight (mass per hectoliter, kg/hL). There were also reported TWM results from 43 instruments.

#### 7.1.1 Reference method

Seventeen participants were using a 1 L device according to ISO 7971-3 (labs 2, 4, 5, 12, 17, 19, 30a, 33, 36, 61, 64, 68, 77a, 80, 94, 98 and 101) and five labs were using a 250 ml device according to ISO 7971-3 (8, 10, 15, 25, 85, and 91). One of these participants (lab 1) used a 1 L device when sample size were enough and 250 ml device according to ISO 7971-3. One lab (15) used a 1 L device according to ISO 7971-2 when sample size was enough for the 1 Liter device and a 250 ml device according to ISO 7971-3 for the remaining samples of smaller sizes. Two labs (32, and 35) used 0.5 L according to ISO 7971.3. One participant used 0.5 L device according to an In-house Franklin drop weight chondrometer (27). One lab (26) used a GAC2500, which is not to be considered a reference method. One lab (17) 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 tendency for 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	82.7	84.6	73.5	80.4	82.2	83.1	83.3	82.9	83.1	80.2

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	63.9	69.2	68.4	72.1	69.7	67.1	69.3	69.8	69.9	70.7

**Table 7.1.1.2 Results for the determination of the mass per hectoliter 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	83.2	85.3	74.0	80.7	82.3	83.5	83.8	83.4	83.3	80.5	82.0	0.33
2	82.4	83.9	73.6	80.1	81.5	82.4	82.5	81.7	82.6	79.6	81.0	-0.65
4	83.1	85.3	74.0	80.9	82.2	83.5	83.6	83.4	83.6	80.7	82.1	0.38
5	82.2	83.6	73.2	80.0	81.0	82.2	82.4	81.8	82.7	79.5	80.9	-0.81
8	82.7	84.9	73.8	80.6	82.4	83.1	83.2	82.8	83.3	80.4	81.7	0.05
10	84.0	86.0	73.4	81.6	82.9	85.0	84.5	84.1	84.8	81.0	82.7	1.05
12	82.7	85.1	73.9	80.7	82.6	83.5	83.4	83.5	83.4	80.8	82.0	0.29
15	82.8	85.1	73.7	80.5	82.3	83.3	83.3	83.0	83.5	80.3	81.8	0.11
17	82.7	84.8	N/A	N/A	82.4	83.4	83.4	83.1	N/A	N/A	83.3	1.63
19	82.9	85.0	73.7	80.5	82.6	83.3	83.4	83.2	83.4	80.6	81.9	0.19
25	82.0	84.7	73.4	80.0	82.3	82.8	83.0	82.5	82.5	80.0	81.3	-0.35
26	82.2	84.3	73.0	79.8	81.6	82.8	82.6	82.3	82.8	79.7	81.1	-0.56
27	82.8	84.8	73.5	80.4	82.2	82.6	83.4	82.6	83.0	80.4	81.6	-0.12
30a	82.8	85.0	73.8	80.5	82.5	83.2	83.3	83.2	83.2	80.4	81.8	0.12
33	82.4	83.9	73.5	80.2	81.5	82.6	82.6	82.0	82.7	79.8	81.1	-0.55
35	82.8	84.6	73.1	80.3	82.2	83.2	83.6	82.6	83.4	80.1	81.6	-0.08
36	82.0	83.9	72.7	79.5	81.3	82.3	82.6	82.0	81.9	79.3	80.7	-0.92
61	82.7	84.8	73.7	80.6	82.2	83.5	83.3	83.1	83.5	80.4	81.8	0.11
64	82.8	85.0	73.7	80.5	82.4	83.3	83.5	82.9	83.1	80.3	81.8	0.08
68	82.5	84.9	73.5	80.5	82.2	83.3	83.4	83.1	83.0	80.6	81.7	0.03
77a	83.0	85.2	72.7	80.5	82.5	83.6	83.6	83.0	83.4	80.2	81.8	0.09
80	82.6	85.1	74.2	80.7	82.5	82.7	83.5	82.9	83.2	80.4	81.8	0.11
85	82.5	81.5	73.9	80.8	82.8	83.0	83.3	83.2	83.1	80.4	81.4	-0.22
91	83.0	84.9	73.2	N/A	N/A	83.2	83.7	83.2	83.0	80.4	81.8	0.17
94	82.4	85.0	73.3	80.4	82.1	83.5	83.5	82.9	83.1	80.3	81.6	-0.02
98	82.3	84.5	73.3	79.9	82.3	83.0	83.0	82.7	82.6	80.1	81.4	-0.30
101	82.5	84.5	73.2	80.2	82.1	83.2	83.0	83.0	83.0	80.0	81.5	-0.20
Average	82.7	84.6	73.5	80.4	82.2	83.1	83.3	82.9	83.1	80.2	81.7	0.0
sd	0.4	0.8	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5
min	82.0	81.5	72.7	79.5	81.0	82.2	82.4	81.7	81.9	79.3	80.7	-0.9
max	84.0	86.0	74.2	81.6	82.9	85.0	84.5	84.1	84.8	81.0	83.3	1.6

Z-scores kg/hL, wheat:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	1.1	1.3	1.0	0.6	0.2	0.7	1.1	1.1	0.4	0.5
2	-0.6	-1.6	0.2	-0.7	-1.3	-1.6	-1.6	-2.3	-1.1	-1.3
4	0.9	1.4	0.9	1.0	0.1	0.8	0.7	1.2	1.0	1.0
5	-0.9	-2.1	-0.6	-0.8	-2.4	-1.9	-1.7	-2.1	-0.8	-1.5
8	0.1	0.5	0.6	0.4	0.4	-0.1	-0.1	-0.1	0.4	0.3
10	2.6	2.7	-0.2	2.3	1.5	3.7	2.5	2.4	3.3	1.5
12	0.1	0.9	0.8	0.6	0.8	0.7	0.3	1.3	0.6	1.1
15	0.3	0.9	0.3	0.2	0.2	0.3	0.1	0.3	0.8	0.1
17	0.1	0.3	N/A	N/A	0.4	0.5	0.3	0.5	N/A	N/A
19	0.4	0.6	0.5	0.2	0.8	0.3	0.3	0.6	0.6	0.7
25	-1.3	0.1	-0.2	-0.8	0.2	-0.7	-0.5	-0.7	-1.2	-0.5
26	-0.9	-0.7	-1.0	-1.2	-1.2	-0.7	-1.3	-1.1	-0.6	-1.1
27	0.3	0.2	0.0	-0.1	0.1	-1.2	0.2	-0.5	-0.3	0.2
30a	0.3	0.7	0.6	0.2	0.6	0.1	0.1	0.7	0.2	0.3
33	-0.5	-1.5	0.0	-0.4	-1.4	-1.1	-1.3	-1.7	-0.8	-0.9
35	0.3	-0.1	-0.8	-0.2	0.0	0.1	0.7	-0.5	0.6	-0.3
36	-1.3	-1.5	-1.7	-1.9	-1.8	-1.7	-1.4	-1.7	-2.4	-1.9
61	0.1	0.3	0.4	0.4	0.0	0.7	0.1	0.5	0.8	0.3
64	0.3	0.7	0.4	0.2	0.4	0.3	0.5	0.1	0.0	0.1
68	-0.3	0.5	0.0	0.2	0.0	0.3	0.3	0.5	-0.2	0.7
77a	0.7	1.1	-1.6	0.1	0.5	0.9	0.7	0.3	0.6	-0.1
80	-0.1	0.9	1.4	0.6	0.6	-0.9	0.5	0.1	0.2	0.3
85	-0.3	-6.3	0.7	0.8	1.2	-0.3	0.1	0.7	0.0	0.3
91	0.6	0.6	-0.6	N/A	N/A	0.2	0.8	0.8	-0.2	0.4
94	-0.5	0.7	-0.3	0.0	-0.2	0.6	0.5	0.1	-0.1	0.1
98	-0.7	-0.3	-0.4	-1.0	0.2	-0.3	-0.5	-0.3	-1.0	-0.3
101	-0.3	-0.3	-0.6	-0.4	-0.2	0.1	-0.5	0.3	-0.2	-0.5

The z-values for the mass per hectoliter 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	63.9	69.2	68.5	72.2	69.7	67.2	69.5	69.8	69.9	70.8	69.1	0.0
2	64.7	69.4	68.8	72.5	70.0	67.7	69.9	70.1	69.9	70.8	69.4	0.4
4	63.6	69.2	68.5	72.3	69.6	67.1	69.4	69.9	69.8	70.6	69.0	0.0
5	64.4	69.3	68.7	72.1	69.6	67.7	69.5	69.5	69.8	70.6	69.1	0.1
8	63.8	68.9	68.3	72.1	69.5	66.9	69.0	69.4	69.8	70.8	68.9	-0.2
10	64.7	70.0	69.2	73.0	70.7	67.7	70.2	70.3	70.4	71.6	69.8	0.7
12	63.9	69.4	68.6	72.3	69.7	67.2	69.8	70.3	70.3	70.7	69.2	0.2
15	63.9	69.4	68.9	72.5	69.9	67.3	69.3	69.8	70.3	71.1	69.2	0.2
17	64.1	N/A	68.5	72.1	69.9	N/A	69.4	N/A	69.9	70.8	69.2	0.2
19	63.4	69.1	68.2	71.9	69.4	66.9	69.1	69.7	69.5	70.6	68.8	-0.3
25	64.3	68.9	67.7	71.2	69.0	66.8	68.5	69.2	69.3	70.3	68.5	-0.5
26	63.6	69.4	68.3	72.3	69.8	67.4	69.6	70.0	69.6	71.1	69.1	0.1
27	64.2	68.7	68.1	71.9	69.6	66.2	66.9	69.2	69.3	69.8	68.4	-0.6
30a	64.0	69.2	68.5	72.1	69.6	67.0	69.5	69.7	70.0	70.7	69.0	0.0
32	63.8	69.0	68.4	71.7	69.6	67.2	69.5	69.6	69.6	70.2	68.9	-0.2
33	64.6	69.6	68.6	72.6	70.1	67.8	69.9	70.2	70.0	70.9	69.4	0.4
35	63.6	69.7	68.0	72.4	69.7	67.6	69.5	70.1	69.7	71.1	69.1	0.1
36	63.6	68.7	68.4	71.5	69.5	66.7	68.9	69.3	69.8	70.2	68.6	-0.4
61	64.4	69.8	68.9	72.6	70.1	67.4	69.6	70.4	70.4	71.0	69.5	0.4
64	63.7	68.9	68.4	71.9	69.5	67.3	69.4	70.0	69.6	70.7	68.9	-0.1
68	64.0	69.0	68.3	72.0	69.7	67.0	69.2	69.8	70.2	70.9	69.0	0.0
77a	63.8	69.2	68.8	71.6	70.0	67.1	69.3	69.6	70.4	71.0	69.1	0.1
91	63.6	69.5	68.2	72.2	69.9	67.0	69.8	69.6	69.9	71.0	69.1	0.0
94	63.6	69.3	68.4	71.8	69.5	66.8	69.3	69.6	70.1	70.7	68.9	-0.1
98	63.3	68.7	68.0	71.6	69.2	66.6	69.0	69.3	69.4	70.2	68.5	-0.5
101	63.3	69.2	68.4	72.0	69.5	66.7	68.9	69.9	69.9	70.8	68.8	-0.2
Average	63.9	69.2	68.4	72.1	69.7	67.1	69.3	69.8	69.9	70.7	69.0	0.0
sd	0.4	0.3	0.3	0.4	0.3	0.4	0.6	0.3	0.3	0.4	0.3	0.3
min	63.3	68.7	67.7	71.2	69.0	66.2	66.9	69.2	69.3	69.8	68.4	-0.6
max	64.7	70.0	69.2	73.0	70.7	67.8	70.2	70.4	70.4	71.6	69.8	0.7

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	0.0	0.0	0.1	0.2	0.0	0.1	0.4	0.1	0.1	0.1
2	1.6	0.4	0.7	0.9	0.7	1.2	1.2	0.7	0.1	0.1
4	-0.7	-0.1	0.1	0.3	-0.1	-0.1	0.3	0.2	-0.2	-0.4
5	1.0	0.2	0.5	0.0	-0.2	1.1	0.4	-0.5	-0.1	-0.3
8	-0.2	-0.6	-0.3	0.0	-0.4	-0.5	-0.6	-0.7	-0.1	0.1
10	1.5	1.5	1.4	1.8	2.0	1.2	1.8	1.1	1.1	1.6
12	0.0	0.4	0.3	0.4	0.0	0.1	1.0	1.1	0.9	-0.1
15	-0.1	0.3	0.8	0.7	0.3	0.3	-0.1	0.0	0.9	0.7
17	0.4	N/A	0.1	0.0	0.4	N/A	0.2	N/A	0.1	0.1
19	-1.1	-0.2	-0.5	-0.4	-0.7	-0.5	-0.5	-0.2	-0.7	-0.4
25	0.8	-0.6	-1.5	-1.8	-1.4	-0.7	-1.6	-1.1	-1.1	-0.9
26	-0.6	0.4	-0.3	0.4	0.2	0.5	0.6	0.5	-0.5	0.7
27	0.5	-1.0	-0.7	-0.3	-0.2	-1.8	-4.8	-1.1	-1.2	-1.9
30a	0.2	0.0	0.1	0.0	-0.2	-0.3	0.4	-0.1	0.3	-0.1
32	-0.2	-0.4	-0.1	-0.8	-0.2	0.1	0.4	-0.3	-0.5	-1.1
33	1.4	0.8	0.3	1.0	0.8	1.3	1.2	0.9	0.3	0.3
35	-0.6	1.0	-0.9	0.6	0.0	0.9	0.4	0.7	-0.3	0.7
36	-0.7	-1.1	-0.1	-1.3	-0.5	-0.9	-0.8	-1.0	-0.1	-1.0
61	1.0	1.2	0.9	1.0	0.8	0.5	0.6	1.3	1.1	0.5
64	-0.4	-0.6	-0.1	-0.4	-0.4	0.3	0.2	0.5	-0.5	-0.1
68	0.2	-0.4	-0.3	-0.2	0.0	-0.3	-0.2	0.1	0.7	0.3
77a	-0.2	0.0	0.7	-1.0	0.6	-0.1	0.0	-0.3	1.0	0.5
91	-0.6	0.5	-0.4	0.2	0.4	-0.3	1.0	-0.3	0.0	0.6
94	-0.5	0.2	0.0	-0.6	-0.3	-0.6	0.0	-0.3	0.4	0.0
98	-1.2	-1.0	-0.9	-1.0	-1.0	-1.1	-0.6	-0.9	-0.9	-1.1
101	-1.2	0.0	-0.2	-0.3	-0.4	-0.9	-0.8	0.2	0.1	0.1

### 7.1.2 Mass per hectoliter 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	82.9	85.0	73.8	80.7	82.6	83.6	83.4	83.0	83.5	80.5
3	0.3	0.4	0.3	0.3	0.4	0.4	0.2	0.2	0.4	0.3

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

1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
2	63.5	69.2	68.4	72.4	69.8	67.3	69.4	70.0	69.9	70.9
3	-0.4	0.0	0.0	0.3	0.1	0.2	0.1	0.2	0.0	0.2

**Table 7.1.2.2 Results for the determination of the mass per hectoliter 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	82.8	84.9	73.7	80.6	82.1	83.6	83.4	82.9	83.5	80.4	81.8	0.0
2	82.9	84.9	73.8	80.4	82.2	83.4	83.4	83.0	83.5	80.5	81.8	0.0
4a	83.3	85.0	74.1	80.7	82.4	83.5	83.6	83.1	83.6	80.6	82.0	0.2
4b	82.9	84.8	73.2	80.4	82.7	83.3	83.4	83.3	83.7	80.4	81.8	0.0
5	82.3	84.5	73.0	80.0	81.8	83.1	82.7	82.4	82.9	79.8	81.3	-0.5
8a	82.8	84.9	73.6	80.5	82.4	83.1	83.2	82.7	83.3	80.1	81.7	-0.1
8b	83.1	85.3	73.8	81.0	82.7	83.7	83.6	83.0	84.1	80.7	82.1	0.3
10	84.0	86.3	75.0	82.0	83.8	85.3	84.6	84.5	84.8	81.6	83.2	1.4
11d	83.0	84.9	73.8	80.5	82.4	83.4	83.4	82.9	83.5	81.0	81.9	0.1
12	82.9	85.1	73.9	80.7	82.5	83.7	83.3	83.1	83.6	80.3	81.9	0.1
15	82.5	84.6	73.4	80.3	82.2	N/A	83.0	82.9	82.6	83.1	81.6	-0.2
17a	82.8	84.7	73.8	80.5	82.5	83.7	83.3	83.0	83.3	80.2	81.8	0.0
17b	82.8	84.8	73.5	80.4	82.7	83.6	83.2	83.0	83.4	80.4	81.8	0.0
18	82.2	84.1	74.6	80.7	81.9	83.0	82.9	82.4	83.0	80.2	81.5	-0.3
19	82.8	84.9	73.6	80.5	82.6	83.4	83.2	83.0	83.4	80.3	81.8	0.0
25	82.8	84.9	73.1	80.2	82.4	83.5	83.2	82.8	83.2	79.9	81.6	-0.2
30a	82.8	84.7	73.1	80.3	82.2	83.2	83.2	83.2	83.4	79.9	81.6	-0.2
30b	82.7	84.6	73.6	80.4	82.4	83.3	83.0	82.4	82.9	79.9	81.5	-0.3
30c	83.2	85.1	74.4	80.9	83.0	84.4	83.5	83.1	83.3	80.5	82.1	0.3
30d	82.8	84.8	74.1	80.8	82.7	83.7	83.4	83.1	83.5	80.6	81.9	0.1
30e	83.0	84.8	74.0	80.7	82.9	83.7	83.6	83.1	83.5	80.4	82.0	0.2
30h	83.1	85.1	73.9	80.7	83.1	83.9	83.4	82.5	83.5	80.6	82.0	0.2
30i	83.2	84.9	73.8	80.6	82.9	83.8	83.6	82.9	83.6	80.6	82.0	0.2
30k	83.2	84.8	74.1	80.9	82.9	83.6	83.8	83.2	83.5	80.6	82.1	0.3
30l	82.5	84.1	72.9	79.9	82.1	82.7	82.7	82.2	82.6	79.5	81.1	-0.7
56	83.2	85.4	74.1	81.0	82.8	83.6	83.6	83.4	84.0	80.4	82.2	0.4
64	82.9	84.7	73.7	80.3	82.5	83.5	83.4	83.1	83.4	80.1	81.8	0.0
66	82.7	85.1	73.4	80.4	82.2	81.7	83.1	82.4	83.3	80.3	81.5	-0.3
68	83.6	85.7	74.7	81.3	82.7	84.2	84.0	83.4	84.0	81.1	82.5	0.7
77a	83.0	85.0	73.0	81.2	82.6	84.2	83.6	82.9	83.9	80.3	82.0	0.2
79a	82.5	84.8	72.5	80.2	N/A	N/A	N/A	N/A	N/A	N/A	80.0	-1.8
79b	82.7	85.2	73.4	80.4	82.4	83.1	83.3	83.2	83.2	80.1	81.7	-0.1
79c	83.1	85.2	73.5	80.7	82.7	82.9	83.6	83.2	83.3	80.3	81.9	0.1
80	82.7	85.1	74.2	80.9	83.1	83.1	83.5	83.1	83.7	80.6	82.0	0.2
82	83.0	85.4	74.3	81.0	82.8	83.2	83.5	83.4	83.7	80.5	82.1	0.3
85	83.2	85.9	74.2	81.2	83.1	83.9	84.0	83.8	84.4	81.0	82.5	0.7
91a	82.9	85.0	73.4	80.5	82.3	83.5	83.5	83.0	83.5	80.4	81.8	0.0
91b	83.0	85.1	73.6	80.8	82.4	83.5	83.5	82.9	83.7	80.7	81.9	0.1
94a	83.3	85.4	73.8	81.0	83.0	84.1	83.8	83.3	83.9	80.8	82.2	0.4
94b	83.0	85.3	74.0	81.0	82.7	84.0	83.7	83.3	83.8	80.8	82.2	0.4
98	83.7	85.8	74.7	81.6	83.4	84.8	83.8	83.7	84.4	81.4	82.7	0.9
99	80.5	82.3	71.1	77.5	79.2	80.5	80.9	80.1	80.9	77.8	79.1	-2.7
Average	82.9	84.9	73.7	80.6	82.5	83.5	83.4	83.0	83.5	80.5	81.8	0.0

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb-Apr 2023

sd	0.5	0.6	0.7	0.6	0.7	0.8	0.5	0.6	0.6	0.7	0.6	0.6
min	80.5	82.3	71.1	77.5	79.2	80.5	80.9	80.1	80.9	77.8	79.1	-2.7
max	84.0	86.3	75.0	82.0	83.8	85.3	84.6	84.5	84.8	83.1	83.2	1.4

Z scores for wheat:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-0.3	-0.2	-0.1	-0.2	-1.0	0.1	-0.1	-0.3	-0.1	-0.2
2	-0.1	-0.2	0.0	-0.5	-0.7	-0.4	-0.1	-0.2	-0.2	-0.1
4a	0.6	-0.1	0.6	0.0	-0.4	-0.2	0.3	0.1	0.1	0.2
4b	-0.1	-0.4	-1.1	-0.5	0.2	-0.4	-0.1	0.6	0.3	-0.2
5	-1.3	-1.0	-1.5	-1.4	-1.6	-0.9	-1.5	-1.3	-1.3	-1.4
8a	-0.3	-0.2	-0.3	-0.4	-0.4	-0.9	-0.5	-0.7	-0.5	-0.8
8b	0.3	0.6	0.1	0.6	0.2	0.3	0.3	-0.1	1.1	0.4
10	2.1	2.6	2.5	2.5	2.3	3.4	2.3	2.8	2.4	2.1
11d	0.0	-0.3	0.0	-0.4	-0.5	-0.3	0.0	-0.3	-0.1	0.9
12	-0.1	0.2	0.2	0.0	-0.2	0.3	-0.3	0.1	0.1	-0.4
15	-0.9	-0.8	-0.7	-0.8	-0.8	N/A	-0.9	-0.3	-1.9	5.2
17a	-0.3	-0.6	0.1	-0.4	-0.2	0.2	-0.4	-0.1	-0.6	-0.6
17b	-0.3	-0.4	-0.5	-0.7	0.1	0.1	-0.5	-0.2	-0.3	-0.2
18	-1.5	-1.8	1.7	0.0	-1.4	-1.1	-1.1	-1.3	-1.1	-0.6
19	-0.3	-0.2	-0.3	-0.4	0.0	-0.3	-0.5	-0.1	-0.3	-0.4
25	-0.3	-0.2	-1.3	-1.0	-0.4	-0.1	-0.5	-0.5	-0.7	-1.2
30a	-0.3	-0.6	-1.3	-0.8	-0.8	-0.7	-0.5	0.3	-0.3	-1.2
30b	-0.5	-0.9	-0.3	-0.7	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2
30c	0.6	0.2	1.2	0.3	0.7	1.7	0.2	0.2	-0.5	-0.1
30d	-0.2	-0.4	0.7	0.2	0.2	0.2	-0.1	0.1	-0.1	0.2
30e	0.1	-0.4	0.5	0.0	0.6	0.3	0.3	0.1	-0.1	-0.2
30h	0.3	0.2	0.2	0.1	1.1	0.7	-0.1	-1.1	0.0	0.1
30i	0.6	-0.2	0.1	-0.1	0.6	0.4	0.4	-0.2	0.1	0.2
30k	0.6	-0.5	0.7	0.5	0.6	0.2	0.8	0.2	0.0	0.1
30l	-1.0	-1.8	-1.7	-1.7	-0.9	-1.7	-1.5	-1.8	-2.0	-2.1
56	0.5	0.8	0.7	0.6	0.4	0.1	0.3	0.7	0.9	-0.2
64	-0.1	-0.6	-0.1	-0.8	-0.2	-0.1	-0.1	0.1	-0.3	-0.8
66	-0.5	0.2	-0.7	-0.6	-0.8	-3.7	-0.7	-1.3	-0.5	-0.4
68	1.3	1.4	1.9	1.2	0.2	1.3	1.1	0.7	0.9	1.2
77a	0.1	0.0	-1.5	1.0	0.0	1.3	0.3	-0.3	0.7	-0.4
79a	-1.0	-0.5	-2.5	-1.0	N/A	N/A	N/A	N/A	N/A	N/A
79b	-0.5	0.4	-0.7	-0.6	-0.4	-0.9	-0.3	0.3	-0.7	-0.8
79c	0.3	0.4	-0.5	0.0	0.2	-1.3	0.3	0.3	-0.5	-0.4
80	-0.5	0.2	1.0	0.3	1.0	-0.9	0.1	0.2	0.4	0.2
82	0.1	0.7	1.1	0.6	0.4	-0.7	0.1	0.8	0.4	0.0
85	0.5	1.8	0.9	1.0	1.0	0.7	1.1	1.5	1.7	1.0
91a	-0.1	0.0	-0.7	-0.4	-0.6	-0.1	0.1	-0.1	-0.1	-0.2
91b	0.1	0.2	-0.3	0.2	-0.4	-0.1	0.1	-0.3	0.3	0.4
94a	0.7	0.8	0.1	0.6	0.8	1.1	0.7	0.5	0.7	0.6
94b	0.1	0.6	0.5	0.6	0.2	0.9	0.5	0.5	0.5	0.6
98	1.5	1.6	1.9	1.8	1.6	2.5	0.7	1.3	1.7	1.8
99	-4.9	-5.4	-5.4	-6.3	-6.8	-6.1	-5.1	-5.9	-5.3	-5.5

The z-values for the mass per hectoliter 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 99 has a large negative systematic shift and should be adjusted accordingly. Lab 79a did not report results for W5-W10, for unknown reasons.

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

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
1	63.2	68.9	68.2	72.1	69.4	67.4	69.2	69.6	69.6	70.5	68.8	68.8
2	64.0	69.7	69.1	73.2	70.5	68.0	69.8	70.4	70.5	71.5	69.7	0.6
4a	62.8	69.2	68.6	72.3	69.6	67.8	69.2	70.0	69.8	70.6	69.0	0.0
4b	63.4	69.0	68.5	72.1	69.6	67.3	69.6	69.9	69.5	70.4	68.9	-0.1
5	63.0	69.2	68.7	72.4	69.7	67.2	69.3	69.6	69.8	70.7	69.0	-0.1
8a	63.6	68.9	68.3	72.4	69.6	67.1	69.3	69.6	69.5	70.5	68.9	-0.1
8b	63.5	69.0	68.3	72.4	69.5	67.2	69.0	69.6	70.1	70.9	69.0	-0.1
10	64.6	70.0	69.3	73.2	70.5	68.3	70.1	70.6	70.8	71.5	69.9	0.9
11d	63.7	69.1	68.4	72.2	69.6	67.0	69.3	69.8	69.9	70.6	69.0	0.0
12	63.7	69.6	68.7	72.7	69.9	67.5	69.7	70.4	70.1	71.6	69.4	0.4
15	63.5	69.2	68.8	72.4	69.9	67.6	69.2	69.8	70.0	71.2	69.2	0.1
17a	63.2	68.9	68.0	71.9	69.5	66.8	68.8	69.7	69.3	70.3	68.6	-0.4
17b	63.5	68.9	68.1	71.9	69.2	67.3	68.9	69.5	69.4	70.4	68.7	-0.3
18	63.0	68.5	67.4	71.9	69.2	66.4	68.6	69.5	69.2	70.0	68.4	-0.6
19	63.0	69.2	68.2	71.9	69.5	67.2	69.0	70.0	69.8	70.8	68.9	-0.2
25	63.3	68.6	68.1	72.0	69.2	66.8	69.2	69.0	69.2	70.3	68.6	-0.4
30a	63.4	68.9	68.1	72.0	69.4	67.2	69.3	69.6	69.9	70.7	68.9	-0.2
30b	63.9	69.4	68.8	72.9	70.3	68.0	69.9	70.5	70.0	71.1	69.5	0.5
30c	64.0	69.7	69.1	73.3	70.8	68.1	70.1	70.8	70.5	71.3	69.8	0.8
30d	64.1	69.9	69.0	72.9	70.3	67.8	70.1	70.5	70.4	71.7	69.7	0.6
30e	63.7	69.8	69.0	72.6	70.2	68.0	70.1	70.5	70.5	71.4	69.6	0.6
30h	63.7	69.4	68.7	72.5	69.8	67.3	69.5	70.3	69.9	71.2	69.2	0.2
30i	63.5	69.3	68.3	72.7	69.8	67.3	69.9	70.1	70.4	71.0	69.2	0.2
30k	64.3	70.4	69.7	73.7	71.0	68.8	71.0	71.6	70.9	71.9	70.3	1.3
30l	63.1	68.9	67.9	72.0	69.4	66.7	69.1	69.7	69.3	70.0	68.6	-0.4
32	63.6	69.4	68.5	72.5	69.8	67.8	69.6	70.2	69.9	71.1	69.2	0.2
56	63.6	69.7	68.9	72.6	69.9	67.8	69.4	70.4	70.2	71.3	69.4	0.4
64	63.4	69.2	68.4	72.3	69.5	67.2	69.5	70.1	69.7	71.1	69.0	0.0
68	64.0	69.3	68.4	73.0	70.1	67.1	69.2	70.1	70.0	71.2	69.2	0.2
79a	63.4	69.8	67.9	73.5	70.3	66.2	N/A	69.3	69.7	71.1	69.0	0.0
79c	62.7	69.1	67.6	72.0	69.5	66.0	N/A	70.0	70.4	70.4	68.6	-0.4
80	63.4	68.7	68.2	72.1	69.3	67.0	69.1	69.6	69.6	70.5	68.7	-0.3
82	63.4	68.9	68.3	72.0	69.5	67.1	69.0	69.7	69.4	70.7	68.8	-0.2

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb-Apr 2023

85	63.1	69.1	68.2	72.4	70.0	67.2	69.5	69.3	70.0	71.0	69.0	0.0
91a	63.3	68.9	68.1	72.0	69.6	67.2	69.2	69.8	69.6	70.6	68.8	-0.2
91b	63.3	69.2	68.5	72.2	69.9	67.2	69.4	69.9	69.8	70.8	69.0	0.0
94a	63.4	69.3	68.3	72.3	69.7	67.3	69.2	69.9	70.0	70.9	69.0	0.0
94b	63.7	69.4	68.5	72.6	69.8	67.4	69.6	70.2	69.9	71.0	69.2	0.2
98	63.6	68.9	68.0	72.0	69.6	66.5	68.4	69.9	69.7	70.8	68.7	-0.3
99	61.3	66.8	65.3	69.7	67.0	64.0	66.3	67.1	66.7	68.1	66.2	-2.8
Average	63.4	69.2	68.4	72.4	69.7	67.2	69.3	69.9	69.8	70.8	69.0	1.7
sd	0.5	0.5	0.7	0.6	0.6	0.8	0.7	0.7	0.7	0.6	0.6	10.9
min	61.3	66.8	65.3	69.7	67.0	64.0	66.3	67.1	66.7	68.1	66.2	-2.8
max	64.6	70.4	69.7	73.7	71.0	68.8	71.0	71.6	70.9	71.9	70.3	68.8

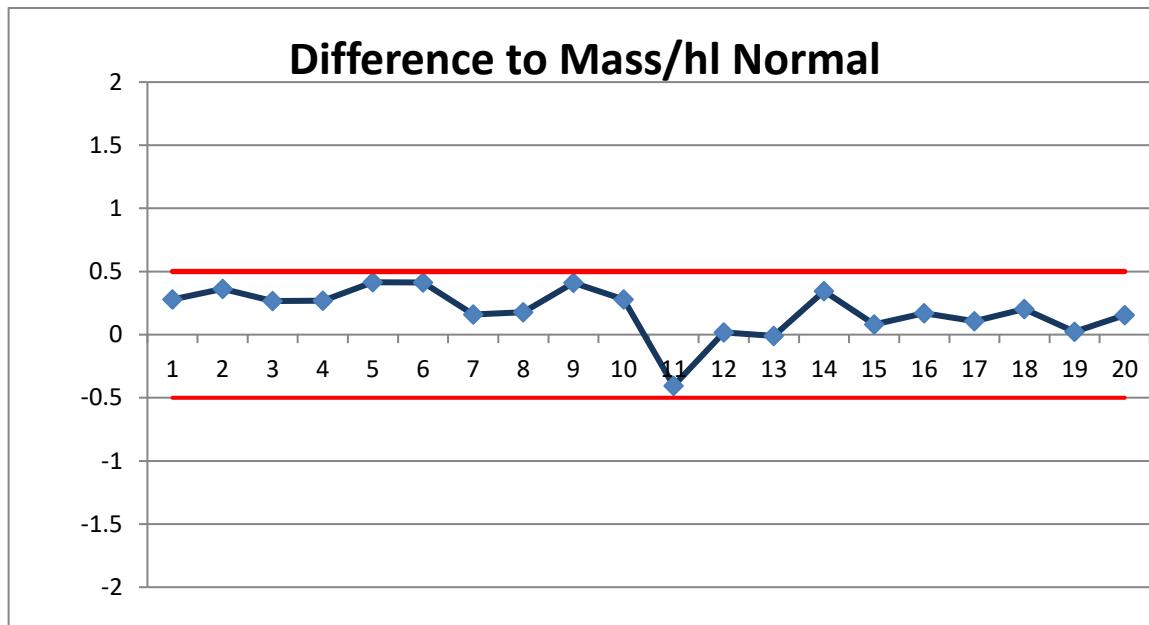
## Z –scores for TWM / barley:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
1	-0.6	-0.7	-0.5	-0.7	-0.8	0.2	-0.4	-0.7	-0.6	-0.8
2	1.0	0.9	1.3	1.5	1.4	1.3	0.7	0.9	1.1	1.2
4a	-1.3	-0.1	0.2	-0.3	-0.3	1.1	-0.5	0.0	-0.2	-0.6
4b	-0.2	-0.4	0.2	-0.7	-0.4	0.0	0.4	-0.1	-0.8	-1.0
5	-1.0	-0.1	0.5	-0.1	-0.2	-0.2	-0.2	-0.7	-0.2	-0.4
8a	0.2	-0.7	-0.3	-0.1	-0.4	-0.4	-0.2	-0.7	-0.8	-0.8
8b	0.0	-0.5	-0.3	-0.1	-0.6	-0.2	-0.8	-0.7	0.4	0.0
10	2.2	1.4	1.6	1.4	1.4	1.9	1.4	1.3	1.7	1.2
11d	0.5	-0.3	0.0	-0.4	-0.3	-0.7	-0.2	-0.4	-0.1	-0.6
12	0.4	0.7	0.5	0.5	0.2	0.4	0.6	0.9	0.4	1.4
15	0.0	-0.1	0.7	-0.1	0.2	0.6	-0.4	-0.3	0.2	0.6
17a	-0.6	-0.7	-1.0	-1.2	-0.7	-1.1	-1.3	-0.5	-1.2	-1.2
17b	0.0	-0.7	-0.8	-1.1	-1.3	-0.1	-1.1	-0.9	-1.0	-1.0
18	-1.0	-1.5	-2.1	-1.1	-1.2	-1.8	-1.6	-0.9	-1.4	-1.8
19	-1.0	-0.1	-0.5	-1.1	-0.6	-0.2	-0.8	0.1	-0.2	-0.2
25	-0.4	-1.3	-0.7	-0.9	-1.2	-1.0	-0.4	-1.9	-1.4	-1.2
30a	-0.2	-0.7	-0.7	-0.9	-0.8	-0.2	-0.2	-0.7	0.0	-0.4
30b	0.8	0.3	0.7	0.8	0.9	1.5	1.0	1.0	0.1	0.5
30c	0.9	0.8	1.4	1.8	2.0	1.7	1.4	1.7	1.2	0.9
30d	1.1	1.2	1.1	1.0	0.9	1.0	1.4	1.1	0.9	1.6
30e	0.4	1.1	1.1	0.3	0.8	1.4	1.4	1.1	1.2	1.0
30h	0.3	0.3	0.5	0.1	0.0	0.0	0.2	0.7	0.1	0.5
30i	0.0	0.1	-0.2	0.5	0.0	0.1	1.1	0.2	0.9	0.2
30k	1.6	2.2	2.6	2.5	2.5	2.9	3.1	3.2	2.1	2.0
30l	-0.7	-0.7	-1.0	-0.8	-0.8	-1.1	-0.6	-0.6	-1.1	-1.8
32	0.2	0.3	0.1	0.1	0.0	1.0	0.4	0.5	0.0	0.4
56	0.2	0.9	0.9	0.3	0.2	1.0	0.0	0.9	0.6	0.8
64	-0.2	-0.1	-0.1	-0.3	-0.6	-0.2	0.2	0.3	-0.4	0.4
68	1.0	0.1	-0.1	1.1	0.6	-0.4	-0.4	0.3	0.2	0.6
79a	-0.3	1.1	-1.1	2.1	1.0	-2.3	N/A	-1.3	-0.4	0.4
79c	-1.6	-0.3	-1.7	-0.9	-0.6	-2.6	N/A	0.1	1.0	-1.0
80	-0.2	-1.1	-0.5	-0.7	-1.0	-0.7	-0.6	-0.8	-0.6	-0.8
82	-0.1	-0.8	-0.4	-0.9	-0.7	-0.5	-0.9	-0.6	-1.0	-0.5
85	-0.8	-0.3	-0.5	-0.1	0.4	-0.2	0.2	-1.3	0.2	0.2
91a	-0.4	-0.7	-0.7	-0.9	-0.4	-0.3	-0.5	-0.3	-0.7	-0.6
91b	-0.4	-0.1	0.1	-0.6	0.2	-0.2	-0.1	-0.2	-0.3	-0.2
94a	-0.2	0.1	-0.3	-0.3	-0.2	0.0	-0.4	-0.1	0.2	0.0
94b	0.4	0.3	0.1	0.3	0.0	0.2	0.4	0.5	0.0	0.2
98	0.2	-0.7	-0.9	-0.9	-0.4	-1.6	-2.0	-0.1	-0.4	-0.2
99	-4.5	-4.8	-6.3	-5.5	-5.7	-6.6	-6.2	-5.8	-6.4	-5.5

The z-values for the mass per hectoliter 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, lab 30k has a positive systematic shift and need to be adjusted. Lab 99 has a large negative shift in the same way as for wheat and need to adjust accordingly.

Performance TWM (difference to mass per hectoliter normal)



The overall performance of Infratec TWM results as compared to mass per hectoliter by reference method is good as can be observed from the figure above.

## 7.2 Falling number

Twenty-three participants reported results for this parameter using ICC 107/1 (8 participants), ISO 3093 (13 participants) and AACC 56-81.04 (2 participants). No predictions were performed.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
1	363	362	341	398	395	308	331	401	409	304	361	-18
2	349	372	355	414	381	314	356	397	398	322	366	-13
4	362	348	337	406	366	323	316	393	398	337	359	-20
5	436	407	388	493	460	353	393	519	466	398	431	53
8	386	336	380	437	396	302	342	401	420	332	373	-6
12	367	353	391	446	381	325	359	417	417	346	380	1
15	375	399	367	469	422	277	339	451	438	365	390	11
17	382	389	379	463	411	337	366	413	413	343	390	11
25	359	382	315	424	375	324	320	417	417	347	368	-11
26	402	381	378	439	412	337	368	443	426	373	396	17
30	357	350	354	414	390	313	329	423	431	328	369	-10
35	426	424	417	515	459	392	389	493	476	396	439	60
61	371	350	368	417	399	313	336	423	393	332	370	-9
64	363	351	370	410	394	322	343	425	411	350	374	-5
66	341	319	328	398	385	322	329	423	399	326	357	-22
68	356	329	374	404	351	314	325	417	402	334	361	-18
80	357	360	389	446	401	344	354	454	454	352	391	12
82	383	361	372	458	392	315	351	434	427	370	386	8
85	365	380	360	385	360	309	336	349	398	326	357	-22
91	362	351	353	420	374	306	328	399	437	356	369	-10
94	381	366	360	449	425	342	364	437	438	350	391	12
98	380	319	276	434	388	332	331	417	411	344	363	-16
101	345	362	355	425	365	336	327	423	432	335	371	-8
Average	372	363	361	433	395	324	345	425	422	346	379	
sd	23.4	26.4	29.0	31.6	27.7	22.1	20.9	33.9	22.2	22.6	21.5	
Min	341	319	276	385	351	277	316	349	393	304	357	
Max	436	424	417	515	460	392	393	519	476	398	439	

Z - values

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
1	-0.2	0.0	-0.5	-0.9	0.0	-0.4	-0.4	-0.6	-0.3	-1.1
2	-0.6	0.2	-0.2	-0.5	-0.4	-0.3	0.3	-0.7	-0.6	-0.6
4	-0.3	-0.4	-0.6	-0.7	-0.7	0.0	-0.7	-0.8	-0.6	-0.2
5	1.6	1.1	0.7	1.5	1.7	0.7	1.2	2.4	1.1	1.3
8	0.3	-0.7	0.5	0.1	0.0	-0.6	-0.1	-0.6	-0.1	-0.4
12	-0.1	-0.3	0.8	0.3	-0.4	0.0	0.4	-0.2	-0.1	0.0
15	0.1	0.9	0.1	0.9	0.7	-1.2	-0.2	0.7	0.4	0.5
17	0.2	0.7	0.5	0.8	0.4	0.3	0.5	-0.3	-0.2	-0.1
25	-0.3	0.5	-1.2	-0.2	-0.5	0.0	-0.6	-0.2	-0.1	0.0
26	0.8	0.5	0.4	0.1	0.4	0.3	0.6	0.5	0.1	0.7
30	-0.4	-0.3	-0.2	-0.5	-0.1	-0.3	-0.4	0.0	0.2	-0.5
35	1.4	1.6	1.4	2.1	1.6	1.7	1.1	1.8	1.4	1.3
61	0.0	-0.3	0.2	-0.4	0.1	-0.3	-0.2	0.0	-0.7	-0.4
64	-0.2	-0.3	0.2	-0.6	0.0	-0.1	0.0	0.0	-0.3	0.1
66	-0.8	-1.1	-0.8	-0.9	-0.2	-0.1	-0.4	0.0	-0.6	-0.5
68	-0.4	-0.9	0.3	-0.7	-1.1	-0.3	-0.5	-0.2	-0.5	-0.3
80	-0.4	-0.1	0.7	0.3	0.2	0.5	0.2	0.8	0.8	0.1
82	0.3	-0.1	0.3	0.6	-0.1	-0.2	0.2	0.2	0.1	0.6
85	-0.2	0.4	0.0	-1.2	-0.9	-0.4	-0.2	-1.9	-0.6	-0.5
91	-0.3	-0.3	-0.2	-0.3	-0.5	-0.5	-0.4	-0.7	0.4	0.2
94	0.2	0.1	0.0	0.4	0.8	0.5	0.5	0.3	0.4	0.1
98	0.2	-1.1	-2.2	0.0	-0.2	0.2	-0.4	-0.2	-0.3	-0.1
101	-0.7	0.0	-0.2	-0.2	-0.8	0.3	-0.5	0.0	0.3	-0.3

For the calculation of the z-scores a fixed value of sR = 39 has been chosen in accordance with ISO/ICC standards as average reproducibility in the range 250-500.

Only three yellow-marked samples for three different labs (5, 35 and 98), 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.

Six participants submitted reference results for this parameter using ICC 116/1 (1 and 8) and ISO 5529 (2, 18, 68 and 98). Thirty-one participants predicted the sedimentation index using ANN prediction models WHZE1 (68), WHZE16 (4b, 17a, 17b), BL440622 (33) or WHZE22 (all other labs).

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
1 2 8 18 68 98	30	51	35	54	49	39	31	38	54	23	40	2
	24	52	36	51	41	38	27	37	50	21	38	-1
	27	53	31	50	47	36	28	35	54	22	38	0
	N/A	42	36	N/A	43	35	29	N/A	N/A	N/A	37	-2
	31	54	40	59	59	43	34	40	64	25	34	-5
	30	60	41	58	48	42	32	38	68	25	44	6
AvG.	28	52	36	54	48	39	30	38	58	23	39	

Predicted values

1	45	48	35	52	51	34	36	36	67	36	44	8
2	35	40	26	44	41	27	27	27	56	28	35	-1
4a	35	39	26	43	41	27	27	26	57	27	35	-2
4b	31	37	25	38	31	29	23	28	45	25	31	-5
8a	35	40	27	42	43	27	27	27	56	28	35	-1
8b	37	41	26	43	42	27	25	22	58	28	35	-2
11a	36	40	28	43	43	27	29	28	57	28	36	0
11b	34	41	28	43	43	27	28	28	57	27	36	-1
11d	33	38	28	40	42	26	27	26	56	27	34	-2
11e	36	40	28	42	41	25	26	26	56	27	35	-1
17a	37	45	30	47	36	35	26	34	54	30	37	1
17b	38	45	31	47	39	34	28	34	54	31	38	2
18	39	44	31	48	46	31	33	30	60	33	39	3
19	35	40	28	43	42	26	27	27	56	28	35	-1
25	33	38	33	42	40	26	25	27	58	26	35	-1
30I	27	38	26	43	43	26	27	26	55	33	35	-2
33	48	52	34	50	52	40	39	41	61	35	45	9
64	35	40	27	42	44	27	28	26	56	28	35	-1
66	31	35	25	39	38	26	26	26	55	27	33	-4
67	44	42	26	46	50	25	31	25	59	28	38	1
68	44	51	39	53	51	43	37	42	62	38	46	10
73	33	40	27	44	34	30	22	29	54	27	34	-2
79a	34	40	27	42	40	27	27	27	56	27	35	-2
79b	34	37	25	41	39	22	25	29	55	24	33	-3
79c	35	39	27	43	42	27	28	29	56	29	35	-1
82	34	39	27	42	40	26	27	28	57	28	35	-1
85	28	31	21	33	33	21	24	23	47	24	29	-8
91a	36	41	26	43	41	26	28	27	57	28	35	-1
91b	35	39	27	44	42	26	28	27	57	28	35	-1
98	44	50	40	55	46	43	36	42	60	39	46	9
101	36	39	28	44	42	27	28	28	57	29	36	-1

AvG.	36	41	28	44	42	29	28	29	56	29	36	
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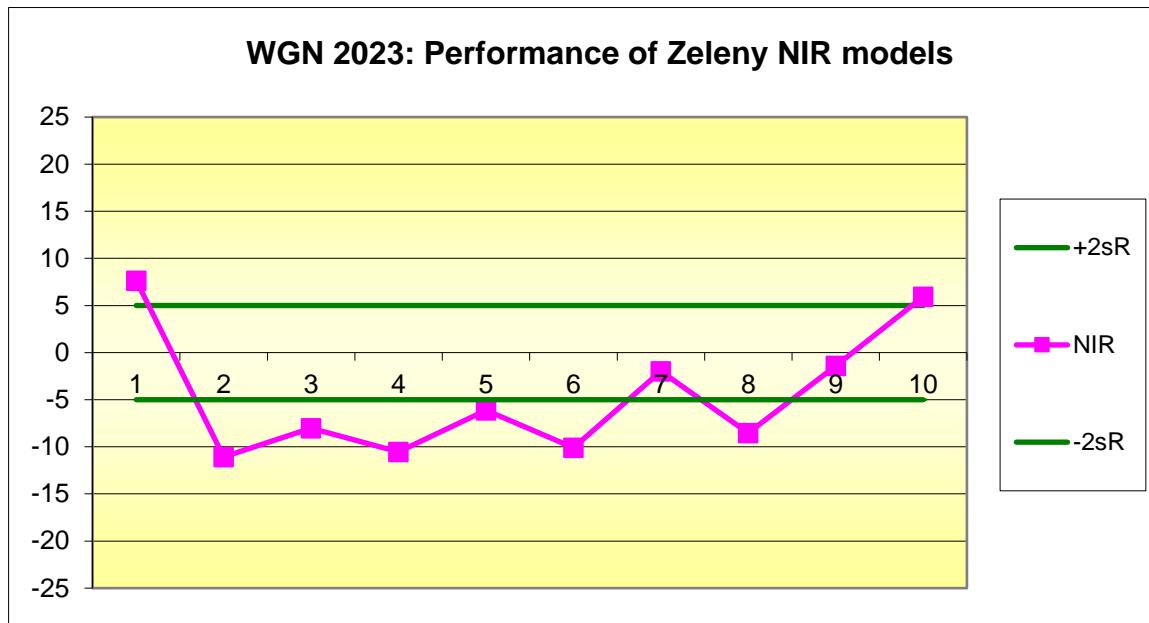


Figure 7.3.1: Deviations of average predicted values against average reference values.

It is a significant positive deviation between the predicted and reference value for W1 and W10. For samples W2-W6 and W8 there is a negative deviation to reference. Samples W7 and W9 have good comparison between predicted and reference methods.

## 7.4 Wet gluten

Fourteen participants reported reference values for wet gluten using ICC 155 (labs 4, 8 and 12), ISO 21415-2 (mechanical) (labs 2, 17, 61, 68, 82 and 98), ISO 21415-1 (manual) (lab 19) and AACC 38-12.02 (labs 26, 35, 73 and 99) methods. Forty-three sets of results with predicted wet gluten results using model versions 24, 25, 27, 32, 34, 36 or 37. One lab had their own model (36). Labs submitting reference results, but no predicted have got their spectra re-predicted with the latest model version WHGL37 (labs 26 and 35). According to z-scores, the reference results look good. For predicted results, lab 12 have one red-marked, lab 36 have three red-marked and labs 66 and 67 have more than three red-marked values.

## Compilation of reported results (wheat samples):

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev
2	22.3	26.2	19.6	27.0	24.6	20.1	21.9	19.5	33.6	21.7	23.7	-0.1
4	22.8	26.7	20.3	29.4	24.9	22.4	20.3	20.6	35.2	22.9	24.5	0.8
8	21.3	25.6	20.2	26.6	23.2	19.0	21.7	18.5	32.9	21.2	23.0	-0.7
12	22.6	26.8	20.5	28.0	25.0	20.1	21.4	20.2	33.6	21.1	23.9	0.2
17	22.9	25.8	19.9	26.8	24.7	20.3	21.7	19.5	33.2	22.3	23.7	-0.1
19	23.5	24.9	19.5	28.1	26.1	20.4	20.5	21.0	34.4	21.5	24.0	0.2
26	23.1	24.8	20.6	26.5	24.6	21.0	21.8	20.5	31.8	21.7	23.6	-0.1
35	23.4	26.5	20.9	29.3	25.3	20.4	22.2	19.8	35.2	23.4	24.6	0.9
61	24.0	24.8	19.3	26.3	23.5	19.3	20.5	18.0	32.9	22.2	23.1	-0.7
68	22.4	27.9	19.9	28.7	24.7	21.0	21.8	20.5	34.6	21.3	24.3	0.5
73	23.4	24.8	18.9	26.3	24.1	19.4	21.6	19.6	34.6	22.3	23.5	-0.3
82	21.4	25.4	19.7	27.6	23.9	18.4	21.5	17.9	33.8	21.6	23.1	-0.6
98	25.6	27.0	20.0	28.6	25.1	21.0	21.5	21.9	33.4	20.4	24.5	0.7
99	21.5	25.0	19.3	27.5	25.1	18.8	21.4	16.4	34.8	22.2	23.2	-0.6
Average	22.9	25.9	19.9	27.6	24.6	20.1	21.4	19.6	33.9	21.8	23.8	0.0
sd	1.1	1.0	0.6	1.1	0.8	1.1	0.6	1.4	1.0	0.8	0.6	0.6
Min	21.3	24.8	18.9	26.3	23.2	18.4	20.3	16.4	31.8	20.4	23.0	-0.7
Max	25.6	27.9	20.9	29.4	26.1	22.4	22.2	21.9	35.2	23.4	24.6	0.9

Predicted values

1	25.2	26.8	21.1	27.2	27.2	21.8	21.9	21.4	32.6	21.9	<b>24.7</b>	0.1
2	25.8	25.8	20.5	26.7	27.1	21.6	21.9	20.8	31.4	22.6	<b>24.4</b>	-0.2
4a	24.5	25.8	21.2	27.1	27.1	23.0	22.3	23.0	31.8	22.2	<b>24.8</b>	0.2
4b	23.6	26.0	18.9	27.2	25.3	20.7	20.5	20.0	31.9	20.2	<b>23.4</b>	-1.2
8a	26.6	26.9	21.3	28.0	27.4	23.1	22.8	22.1	31.8	22.3	<b>25.2</b>	0.6
8b	26.4	27.0	21.3	28.2	26.9	22.8	22.7	22.0	32.0	22.3	<b>25.2</b>	0.5
11a	23.9	25.8	20.5	26.9	26.1	22.2	21.7	23.6	32.9	21.2	<b>24.5</b>	-0.1
11b	23.4	25.8	20.7	26.4	27.7	22.1	21.4	24.2	32.1	21.0	<b>24.5</b>	-0.1
11d	23.8	25.8	21.0	26.8	25.9	22.2	21.0	22.5	32.5	21.2	<b>24.3</b>	-0.4
11e	23.7	25.8	21.1	26.8	26.0	22.4	21.4	24.1	32.0	21.7	<b>24.5</b>	-0.1
12	22.6	24.8	19.1	26.1	24.3	20.5	19.4	19.4	31.1	20.4	<b>22.8</b>	-1.8
17a	24.1	26.5	20.7	26.7	25.5	22.5	21.1	21.5	31.4	22.2	<b>24.2</b>	-0.4
17b	24.3	26.5	21.0	26.7	25.4	22.3	21.4	21.9	31.3	21.9	<b>24.2</b>	-0.4
18	26.2	27.3	21.6	28.1	28.1	23.2	23.5	22.3	33.3	24.2	<b>25.8</b>	1.2
19	24.8	26.5	20.9	27.5	26.7	22.5	21.2	22.6	33.5	22.5	<b>24.9</b>	0.3
25	24.5	26.1	20.0	27.3	26.7	22.8	21.6	22.6	32.1	21.5	<b>24.5</b>	-0.1
26	23.9	26.0	20.3	27.3	25.9	21.9	21.5	22.7	32.6	21.8	<b>24.4</b>	-0.2
30I	22.4	26.2	20.8	27.7	27.4	22.4	22.4	23.8	32.7	25.2	<b>25.1</b>	0.5
33	24.6	25.6	20.1	26.9	28.4	20.8	22.9	21.5	31.2	21.1	<b>24.3</b>	-0.3
35a	23.5	25.9	20.3	27.2	26.0	22.1	21.5	23.5	32.6	21.7	<b>24.4</b>	-0.2
35b	24.0	25.9	20.7	27.2	26.1	22.3	21.3	23.8	31.9	22.0	<b>24.5</b>	-0.1
35c	24.1	25.9	21.0	27.0	26.2	22.3	21.4	24.1	32.0	21.8	<b>24.6</b>	0.0
35d	23.9	25.8	20.9	26.7	27.0	22.3	21.6	24.4	31.4	21.4	<b>24.5</b>	-0.1
36	27.4	28.8	22.2	30.1	29.1	23.5	26.0	22.9	33.7	25.4	<b>26.9</b>	2.3

56	24.0	25.9	20.7	26.9	25.7	22.1	21.3	23.1	32.3	21.9	<b>24.4</b>	-0.2
61	24.7	25.2	20.2	26.7	26.1	21.7	22.3	21.3	31.2	22.0	<b>24.1</b>	-0.5
64	24.5	26.5	20.6	27.0	27.5	22.3	22.1	21.3	32.3	22.2	<b>24.6</b>	0.0
66	24.8	26.2	23.3	29.1	27.9	26.4	23.7	27.5	36.6	25.3	<b>27.1</b>	2.5
67	34.1	28.4	28.1	30.2	34.9	21.9	27.6	20.9	33.4	23.3	<b>28.3</b>	3.7
68	24.1	26.1	20.9	27.5	26.2	22.6	21.2	23.0	32.5	21.7	<b>24.6</b>	0.0
73	25.8	26.8	21.1	27.9	27.0	22.8	21.9	22.4	32.8	21.6	<b>25.0</b>	0.4
79a	23.5	25.0	21.1	25.5	26.8	21.9	21.6	21.6	30.8	22.6	<b>24.0</b>	-0.6
79b	22.5	23.2	19.6	25.7	27.0	21.8	21.3	23.2	31.7	21.2	<b>23.7</b>	-0.9
79c	23.9	24.2	20.6	26.3	27.2	22.7	22.2	23.1	33.4	23.7	<b>24.7</b>	0.1
80	23.3	24.5	19.4	26.1	27.1	22.2	20.5	21.7	33.8	22.3	<b>24.1</b>	-0.5
82	23.6	24.9	19.8	27.0	25.9	21.6	20.1	23.2	33.5	22.3	<b>24.2</b>	-0.4
85	24.0	24.0	20.0	27.0	27.0	23.0	22.0	23.0	35.0	23.0	<b>24.8</b>	0.2
91a	24.9	26.9	20.7	28.0	26.8	22.4	21.3	22.5	33.8	22.5	<b>25.0</b>	0.3
91b	26.0	26.0	20.4	27.2	26.9	21.6	20.7	21.7	33.1	22.4	<b>24.6</b>	-0.1
94a	22.2	24.0	19.2	25.1	24.2	20.1	19.4	21.9	30.3	20.1	<b>22.7</b>	-2.0
94b	22.0	24.1	18.5	25.0	24.1	19.9	19.4	21.4	30.6	20.0	<b>22.5</b>	-2.1
98	24.3	26.1	20.9	27.5	25.8	22.3	21.5	23.1	32.7	21.6	<b>24.6</b>	0.0
101	25.0	26.6	21.4	27.7	26.8	23.0	21.5	21.9	33.8	22.9	<b>25.1</b>	0.4
Average	<b>24.5</b>	<b>25.9</b>	<b>20.8</b>	<b>27.1</b>	<b>26.8</b>	<b>22.2</b>	<b>21.8</b>	<b>22.5</b>	<b>32.4</b>	<b>22.1</b>	<b>24.6</b>	

z-values:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10		
2	-0.5	0.3	-0.3	-0.6	0.0	0.0	0.5	0.0	-0.2	-0.2		
4	-0.1	0.8	0.4	1.8	0.3	<b>2.3</b>	-1.1	1.0	1.4	1.1		
8	-1.6	-0.3	0.3	-1.0	-1.4	-1.1	0.3	-1.1	-1.0	-0.6		
12	-0.3	0.9	0.6	0.4	0.4	0.0	0.0	0.6	-0.3	-0.7		
17	0.0	-0.1	0.0	-0.8	0.1	0.2	0.3	-0.1	-0.7	0.5		
19	0.6	-1.0	-0.4	0.5	1.5	0.3	-0.9	1.4	0.5	-0.3		
26	0.2	-1.1	0.7	-1.1	0.0	0.9	0.4	0.9	<b>-2.1</b>	-0.1		
35	0.5	0.6	1.0	1.7	0.6	0.2	0.8	0.2	1.3	1.5		
61	1.1	-1.1	-0.6	-1.3	-1.1	-0.8	-0.9	-1.6	-1.0	0.4		
68	-0.5	<b>2.1</b>	0.0	1.1	0.1	0.9	0.4	0.9	0.7	-0.5		
73	0.5	-1.1	-1.0	-1.3	-0.5	-0.7	0.2	0.0	0.7	0.5		
82	-1.5	-0.5	-0.2	0.0	-0.7	-1.7	0.1	-1.7	-0.1	-0.2		
98	<b>2.7</b>	1.1	0.1	1.0	0.5	0.9	0.1	<b>2.3</b>	-0.5	-1.4		
99	-1.4	-0.9	-0.6	-0.2	0.4	-1.3	0.0	-3.2	0.9	0.3		
p1	0.7	0.9	0.3	0.1	0.4	-0.4	0.1	-1.1	0.2	-0.2		
p2	1.3	-0.1	-0.3	-0.5	0.3	-0.7	0.1	-1.8	-1.1	0.4		
p4a	0.0	-0.1	0.4	0.0	0.3	0.8	0.6	0.5	-0.6	0.1		
p4b	-1.0	0.1	-1.9	0.0	-1.5	-1.6	-1.2	<b>-2.6</b>	-0.6	-1.9		
p8a	<b>2.1</b>	1.0	0.5	0.9	0.6	0.9	1.0	-0.4	-0.6	0.2		
p8b	1.9	1.1	0.5	1.1	0.1	0.6	0.9	-0.5	-0.4	0.2		
p11a	-0.6	-0.1	-0.3	-0.2	-0.6	0.0	0.0	1.1	0.5	-0.9		

p11b	-1.1	-0.1	-0.1	-0.7	1.0	-0.2	-0.3	1.7	-0.3	-1.1
p11d	-0.7	-0.1	0.2	-0.4	-0.9	0.0	-0.8	0.0	0.1	-0.9
p11e	-0.8	-0.1	0.3	-0.4	-0.8	0.2	-0.4	1.6	-0.5	-0.5
p12	-1.9	-1.1	-1.7	-1.0	-2.5	-1.7	-2.4	-3.1	-1.3	-1.7
p17a	-0.5	0.5	-0.1	-0.4	-1.3	0.3	-0.7	-1.1	-1.0	0.0
p17b	-0.3	0.6	0.2	-0.5	-1.4	0.1	-0.4	-0.7	-1.1	-0.2
p18	1.7	1.4	0.8	1.0	1.3	1.0	1.7	-0.2	0.9	2.1
p109	0.3	0.6	0.1	0.4	-0.1	0.3	-0.6	0.1	1.1	0.4
p25	0.0	0.2	-0.7	0.1	-0.1	0.6	-0.2	0.1	-0.4	-0.6
p26	-0.6	0.1	-0.5	0.1	-0.8	-0.3	-0.3	0.2	0.2	-0.3
p30l	-2.2	0.3	0.1	0.6	0.6	0.2	0.6	1.3	0.2	3.0
p33	0.1	-0.3	-0.7	-0.2	1.6	-1.4	1.1	-1.0	-1.2	-1.0
p35a	-1.1	0.0	-0.5	0.0	-0.7	-0.1	-0.3	1.0	0.1	-0.4
p35b	-0.5	0.0	-0.1	0.1	-0.6	0.1	-0.5	1.2	-0.5	-0.1
p35c	-0.5	0.0	0.2	-0.2	-0.5	0.1	-0.4	1.5	-0.4	-0.4
p35d	-0.6	-0.1	0.1	-0.4	0.2	0.1	-0.2	1.8	-1.0	-0.7
p36	2.9	2.9	1.4	3.0	2.3	1.3	4.2	0.4	1.3	3.3
p56	-0.5	0.0	-0.1	-0.2	-1.1	-0.1	-0.5	0.6	-0.1	-0.2
p61	0.2	-0.7	-0.6	-0.4	-0.7	-0.5	0.5	-1.2	-1.2	-0.1
p64	0.0	0.6	-0.2	-0.1	0.7	0.1	0.3	-1.2	-0.1	0.1
p66	0.3	0.3	2.5	2.0	1.1	4.2	1.9	5.0	4.2	3.2
p67	9.6	2.5	7.3	3.1	8.2	-0.3	5.9	-1.7	1.0	1.2
p68	-0.4	0.2	0.2	0.4	-0.5	0.3	-0.6	0.5	0.0	-0.4
p73	-1.0	-0.9	0.3	-1.6	0.0	-0.3	-0.2	-0.9	-1.6	0.5
p79a	-2.0	-2.7	-1.2	-1.4	0.2	-0.4	-0.5	0.7	-0.7	-0.9
p79b	-0.6	-1.7	-0.2	-0.8	0.4	0.5	0.4	0.6	1.0	1.6
p79c	-1.3	-1.4	-1.4	-1.1	0.4	0.0	-1.3	-0.9	1.4	0.2
p80	-0.9	-1.0	-0.9	-0.1	-0.9	-0.6	-1.6	0.7	1.0	0.2
p82	-0.9	-1.0	-0.9	-0.1	-0.9	-0.6	-1.6	0.7	1.0	0.2
p85	-0.5	-1.9	-0.8	-0.1	0.2	0.8	0.2	0.5	2.6	0.9
p91a	0.3	1.0	-0.1	0.8	0.0	0.1	-0.5	-0.1	1.4	0.4
p91b	1.4	0.0	-0.4	0.0	0.1	-0.7	-1.1	-0.9	0.7	0.2
p94b	-2.3	-1.9	-1.6	-2.0	-2.6	-2.1	-2.4	-0.6	-2.1	-2.0
p94b	-2.5	-1.8	-2.3	-2.1	-2.7	-2.3	-2.4	-1.1	-1.8	-2.1
p98	-0.2	0.2	0.1	0.4	-1.0	0.1	-0.3	0.6	0.3	-0.5
p101	0.5	0.7	0.6	0.6	0.0	0.8	-0.3	-0.6	1.4	0.8

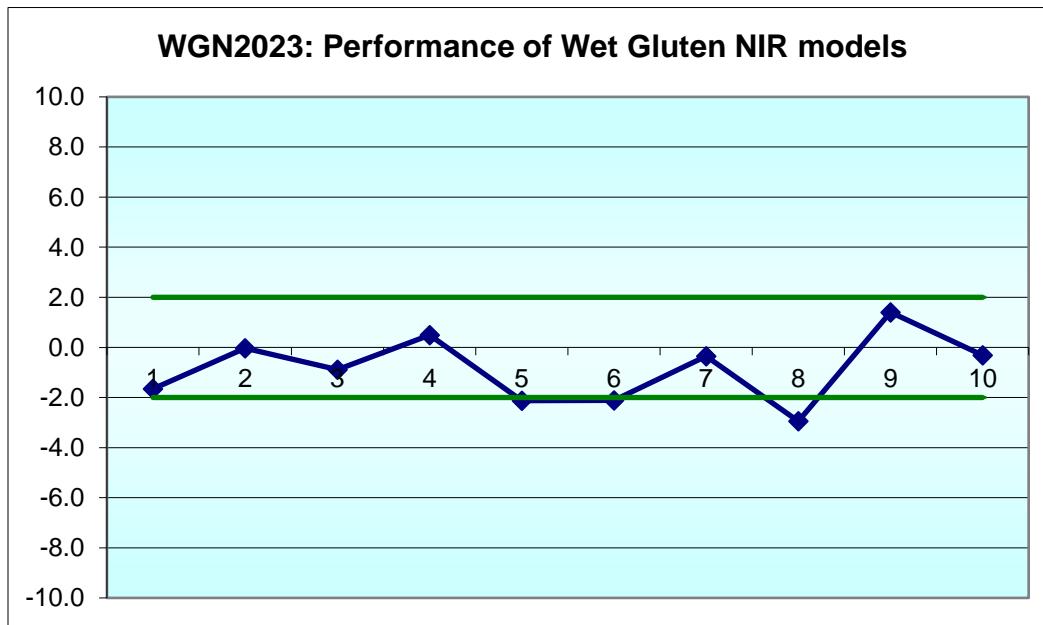


Fig. 7.4.1: Deviation of average results from prediction models against average values of reference results for wet gluten. Green lines =  $\pm 2$  sR.

The overall performance of the Infratec prediction models is rather good where most of the samples falls within the error limits of the reference method, except for W8, which is just outside the limit.

## 7.5 Starch in wheat

Six participants submitted results for starch in wheat determined by reference methods.

The methods used were:

S04	Lab 8, 80	EN ISO 10520 (Ewers)
S06	Lab 12	EN ISO 6493 (polarimetric, HCl)
S06	Lab 5	Enzymatic + HPLC
S06	Lab 68	MSZ 6830-18:1988 Sec.2. (Polarimetric, HCl)

In addition, twenty-nine sets of results were also submitted by predicting with different models: WBST1 (4b, 17a, 17b), WBST6 (4a, 8a, 8b, 25, 67, 79b, and 79c), WBST10 (19, 80, 82, 91a, and 101), WBST14 (2, 30l, 66, and 91b) and WBST16 (5, 11, 12, and 94). Labs submitting reference results, but no predicted have got their spectra re-predicted with the latest model version WBST16 (68 and 98).

Lab 68 have 4 red-marked results by reference, whereas labs 5 and 98 have one red-marked results each. Only labs 4b and 5 have 2 and 1 red-marked results by prediction, respectively.

### Collation of data:

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	dev
5	66.4	65.5	67.8	66.3	67.3	66.2	68.1	67.6	63.8	66.6	66.6	-1.8
8	68.0	67.8	69.8	67.8	69.6	68.3	70.1	69.8	67.8	69.6	68.9	0.5
12	68.4	68.4	72.3	69.2	69.6	70.4	71.2	71.2	66.4	70.3	69.7	1.3
68	68.5	69.7	77.1	69.5	68.0	71.2	68.7	75.9	72.6	72.0	71.3	2.9
80	67.6	66.3	67.7	66.6	68.4	69.0	68.9	70.7	64.8	69.2	67.9	-0.5
98	64.5	64.2	67.6	66.8	66.1	66.6	67.0	68.7	64.5	64.0	66.0	-2.4
AvG	67.2	67.0	70.4	67.7	68.2	68.6	69.0	70.7	66.6	68.6	68.4	
sd	1.5	2.0	3.8	1.4	1.4	2.0	1.5	2.9	3.3	2.9	2.0	
rsd	2.3	3.0	5.3	2.0	2.0	2.9	2.1	4.1	4.9	4.2	2.9	

Predicted values:

2	69.4	68.6	70.0	67.4	69.5	70.8	70.6	70.8	67.0	71.5	<b>69.6</b>	0.5
4a	69.4	67.9	69.4	67.3	69.4	69.2	70.6	67.8	66.2	70.6	<b>68.8</b>	-0.2
4b	67.2	65.2	67.0	64.7	67.5	66.0	68.6	65.3	63.7	68.0	<b>66.3</b>	-2.7
5	66.8	65.5	67.5	64.5	67.5	68.2	68.4	68.0	63.3	68.1	<b>66.8</b>	-2.2
8a	70.7	69.1	70.9	69.3	70.3	69.7	71.7	67.8	68.8	71.1	<b>69.9</b>	0.9
8b	70.4	69.1	71.2	69.1	70.3	69.7	72.1	67.9	68.6	71.6	<b>70.0</b>	1.0
11a	68.8	67.9	69.8	67.3	69.9	70.3	70.6	70.4	66.3	70.3	<b>69.2</b>	0.1
11b	68.6	67.3	69.4	67.0	69.3	70.0	69.8	69.5	66.0	69.8	<b>68.7</b>	-0.4
11d	68.6	67.6	69.5	65.7	69.4	70.2	70.1	69.9	65.2	70.1	<b>68.6</b>	-0.4
11e	68.2	67.0	69.3	65.9	68.9	69.9	69.7	69.4	64.4	69.6	<b>68.2</b>	-0.8
12	68.5	67.3	69.1	66.8	69.3	69.6	70.0	70.0	66.8	69.8	<b>68.7</b>	-0.3
17a	67.9	67.2	69.9	66.4	68.5	68.7	69.9	68.6	66.0	70.0	<b>68.3</b>	-0.7

<b>17b</b>	66.7	66.4	69.3	65.6	67.4	68.6	69.5	68.0	65.3	69.5	<b>67.6</b>	-1.4
<b>19</b>	69.4	68.6	70.3	67.5	69.4	70.9	71.1	70.3	67.0	71.0	<b>69.6</b>	0.5
<b>25</b>	69.5	68.4	70.1	67.5	69.8	70.0	71.8	68.4	67.1	71.3	<b>69.4</b>	0.4
<b>30I</b>	71.2	68.9	71.0	68.6	70.3	71.1	71.1	71.0	67.1	69.8	<b>70.0</b>	1.0
<b>64</b>	70.1	68.7	70.6	68.3	70.1	70.3	71.8	68.8	67.5	71.4	<b>69.8</b>	0.7
<b>66</b>	69.1	67.9	69.7	67.6	69.6	70.3	70.7	71.0	67.2	70.9	<b>69.4</b>	0.4
<b>67</b>	68.8	68.4	70.2	68.2	69.5	69.8	70.9	68.0	67.1	71.0	<b>69.2</b>	0.2
<b>68</b>	70.8	67.3	69.1	67.1	70.7	69.9	71.7	69.9	65.9	70.6	<b>69.3</b>	0.3
<b>79b</b>	70.2	69.4	70.3	68.6	70.1	68.7	71.0	67.7	67.6	70.5	<b>69.4</b>	0.4
<b>79c</b>	70.3	69.1	70.3	68.3	70.5	71.6	71.5	71.3	68.1	71.9	<b>70.3</b>	1.3
<b>80</b>	68.3	67.4	69.1	66.6	68.4	70.5	70.0	70.4	66.4	70.8	<b>68.8</b>	-0.2
<b>82</b>	69.3	67.9	69.4	67.3	70.0	70.5	70.9	70.3	66.9	70.5	<b>69.3</b>	0.3
<b>91a</b>	69.0	68.1	69.9	67.1	69.4	70.6	70.7	70.2	66.6	71.1	<b>69.3</b>	0.3
<b>91b</b>	69.4	68.5	70.6	68.3	70.0	70.5	71.1	70.8	67.1	71.0	<b>69.7</b>	0.7
<b>94a</b>	67.9	66.6	68.6	65.5	68.4	69.5	69.8	69.2	64.0	69.2	<b>67.9</b>	-1.1
<b>98</b>	69.2	68.4	70.3	68.6	71.0	70.4	71.1	70.2	69.0	71.5	<b>70.0</b>	1.0
<b>101</b>	69.4	68.9	70.4	67.8	69.3	71.1	70.8	70.5	66.5	71.3	<b>69.6</b>	0.6
<b>AvG</b>	<b>69.1</b>	<b>67.9</b>	<b>69.7</b>	<b>67.2</b>	<b>69.4</b>	<b>69.9</b>	<b>70.6</b>	<b>69.4</b>	<b>66.5</b>	<b>70.5</b>	<b>69.0</b>	<b>0.0</b>

**Z-Scores:**

<b>Lab</b>	<b>W1</b>	<b>W2</b>	<b>W3</b>	<b>W4</b>	<b>W5</b>	<b>W6</b>	<b>W7</b>	<b>W8</b>	<b>W9</b>	<b>W10</b>
5	-0.9	-1.5	-2.6	-1.4	-0.9	-2.4	-0.9	-3.0	-2.9	-2.1
	0.8	0.8	-0.6	0.1	1.4	-0.3	1.1	-0.9	1.2	1.0
	1.2	1.4	1.9	1.5	1.4	1.8	2.2	0.5	-0.2	1.7
	1.3	2.7	6.7	1.8	-0.2	2.6	-0.3	5.2	6.0	3.4
	0.4	-0.7	-2.7	-1.1	0.2	0.4	-0.1	0.1	-1.9	0.6
	-2.7	-2.8	-2.8	-0.9	-2.1	-2.0	-2.0	-2.0	-2.1	-4.6
p2	0.4	0.7	0.2	0.2	0.0	1.0	0.0	1.4	0.5	1.0
p4a	0.4	0.0	-0.3	0.1	-0.1	-0.7	0.0	-1.5	-0.3	0.1
p4b	-1.9	-2.7	-2.7	-2.5	-1.9	-3.9	-2.0	-4.1	-2.8	-2.5
p5	-2.3	-2.4	-2.2	-2.7	-1.9	-1.7	-2.2	-1.4	-3.2	-2.4
p8a	1.6	1.2	1.2	2.1	0.9	-0.2	1.1	-1.6	2.3	0.6
p8b	1.3	1.2	1.5	1.9	0.9	-0.2	1.5	-1.5	2.1	1.1
p11a	-0.2	0.0	0.1	0.1	0.4	0.4	0.0	1.0	-0.2	-0.2
p11b	-0.5	-0.6	-0.4	-0.2	-0.2	0.1	-0.9	0.2	-0.5	-0.6
p11d	-0.5	-0.3	-0.2	-1.6	0.0	0.3	-0.5	0.5	-1.3	-0.4
p11e	-0.9	-0.9	-0.4	-1.4	-0.6	0.0	-0.9	0.0	-2.1	-0.8
p12	-0.6	-0.6	-0.6	-0.4	-0.1	-0.3	-0.6	0.6	0.3	-0.7
p17a	-1.2	-0.7	0.1	-0.8	-0.9	-1.2	-0.8	-0.8	-0.6	-0.5
p17b	-2.4	-1.5	-0.4	-1.7	-2.0	-1.3	-1.1	-1.4	-1.3	-1.0
p19	0.3	0.7	0.6	0.3	0.0	1.0	0.5	0.9	0.5	0.5
p25	0.4	0.5	0.4	0.3	0.4	0.1	1.2	-1.0	0.6	0.8
p30l	2.1	1.0	1.3	1.3	0.9	1.2	0.5	1.7	0.6	-0.7
p64	1.0	0.8	0.9	1.1	0.7	0.4	1.2	-0.6	1.0	0.9
p66	0.0	0.0	0.0	0.4	0.2	0.4	0.1	1.6	0.7	0.4
p67	-0.3	0.5	0.5	1.0	0.1	-0.1	0.3	-1.4	0.6	0.5
p68	1.7	-0.5	-0.6	-0.1	1.3	0.0	1.1	0.5	-0.6	0.1
p79b	1.1	1.5	0.6	1.4	0.7	-1.2	0.4	-1.7	1.1	0.0
p79c	1.2	1.2	0.6	1.1	1.1	1.7	0.9	1.9	1.6	1.4
p80	-0.8	-0.5	-0.7	-0.6	-1.1	0.6	-0.6	1.0	-0.1	0.3
p82	0.2	0.1	-0.3	0.1	0.5	0.6	0.3	0.9	0.4	0.0
p91a	-0.1	0.2	0.2	-0.1	0.0	0.7	0.1	0.8	0.1	0.6
p91b	0.3	0.6	0.9	1.1	0.6	0.6	0.5	1.4	0.6	0.5
p94a	-1.2	-1.3	-1.1	-1.7	-1.0	-0.4	-0.8	-0.2	-2.5	-1.3
p98	0.1	0.5	0.6	1.4	1.6	0.5	0.5	0.9	2.5	1.1
p101	0.3	1.0	0.7	0.6	-0.1	1.2	0.2	1.1	0.0	0.8

P = predicted

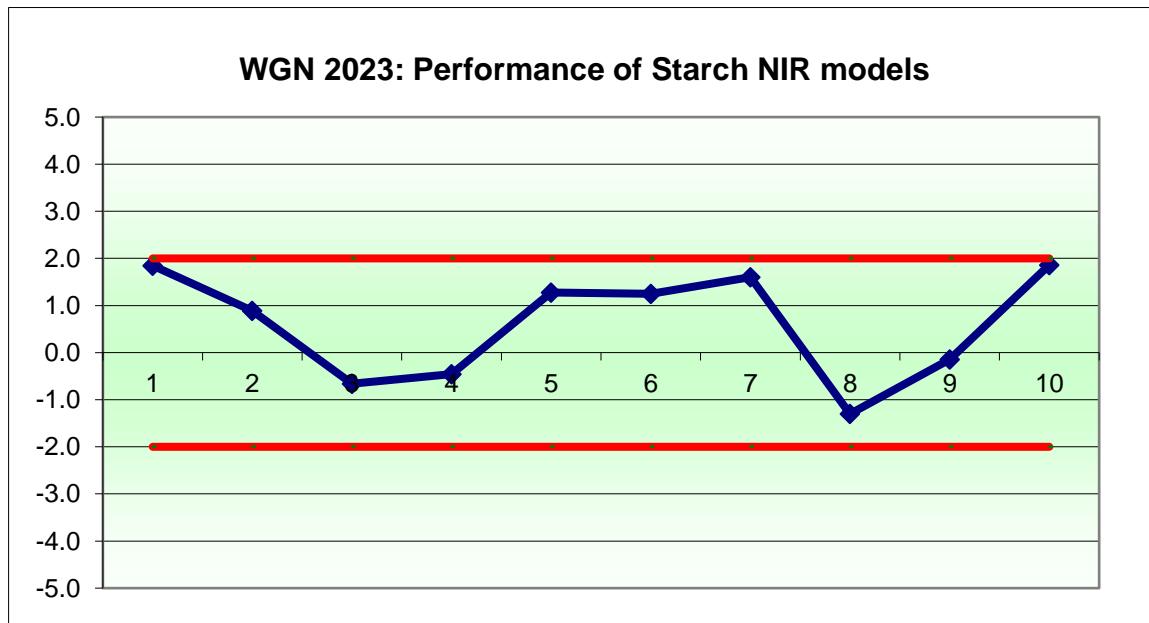


Fig. 7.5.1: Performance of average results of predictions against average reference values for starch in wheat. Red lines =  $\pm 2 s_R$ .

The overall performance of the starch NIR models is aligned and inside the limits for the reference method.

## 7.6 Starch in barley

Three labs (5, 12, and 68) submitted results by reference method. They used the same as for wheat (see section 7.5). Nine sets of predicted results were submitted for starch in barley. The models used were BAST12 (12 and 17), WBST6 (5) 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	57.9	60.8	56.9	57.3	61.2	56.1	55.8	57.3	55.9	61.6	58.1	-2.0
12	61.6	63.8	59.8	61.3	63.9	62.4	61.5	61.1	60.8	62.7	61.9	1.8
68	60.4	61.8	58.4	59.2	60.3	60.6	60.7	61.1	59.7	61.6	60.4	0.3
AvG	<b>60.0</b>	<b>62.1</b>	<b>58.4</b>	<b>59.3</b>	<b>61.8</b>	<b>59.7</b>	<b>59.3</b>	<b>59.8</b>	<b>58.8</b>	<b>62.0</b>	<b>60.1</b>	<b>0.0</b>
sd	1.9	1.5	1.4	2.0	1.9	3.2	3.1	2.2	2.6	0.6	1.9	
rsd	3.1	2.4	2.4	3.4	3.0	5.4	5.2	3.7	4.4	1.0	3.2	

Predicted values:

Lab	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	dev
5	60.0	62.9	59.7	61.1	63.7	60.0	59.9	61.3	60.7	63.3	<b>61.3</b>	-1.1
11a	60.5	63.6	60.7	63.0	64.8	60.2	61.1	62.9	60.9	64.1	<b>62.2</b>	-0.2
11b	60.5	63.5	60.5	63.3	64.6	59.5	60.0	62.2	60.3	64.5	<b>61.9</b>	-0.5
11d	61.3	64.1	60.6	63.4	65.4	60.4	60.5	63.1	60.7	64.9	<b>62.4</b>	0.0
11e	60.8	64.0	60.8	63.3	64.4	60.2	59.7	62.7	60.3	64.8	<b>62.1</b>	-0.3
12	60.0	63.2	61.1	63.3	66.1	63.1	62.0	63.4	62.2	65.5	<b>63.0</b>	0.6
17a	62.2	64.7	62.0	63.8	66.0	63.9	63.0	64.3	63.0	66.0	<b>63.9</b>	1.5
17b	62.5	64.9	62.2	63.7	65.8	63.6	63.2	64.5	63.1	65.9	<b>63.9</b>	1.5
68	56.5	62.7	59.8	63.0	62.2	58.9	60.3	61.9	60.3	63.7	<b>60.9</b>	-1.5
AvG	<b>60.5</b>	<b>63.7</b>	<b>60.8</b>	<b>63.1</b>	<b>64.8</b>	<b>61.1</b>	<b>61.1</b>	<b>62.9</b>	<b>61.3</b>	<b>64.7</b>	<b>62.4</b>	

Too few reference data for statistical analysis.

## 7.7 Hardness

Only one participant reported values for the parameter “Hardness”. The methods used was SKCS (lab 10). In addition, two labs reported predicted values using WHHA26 (10) and WHHA36 (lab 11).

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. Vitreousness depends on the structure of the starch whereas hardness is the crashworthiness.

Lab	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
10	66.5	82.0	56.0	67.5	76.5	66.5	63.0	79.0	54.0	60.0

Predicted values

10	87.3	110.5	70.2	94.5	93.0	89.3	76.8	99.1	83.2	63.0
11a	49.6	66.0	51.6	58.5	71.9	60.4	58.2	57.5	52.7	35.2
11b	50.6	70.2	49.9	62.0	71.9	56.2	61.6	58.9	53.0	35.3
11d	51.0	69.6	51.8	59.2	63.7	67.9	58.0	61.6	57.9	40.3
11e	53.0	68.6	53.0	66.8	63.9	66.7	61.3	56.2	56.4	38.9
Average	<b>58.3</b>	<b>77.0</b>	<b>55.3</b>	<b>68.2</b>	<b>72.9</b>	<b>68.1</b>	<b>63.2</b>	<b>66.7</b>	<b>60.7</b>	<b>42.5</b>

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 WGN2023 exercise. It seems it is only a substantial interest for Protein, so we may decide to omit the other parameters in future ring tests.

Parameter	# labs reporting (ref + pred)
Protein	8+25
Glucosinolates	1+8
Erucic acid	3+11
Oleic acid	3+13
Linolenic acid	3+13
Linoleic acid	3+2
FFA (Acidity index)	1+0
Saturated fats	2+2
Iodine values	1+3

### 8.1 Protein

Reference results for protein in rapeseed were submitted from eight labs. Three participants reported Infratec predictions with local PLS model RAPR10 (27a, 27b, 35a, 35d, and 67), one with RAPR11 (19) and RAPR13 (5, 12, 56). Customer models were used by one lab (36). Re-predictions were made with RAPR13 (labs 11, 33, 35b-35c, 68, 91a, 91b, and 98). In addition, two results were submitted from NIRS DS2500 (35e and 35f), and one from an XDS (91c).

#### Collation of results

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
2	20.2	21.6	16.7	20.1	17.4	22.0	18.5	20.5	22.3	19.6	<b>19.89</b>	0.27
5	19.3	20.1	15.7	18.9	16.5	21.2	17.8	19.5	21.2	18.8	<b>18.90</b>	-0.72
12	21.2	21.6	16.6	20.3	17.9	22.5	18.5	20.8	22.4	20.1	<b>20.19</b>	0.57
27	20.7	19.2	15.9	18.8	16.3	21.3	17.5	18.7	18.3	17.8	<b>18.44</b>	-1.18
33	21.0	21.5	16.9	19.8	17.5	22.1	18.0	20.5	21.8	19.5	<b>19.86</b>	0.24
35	21.3	21.3	17.0	20.2	17.6	22.5	18.4	20.9	22.3	20.0	<b>20.15</b>	0.53
68	21.0	21.2	16.9	20.0	17.2	21.9	18.1	20.4	21.9	19.7	<b>19.82</b>	0.20
98	21.0	21.6	16.7	19.7	17.1	21.8	18.0	20.1	21.6	19.5	<b>19.71</b>	0.09
Average	20.7	21.0	16.5	19.7	17.2	21.9	18.1	20.2	21.5	19.4	19.6	0.0
sd	0.7	0.9	0.5	0.6	0.5	0.5	0.3	0.7	1.3	0.7	0.6	0.6
min	19.3	19.2	15.7	18.8	16.3	21.2	17.5	18.7	18.3	17.8	18.4	-1.2
max	21.3	21.6	17.0	20.3	17.9	22.5	18.5	20.9	22.4	20.1	20.2	0.6

2	20.74	20.93	16.92	19.23	16.85	22.47	17.59	19.93	21.63	19.93	<b>19.62</b>	-0.09
5	21.10	21.30	16.80	19.60	17.10	22.50	18.00	20.30	22.00	19.80	<b>19.85</b>	0.14
11a	20.58	20.57	15.75	18.91	16.02	21.29	16.91	19.04	21.12	19.28	<b>18.95</b>	-0.77
11b	20.26	20.06	14.98	19.29	15.94	21.68	17.04	19.52	21.17	19.72	<b>18.96</b>	-0.75
11d	20.76	20.66	16.29	19.67	16.75	22.35	18.36	20.10	21.70	19.96	<b>19.66</b>	-0.05
11e	20.48	20.79	16.66	18.65	16.80	22.12	17.77	19.96	21.39	19.76	<b>19.44</b>	-0.27
12	20.10	21.30	15.40	19.40	16.80	22.00	18.20	20.80	21.60	19.70	<b>19.53</b>	-0.18
19	21.01	21.10	16.63	19.71	17.27	22.56	18.23	20.15	21.76	20.18	<b>19.86</b>	0.15
27a	20.31	22.27	16.70	18.72	17.17	22.56	18.40	19.58	22.44	19.83	<b>19.80</b>	0.08
27b	20.46	18.86	16.49	17.95	16.15	21.07	17.64	17.74	20.04	19.40	<b>18.58</b>	-1.13
33	20.74	21.05	16.52	19.17	15.68	22.49	17.57	19.96	21.53	18.31	<b>19.30</b>	-0.41
35a	22.70	23.60	19.80	20.70	18.20	22.20	20.70	18.20	24.00	21.70	<b>21.18</b>	1.47
35b	20.93	21.18	16.96	19.62	16.88	22.14	17.79	19.99	21.61	20.13	<b>19.72</b>	0.01
35c	20.59	20.93	16.93	19.79	17.06	22.41	18.00	20.49	21.71	20.02	<b>19.79</b>	0.08
35d	22.10	22.60	19.40	21.20	17.10	22.60	20.20	21.00	23.50	22.20	<b>21.19</b>	1.48
35e	21.50	21.60	17.20	21.00	17.70	22.80	18.90	21.20	22.30	20.60	<b>20.48</b>	0.77
35f	21.30	21.70	17.40	20.70	17.80	22.90	18.60	21.30	22.20	20.40	<b>20.43</b>	0.72
36	20.86	21.12	17.25	19.33	17.32	22.20	18.18	20.11	21.97	19.83	<b>19.82</b>	0.10
56	20.60	20.40	16.80	18.80	16.50	21.90	17.60	19.90	21.30	19.60	<b>19.34</b>	-0.37
67	20.10	18.80	16.60	17.10	15.60	20.20	16.80	19.00	19.50	18.60	<b>18.23</b>	-1.48
68	21.21	22.05	17.19	20.43	17.16	21.90	17.54	19.83	22.27	20.32	<b>19.99</b>	0.28
91a	21.03	20.70	16.12	19.65	16.85	22.19	17.77	19.55	21.48	19.92	<b>19.52</b>	-0.19
91b	20.67	20.86	16.84	19.57	16.91	22.41	18.35	20.18	21.87	19.89	<b>19.75</b>	0.04
91c	21.30	21.80	16.60	20.60	17.60	22.50	18.00	21.30	22.40	20.20	<b>20.23</b>	0.52
98	20.67	21.35	16.38	19.87	16.30	22.51	17.62	20.03	22.03	19.35	<b>19.61</b>	-0.10

AvG.	<b>20.88</b>	<b>21.10</b>	<b>16.82</b>	<b>19.55</b>	<b>16.86</b>	<b>22.16</b>	<b>18.07</b>	<b>19.97</b>	<b>21.78</b>	<b>19.94</b>	<b>19.71</b>	
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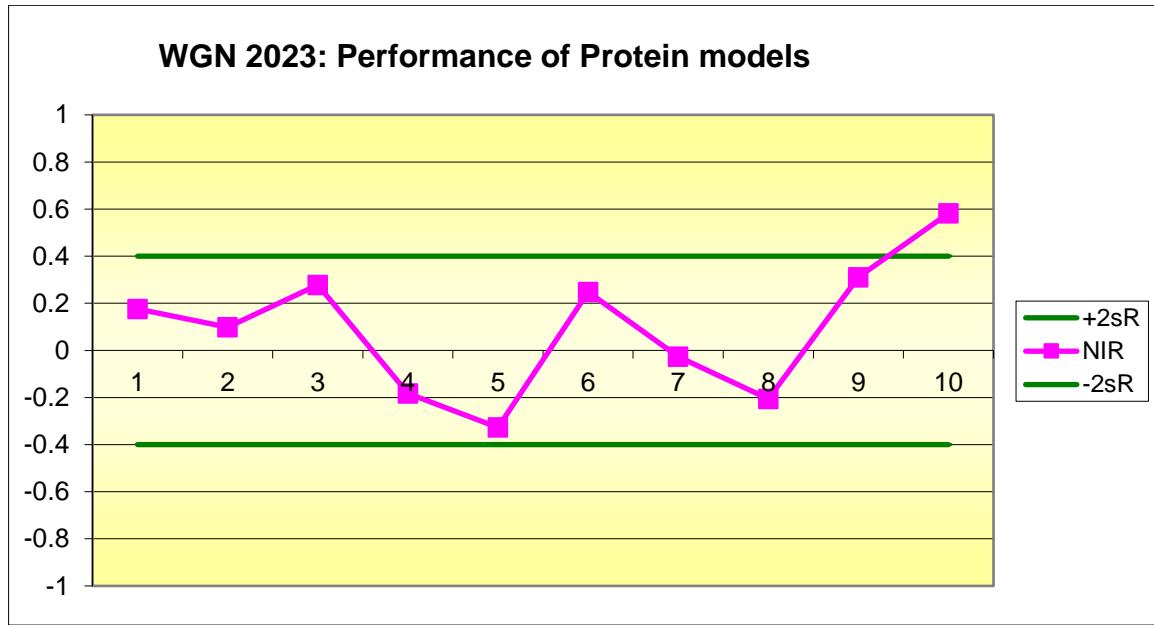


Fig. 8.2.1: Performance of average results of predictions against average reference values for protein in Rapeseed. Red lines = +/- 2 SR.

## 8.2 Glucosinolates

Only one participant submitted results for Glucosinolates using a national standard method (68). Predicted results using model RAGU4 were performed for 3 instruments using extended range (11d, 11e, 35a, 35b, 35c and 35d). In addition, two results from NIRS DS2500 were submitted (35e and 35f).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
68	12	10	12	15	13	24	15	20	12	14	15	1
11d	10	9	5	7	5	25	6	7	13	4	9	-2
11e	9	16	12	7	6	33	7	20	13	1	13	2
35a	8	12	0	0	1	24	1	3	10	0	6	-5
35b	11	9	7	7	2	31	3	10	16	5	10	-1
35c	13	19	9	11	11	29	11	12	20	9	14	4
35d	13	17	5	6	2	29	8	14	17	11	12	2
35e	6	9	9	10	7	18	10	13	9	9	10	-1
35f	8	11	10	11	8	19	10	14	10	10	11	0
AvG.	10	13	7	7	5	26	7	12	13	6	11	

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

## 8.3 Erucic acid

Three participants (15a, 35 and 68) submitted results for Erucic acid using a GC method (EN ISO-12966-2). Spectra from 11 instruments were re-predicted using model RAEU7 (11, 15, 35 and 68). 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
15a	0.05	0.17	0.05	0.17	0.10	0.08	0.05	0.06	0.05	0.05	0.08	-0.03
35	0.21	0.21	0.01	0.13	0.10	0.07	0.17	0.07	0.15	0.00	0.11	0.00
68	0.19	0.20	0.05	0.22	0.11	0.10	0.15	0.09	0.15	0.05	0.13	0.02
AvG.	0.15	0.19	0.04	0.17	0.10	0.08	0.12	0.07	0.12	0.03	0.11	
11a	0.00	2.38	0.00	0.00	0.00	0.00	0.00	6.69	8.21	0.31	1.76	0.16
11b	10.74	5.31	11.16	0.00	0.00	0.00	0.00	6.18	10.08	0.00	4.35	2.75

<b>11d</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.24	0.00	<b>0.42</b>	-1.18
<b>11e</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68	0.00	<b>0.17</b>	-1.43
<b>15a</b>	0.00	10.68	1.57	0.00	0.00	0.00	0.00	0.00	0.51	0.00	<b>1.28</b>	-0.33
<b>15b</b>	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	<b>0.05</b>	-1.56
<b>35a</b>	0.00	5.06	0.72	0.00	0.00	0.00	0.00	1.08	9.90	0.00	<b>1.68</b>	0.08
<b>35b</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	<b>0.03</b>	-1.57
<b>35c</b>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>	-1.60
<b>35d</b>	0.00	0.21	0.00	0.00	0.00	0.00	0.00	2.40	5.94	6.06	<b>1.46</b>	-0.14
<b>68</b>	3.64	11.87	12.08	2.08	0.00	0.00	2.19	3.52	16.67	12.12	<b>6.42</b>	4.82

AvG.	<b>1.31</b>	<b>3.24</b>	<b>2.32</b>	<b>0.19</b>	<b>0.00</b>	<b>0.00</b>	<b>0.20</b>	<b>1.81</b>	<b>5.26</b>	<b>1.68</b>	<b>1.60</b>	
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## 8.4 Oleic acid

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

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
15a	55.73	58.82	61.17	63.54	62.43	63.18	60.41	72.51	58.98	58.14	<b>61.49</b>	-2.10
35	59.45	61.33	63.96	66.16	65.90	65.96	63.49	76.01	61.52	61.89	<b>64.57</b>	0.98
68	59.57	61.64	64.22	66.17	66.11	66.07	63.60	76.32	61.64	61.76	<b>64.71</b>	1.12
AvG.	<b>58.25</b>	<b>60.60</b>	<b>63.12</b>	<b>65.29</b>	<b>64.81</b>	<b>65.07</b>	<b>62.50</b>	<b>74.95</b>	<b>60.71</b>	<b>60.60</b>	<b>63.59</b>	

<b>11a</b>	64.86	66.68	67.91	68.68	69.58	65.78	68.15	73.92	66.43	66.34	<b>67.83</b>	0.26
<b>11b</b>	68.04	66.33	67.90	67.95	69.15	66.02	67.95	72.35	64.88	66.12	<b>67.67</b>	0.09
<b>11d</b>	67.59	66.96	68.35	70.29	70.52	67.27	68.16	74.43	66.46	69.80	<b>68.98</b>	1.41
<b>11e</b>	67.25	66.14	68.83	67.50	69.54	67.17	68.23	72.14	67.04	67.52	<b>68.14</b>	0.56
<b>15a</b>	68.21	67.67	69.72	70.00	70.72	66.42	67.88	73.76	65.63	67.36	<b>68.74</b>	1.16
<b>15b</b>	65.99	66.68	69.19	68.04	69.29	66.64	66.68	73.82	67.10	66.89	<b>68.03</b>	0.46
<b>35a</b>	66.67	66.18	69.63	68.16	69.37	65.78	66.76	72.64	65.96	67.50	<b>67.86</b>	0.29
<b>35b</b>	69.49	66.75	68.19	69.94	68.87	65.87	68.03	74.06	65.97	68.51	<b>68.57</b>	0.99
<b>35c</b>	66.29	65.76	69.51	67.69	69.89	66.70	66.78	72.86	65.10	67.88	<b>67.85</b>	0.27
<b>35d</b>	65.78	65.38	68.27	68.46	68.87	66.63	67.18	73.10	65.39	68.07	<b>67.71</b>	0.14
<b>35e</b>	59.57	62.13	64.38	65.27	67.39	65.01	63.11	72.98	61.82	61.67	<b>64.33</b>	-3.24
<b>35f</b>	59.70	61.91	64.16	65.38	67.24	65.08	63.22	73.20	61.78	61.94	<b>64.36</b>	-3.21
AvG.	<b>65.76</b>	<b>65.77</b>	<b>68.24</b>	<b>68.19</b>	<b>69.23</b>	<b>66.23</b>	<b>67.01</b>	<b>73.18</b>	<b>65.37</b>	<b>66.78</b>	<b>67.58</b>	

There is a clear bias for the Infratec prediction model relative the reference method, so at least a bias adjustment is required for RALOA3 to work properly. The NIR reflectance models seems to work better (35d-35f).

## 8.5 Linolenic acid

Three participants (15a, 35 and 68) submitted results for Linolenic acid using a GC method (EN ISO-12966-2). Spectra from 11 instruments were re-predicted using model RALN3 (11, 15, 35a-35d and 68). Predicted results from NIRS DS2500 (35e and 35f) were also received.

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
15a	11.38	10.31	8.47	8.45	6.85	6.86	9.14	3.03	10.50	10.03	<b>8.50</b>	-0.11
35	11.39	10.46	8.51	8.61	6.91	6.97	9.17	3.00	10.60	10.21	<b>8.58</b>	-0.03
68	11.52	10.54	8.62	8.81	7.11	7.10	9.37	3.08	10.81	10.53	<b>8.75</b>	0.14
AvG.	<b>11.43</b>	<b>10.44</b>	<b>8.53</b>	<b>8.62</b>	<b>6.96</b>	<b>6.98</b>	<b>9.23</b>	<b>3.04</b>	<b>10.64</b>	<b>10.26</b>	<b>8.61</b>	

11a	7.74	6.75	6.14	5.28	4.77	6.98	5.92	1.83	7.13	6.92	<b>5.95</b>	-0.33
11b	5.50	7.39	5.75	5.78	5.16	6.66	6.25	2.74	8.11	7.17	<b>6.05</b>	-0.23
11d	6.09	6.71	5.45	4.41	4.01	5.87	5.93	1.56	6.51	4.87	<b>5.14</b>	-1.13
11e	5.85	6.71	5.24	5.74	4.46	5.40	6.01	2.50	6.71	5.70	<b>5.43</b>	-0.84
15a	5.70	5.72	4.37	4.07	3.57	5.67	6.26	1.78	6.90	5.99	<b>5.00</b>	-1.27
15b	6.67	6.42	5.13	5.30	4.49	5.95	6.79	1.93	6.33	6.34	<b>5.53</b>	-0.74
35a	7.05	7.34	5.59	5.95	5.26	7.08	7.09	2.69	7.72	6.68	<b>6.24</b>	-0.03
35b	4.96	6.35	5.60	4.35	4.75	6.43	5.86	1.84	6.98	5.20	<b>5.23</b>	-1.04
35c	6.64	7.24	4.81	5.56	4.13	5.56	6.51	2.32	7.34	5.63	<b>5.57</b>	-0.70
35d	7.62	8.23	6.39	6.13	5.55	6.74	7.46	2.91	8.13	6.57	<b>6.57</b>	0.30
35e	12.13	10.67	9.68	8.50	7.14	7.50	9.89	3.39	10.78	10.91	<b>9.06</b>	2.78
35f	11.97	10.68	9.59	8.46	7.07	7.42	9.74	3.07	10.85	10.73	<b>8.96</b>	2.68
68	8.49	7.86	5.44	6.81	6.24	7.91	7.09	4.09	8.32	6.12	<b>6.84</b>	0.56
AvG.	<b>7.42</b>	<b>7.54</b>	<b>6.09</b>	<b>5.87</b>	<b>5.12</b>	<b>6.55</b>	<b>6.98</b>	<b>2.51</b>	<b>7.83</b>	<b>6.83</b>	<b>6.28</b>	

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 (35d-35f).

## 8.6 Linoleic acid

Three participants (15a, 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 35f).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
15a	20.64	19.54	18.97	16.48	17.23	18.66	19.15	12.76	19.67	19.77	<b>18.29</b>	-1.76
35	19.80	19.22	18.47	16.00	16.66	18.11	18.43	12.33	19.08	19.09	<b>19.29</b>	-0.76
68	20.25	19.42	18.68	16.16	16.99	18.49	18.78	12.57	19.42	19.49	<b>22.57</b>	2.52
AvG.	<b>20.23</b>	<b>19.39</b>	<b>18.71</b>	<b>16.21</b>	<b>16.96</b>	<b>18.42</b>	<b>18.79</b>	<b>12.55</b>	<b>19.39</b>	<b>19.45</b>	<b>20.05</b>	
35e	19.32	18.44	17.25	17.18	16.44	18.36	18.29	14.58	18.98	18.90	<b>17.77</b>	-0.14
35f	19.63	19.16	17.82	17.29	16.66	18.60	18.56	14.81	19.13	18.95	<b>18.06</b>	0.14
AvG.	<b>19.48</b>	<b>18.80</b>	<b>17.53</b>	<b>17.23</b>	<b>16.55</b>	<b>18.48</b>	<b>18.43</b>	<b>14.70</b>	<b>19.06</b>	<b>18.92</b>	<b>17.92</b>	

## 8.7 Free fatty acid acidity index (FFA)

Only one participant (35) submitted results for Free fatty acid using 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. No predicted results have been received.

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
35	0.17	0.11	0.34	0.19	0.23	0.79	0.19	0.33	0.12	0.29	<b>0.28</b>	0.00

## 8.8 Saturated Fats

Two participants (35 and 68) submitted results for Saturated fats using a GC method (ISO-12966-1). Predicted results have also been supplied from NIRS DS2500 (35e and 35f).

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
35	6.74	6.37	6.95	6.94	8.33	6.63	6.53	6.05	6.27	6.65	<b>6.75</b>	-0.2
68	6.96	6.64	7.15	7.15	8.42	6.76	6.66	6.23	6.38	6.80	<b>6.92</b>	0.0
<hr/>												
AvG.	<b>6.96</b>	<b>6.64</b>	<b>7.15</b>	<b>7.15</b>	<b>8.42</b>	<b>6.76</b>	<b>6.66</b>	<b>6.23</b>	<b>6.38</b>	<b>6.80</b>	<b>6.92</b>	
<hr/>												
35e	6.81	6.43	6.61	6.79	6.95	6.98	6.77	6.89	6.26	6.63	<b>6.71</b>	0.02
35f	6.76	6.32	6.62	6.71	6.95	6.94	6.73	6.88	6.19	6.60	<b>6.67</b>	-0.02
AvG.	<b>6.78</b>	<b>6.38</b>	<b>6.61</b>	<b>6.75</b>	<b>6.95</b>	<b>6.96</b>	<b>6.75</b>	<b>6.89</b>	<b>6.22</b>	<b>6.61</b>	<b>6.69</b>	

## 8.9 Iodine Value

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

Compilation of results:

Lab	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	dev
35	116.8	115.0	110.5	108.5	104.8	107.7	111.9	96.2	115.2	114.3	<b>110.1</b>	0.0
<hr/>												
27a	107.3	121.2	108.3	114.2	101.6	113.4	106.4	97.0	113.6	105.9	<b>108.9</b>	-1.3
35e	117.5	114.6	111.6	109.2	106.1	108.5	112.8	98.0	115.3	115.2	<b>110.9</b>	0.7
35f	117.3	115.0	111.7	109.2	106.2	108.5	112.7	97.6	115.5	114.9	<b>110.9</b>	0.7
AvG.	<b>114.0</b>	<b>116.9</b>	<b>110.5</b>	<b>110.9</b>	<b>104.6</b>	<b>110.1</b>	<b>110.6</b>	<b>97.5</b>	<b>114.8</b>	<b>112.0</b>	<b>110.2</b>	

## 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	12.00	12.60	10.80	13.00	12.40	10.90	10.90	11.00	15.00	10.90	11.95	-0.09	0.07
2	11.96	12.59	10.85	13.19	12.46	11.05	10.94	10.92	14.91	10.94	11.98	-0.06	0.06
4a	12.07	12.55	10.87	13.11	12.51	11.07	11.06	10.98	15.02	11.01	12.03	-0.02	0.03
4b	12.29	12.72	11.03	13.14	12.55	11.14	11.15	11.03	15.02	11.06	12.11	0.07	0.07
5	12.20	12.70	11.00	13.20	12.70	11.00	11.10	11.00	15.10	11.00	12.10	0.06	0.06
8a	12.10	12.60	10.90	13.10	12.70	11.10	11.00	11.10	15.10	11.20	12.09	0.05	0.07
8b	12.10	12.70	10.90	13.20	12.60	11.20	11.10	11.10	15.20	11.20	12.13	0.09	0.08
10	12.10	12.40	11.05	12.95	12.60	10.85	11.25	11.10	14.60	11.00	11.99	-0.05	0.18
11a	12.09	12.54	10.79	13.09	12.56	11.05	11.11	10.88	15.08	10.90	12.01	-0.03	0.08
11b	11.97	12.61	10.93	13.06	12.54	11.13	11.10	11.10	15.07	10.93	12.04	0.00	0.08
12	11.90	12.40	10.60	13.00	12.30	10.90	10.60	10.70	14.80	10.80	11.80	-0.24	0.09
15	12.22	12.68	10.82	13.30	12.68	11.05	11.13	11.11	15.15	11.14	12.13	0.09	0.08
17a	12.10	12.65	10.90	13.20	12.45	11.05	10.95	11.00	14.90	11.05	12.03	-0.02	0.07
17b	12.25	12.60	10.90	13.20	12.60	11.00	11.05	11.00	15.00	11.10	12.07	0.03	0.06
18	12.00	12.70	10.90	13.20	12.60	11.10	11.20	11.00	15.00	11.20	12.09	0.05	0.09
19	12.11	12.57	10.77	13.01	12.45	10.92	10.88	11.00	14.82	10.86	11.94	-0.10	0.06
25	11.90	12.50	10.60	13.10	12.50	11.10	10.90	11.10	15.10	10.90	11.97	-0.07	0.13
26	12.40	13.00	11.00	13.50	12.80	11.40	11.40	11.30	15.40	11.30	12.35	0.31	0.10
27a	12.19	12.88	11.16	13.21	12.83	11.21	11.31	11.33	15.30	11.04	12.25	0.21	0.11
27b	12.28	12.74	11.17	13.37	12.73	11.33	11.26	11.28	15.11	11.00	12.23	0.19	0.09
30a	12.34	12.74	11.11	13.35	12.71	11.17	11.11	11.05	15.09	11.10	12.18	0.14	0.07
30b	12.26	12.83	11.16	13.44	12.91	11.31	11.40	11.35	15.19	11.34	12.32	0.28	0.07
30c	12.30	12.68	11.02	13.31	12.67	11.30	11.20	11.22	15.28	11.32	12.23	0.19	0.08
30d	12.22	12.80	11.17	13.33	12.76	11.27	11.24	11.24	15.19	11.25	12.25	0.21	0.04
30e	12.15	12.83	10.92	13.40	12.72	11.25	11.20	11.16	15.24	11.23	12.21	0.17	0.09
30f	12.06	12.77	11.01	13.22	12.64	11.30	11.10	11.22	14.99	11.31	12.16	0.12	0.11
30h	12.39	12.73	11.36	13.30	12.84	11.36	11.36	11.48	15.23	11.36	12.34	0.30	0.10

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb-Apr 2023

<b>30i</b>	12.17	12.75	11.07	13.23	12.72	11.26	11.26	11.10	15.24	11.13	12.19	0.15	0.06
<b>30k</b>	12.13	12.72	11.15	13.33	12.83	11.25	11.06	11.27	15.18	11.45	12.24	0.20	0.12
<b>30l</b>	12.11	12.73	10.97	13.38	12.80	11.24	11.31	11.24	15.26	11.25	12.23	0.19	0.09
<b>33</b>	12.10	12.60	10.80	13.10	12.60	11.10	11.00	11.00	14.90	11.10	12.03	-0.01	0.06
<b>35a</b>	12.40	12.90	11.00	13.50	12.80	11.30	11.30	11.30	15.40	11.30	12.32	0.28	0.09
<b>35b</b>	12.40	12.80	11.10	13.50	12.80	11.30	11.20	11.30	15.10	11.30	12.28	0.24	0.07
<b>35c</b>	12.30	12.80	11.20	13.40	12.80	11.30	11.30	11.30	15.30	11.20	12.29	0.25	0.04
<b>35d</b>	12.40	12.80	11.20	13.40	12.90	11.30	11.30	11.20	15.10	11.10	12.27	0.23	0.08
<b>36</b>	11.91	12.36	10.67	13.15	12.58	10.79	11.01	10.67	14.94	10.67	11.88	-0.16	0.14
<b>56</b>	11.70	12.20	11.70	12.60	12.10	10.60	10.60	10.60	14.60	10.50	11.72	-0.32	0.39
<b>61</b>	11.90	12.30	10.50	12.90	12.10	10.70	10.90	10.90	14.50	10.90	11.76	-0.28	0.14
<b>64</b>	12.00	12.50	10.80	13.00	12.50	11.00	11.00	10.80	14.90	11.00	11.95	-0.09	0.06
<b>66</b>	12.00	12.40	10.90	13.10	12.40	11.10	11.00	11.00	15.00	11.10	12.00	-0.04	0.09
<b>67</b>	12.00	12.50	10.90	13.00	12.50	11.20	11.00	11.20	14.90	10.90	12.01	-0.03	0.11
<b>68</b>	11.90	12.60	10.80	13.20	12.70	11.19	10.90	10.90	15.10	10.90	12.02	-0.02	0.13
<b>73</b>	12.15	11.80	10.17	12.33	11.86	10.38	10.39	10.26	14.03	10.32	11.37	-0.67	0.13
<b>77a</b>	12.10	12.70	11.00	13.18	12.60	11.00	11.10	11.10	14.90	11.00	12.07	0.03	0.06
<b>79a</b>	12.00	12.60	11.00	13.10	12.60	11.00	11.10	11.00	14.90	11.00	12.03	-0.01	0.06
<b>79b</b>	12.00	12.40	10.70	13.00	12.40	10.80	10.90	11.10	14.80	10.80	11.89	-0.15	0.09
<b>79c</b>	12.00	12.40	10.80	13.10	12.60	11.00	11.00	11.10	14.80	11.10	11.99	-0.05	0.10
<b>80</b>	12.07	12.41	10.77	12.96	12.58	11.01	10.90	10.94	14.96	10.92	11.95	-0.09	0.06
<b>82</b>	12.10	12.47	10.77	13.10	12.40	10.87	10.80	10.87	14.93	10.87	11.92	-0.12	0.07
<b>85</b>	11.60	12.10	10.40	12.80	12.10	10.60	10.70	10.70	14.80	10.60	11.64	-0.40	0.10
<b>91a</b>	12.20	12.70	10.70	13.00	12.50	10.90	10.90	11.00	15.00	10.80	11.97	-0.07	0.12
<b>91b</b>	12.20	12.60	10.90	13.10	12.60	10.90	10.90	10.90	14.90	11.00	12.00	-0.04	0.08
<b>94a</b>	12.00	12.50	10.80	13.10	12.50	10.90	10.90	11.00	15.00	10.90	11.96	-0.08	0.05
<b>94b</b>	11.80	12.40	10.50	12.80	12.30	10.70	10.80	10.70	14.80	10.80	11.76	-0.28	0.07
<b>98</b>	12.10	12.50	10.90	13.20	12.40	11.10	10.90	11.00	14.80	10.90	11.98	-0.06	0.09
<b>100</b>	11.83	12.47	11.07	12.41	12.90	10.23	10.25	10.35	14.52	10.57	11.66	-0.38	0.40
<b>101</b>	12.10	12.40	10.90	12.90	12.50	11.10	10.90	11.00	14.90	11.00	11.97	-0.07	0.09
<b>Average</b>	12.10	12.59	10.91	13.13	12.58	11.05	11.03	11.03	14.99	11.01	12.04	0.00	0.10
<b>Std</b>	0.17	0.21	0.24	0.23	0.21	0.24	0.23	0.23	0.24	0.22	0.19	0.19	0.06

<b>Min</b>	11.6	11.8	10.2	12.3	11.9	10.2	10.3	10.3	14.0	10.3	11.4	-0.7	0.0
<b>Max</b>	12.4	13.0	11.7	13.5	12.9	11.4	11.4	11.5	15.4	11.5	12.4	0.3	0.4

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

<b>Lab Code</b>	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>B4</b>	<b>B5</b>	<b>B6</b>	<b>B7</b>	<b>B8</b>	<b>B9</b>	<b>B10</b>	<b>Mean</b>	<b>Dev</b>	<b>SDD</b>
1	11.10	9.70	11.70	11.40	9.10	11.90	12.20	11.80	11.60	9.90	11.04	-0.01	0.09
2	10.72	8.99	11.57	11.00	8.69	11.37	12.03	11.26	11.28	9.70	10.66	-0.39	0.11
4a	11.45	9.74	11.58	11.50	9.10	11.77	12.03	11.72	11.72	9.72	11.03	-0.02	0.22
4b	11.01	9.57	11.88	11.38	9.26	11.95	12.35	11.82	11.65	9.80	11.07	0.01	0.07
5	10.80	9.50	12.00	11.60	9.30	12.10	12.50	11.70	11.70	10.10	11.13	0.08	0.15
8a	11.10	9.60	11.60	11.30	9.00	11.80	12.30	11.70	11.50	10.00	10.99	-0.06	0.10
8b	10.90	9.60	11.70	11.30	9.20	11.90	12.10	11.70	11.60	9.90	10.99	-0.06	0.10
10	10.90	9.70	11.65	11.20	9.20	11.35	12.10	11.45	11.45	9.90	10.89	-0.16	0.20
11a	11.16	9.39	11.89	11.26	9.12	11.95	12.23	11.84	11.52	10.15	11.05	0.00	0.12
11b	11.64	9.54	11.87	11.56	9.12	11.83	12.28	11.65	11.57	9.87	11.09	0.04	0.21
12	10.90	9.40	11.70	11.30	9.10	11.90	12.20	11.70	11.40	9.50	10.91	-0.14	0.12
15	11.31	10.06	11.94	11.63	9.38	12.19	12.44	11.88	11.75	10.13	11.27	0.22	0.13
17a	11.10	9.50	11.85	11.10	9.00	11.80	12.25	11.55	11.60	9.75	10.95	-0.10	0.11
17b	11.20	9.30	11.80	11.50	9.25	11.90	12.35	11.75	11.55	9.85	11.05	-0.01	0.11
18	11.00	9.40	11.90	11.40	9.20	11.80	12.50	11.80	11.70	10.00	11.07	0.02	0.09
19	10.72	9.39	11.80	11.30	9.12	11.92	12.38	11.71	11.62	9.86	10.98	-0.07	0.11
25	10.80	9.40	12.00	11.40	9.00	11.80	12.10	11.90	11.50	9.70	10.96	-0.09	0.16
26	11.70	10.20	12.00	11.60	9.60	12.20	12.50	11.80	11.90	10.20	11.37	0.32	0.21
27a	11.65	9.85	12.26	11.95	9.57	12.31	12.80	12.43	12.04	10.42	11.53	0.47	0.10
27b	11.28	9.60	12.11	11.83	9.40	12.32	12.49	12.05	11.91	10.40	11.34	0.29	0.12
30a	11.44	9.69	12.09	11.28	9.31	11.94	12.66	11.88	11.94	10.19	11.24	0.19	0.15
30b	11.00	9.50	12.00	11.50	9.00	11.75	12.25	12.00	11.81	10.13	11.09	0.04	0.15
30c	11.25	9.69	12.00	11.63	9.31	12.13	12.38	11.94	11.81	10.38	11.25	0.20	0.10
30d	10.88	9.31	11.63	11.25	9.19	12.00	12.31	11.69	11.69	10.06	11.00	-0.05	0.12
30e	10.88	9.50	11.69	11.25	9.06	11.88	12.56	11.81	11.69	9.94	11.03	-0.03	0.12
30f	11.19	9.50	12.00	11.56	9.06	11.69	12.25	11.88	11.94	10.25	11.13	0.08	0.18
30h	11.13	9.81	11.81	11.44	9.13	11.75	12.50	12.00	11.63	9.81	11.10	0.05	0.15
30i	11.13	9.56	12.06	11.63	9.31	11.88	12.44	11.94	11.94	10.19	11.21	0.15	0.11
30k	10.88	9.63	11.88	11.38	9.13	11.88	12.44	11.75	11.75	9.94	11.07	0.01	0.09
30l	10.81	9.63	11.69	11.38	9.06	11.88	12.25	11.75	11.63	9.81	10.99	-0.06	0.10

<b>32</b>	10.80	9.10	11.60	11.00	8.90	11.60	12.00	11.40	11.20	9.60	10.72	-0.33	0.07
<b>33</b>	11.30	9.50	11.80	11.50	9.60	12.10	12.60	11.90	11.70	10.10	11.21	0.16	0.13
<b>35a</b>	11.60	10.10	12.00	11.60	9.90	12.30	13.50	12.10	11.90	10.40	11.54	0.49	0.29
<b>35b</b>	11.20	9.80	12.10	11.50	9.30	12.00	12.30	11.90	11.90	10.20	11.22	0.17	0.11
<b>35c</b>	11.50	9.90	12.10	11.70	9.50	12.40	12.70	11.80	11.90	10.10	11.36	0.31	0.14
<b>35d</b>	11.70	9.90	12.00	11.60	9.30	12.30	12.50	12.00	11.70	10.10	11.31	0.26	0.17
<b>36</b>	11.10	9.80	11.80	11.50	9.30	12.10	12.40	12.20	11.80	10.00	11.20	0.15	0.13
<b>56</b>	10.20	8.80	11.50	11.00	8.90	11.60	12.10	11.50	11.10	9.40	10.61	-0.44	0.21
<b>61</b>	10.90	9.40	11.50	11.30	8.90	11.60	12.20	11.50	11.30	9.60	10.82	-0.23	0.10
<b>64</b>	10.90	9.50	11.80	11.20	9.20	11.70	12.30	11.90	11.60	9.80	10.99	-0.06	0.11
<b>68</b>	11.14	9.22	11.89	11.36	9.18	12.23	12.33	11.75	11.49	9.85	11.04	-0.01	0.16
<b>77a</b>	11.10	9.80	11.30	11.40	9.20	11.80	11.80	11.60	11.48	9.93	10.94	-0.11	0.25
<b>79a</b>	11.00	9.00	11.30	11.30	8.90	11.70	N/A	11.60	11.60	10.10	10.72	-0.33	0.22
<b>79c</b>	10.80	9.30	11.50	11.40	9.00	11.80	N/A	12.30	11.50	9.80	10.82	-0.23	0.25
<b>80</b>	10.75	9.39	11.86	11.30	9.14	11.99	12.23	11.68	11.71	10.12	11.02	-0.04	0.14
<b>82</b>	10.90	9.30	11.60	11.30	9.05	11.85	12.25	11.75	11.70	9.85	10.96	-0.10	0.09
<b>84</b>	11.00	9.20	11.70	11.00	9.00	11.50	N/A	11.60	11.60	9.80	10.71	-0.34	0.14
<b>85</b>	11.20	9.50	11.70	11.30	8.90	12.10	12.20	11.70	11.60	10.00	11.02	-0.03	0.13
<b>91a</b>	11.00	9.50	11.90	11.25	9.10	11.90	12.35	11.75	11.50	10.00	11.03	-0.03	0.07
<b>91b</b>	10.90	9.32	11.73	11.27	9.06	11.85	12.50	11.61	11.54	9.80	10.96	-0.10	0.10
<b>94a</b>	11.00	9.40	12.00	11.40	9.10	12.00	12.20	11.70	11.40	9.80	11.00	-0.05	0.13
<b>94b</b>	11.00	9.20	11.80	11.60	9.20	12.10	12.40	11.80	11.70	10.10	11.09	0.04	0.15
<b>98</b>	11.00	9.60	12.00	11.30	9.20	12.00	12.70	11.60	11.50	9.80	11.07	0.02	0.17
<b>101</b>	11.10	9.50	11.83	11.40	9.20	11.80	12.30	11.70	11.60	9.90	11.03	-0.02	0.05
<b>Average</b>	11.08	9.52	11.81	11.39	9.17	11.91	12.35	11.78	11.64	9.96	11.05	0.00	0.14
<b>Std</b>	0.28	0.27	0.21	0.20	0.21	0.23	0.25	0.21	0.19	0.22	0.19	0.19	0.05
<b>Min</b>	10.2	8.8	11.3	11.0	8.7	11.4	11.8	11.3	11.1	9.4	10.6	-0.4	0.0
<b>Max</b>	11.7	10.2	12.3	12.0	9.9	12.4	13.5	12.4	12.0	10.4	11.5	0.5	0.3

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

<b>Lab Code</b>	<b>W1</b>	<b>W2</b>	<b>W3</b>	<b>W4</b>	<b>W5</b>	<b>W6</b>	<b>W7</b>	<b>W8</b>	<b>W9</b>	<b>W10</b>	<b>Mean</b>	<b>Dev</b>	<b>SDD</b>
1	10.79	13.07	13.64	12.82	11.04	14.50	11.57	14.91	13.62	13.11	12.9	0.29	0.13
2	11.04	13.30	13.84	13.00	11.33	14.70	11.82	15.19	13.77	13.30	13.1	0.51	0.13
4a	10.65	13.19	13.80	12.87	11.02	14.79	11.58	15.34	13.80	13.26	13.0	0.41	0.19
4b	10.77	13.11	13.67	12.80	11.07	14.57	11.60	15.09	13.63	13.10	12.9	0.32	0.13
5	10.80	13.05	13.60	12.80	11.10	14.40	11.60	14.90	13.50	13.00	12.9	0.26	0.15
8a	10.80	13.00	13.60	12.70	11.00	14.40	11.60	14.90	13.50	13.00	12.9	0.23	0.13
8b	10.70	12.90	13.50	12.70	11.00	14.30	11.50	14.80	13.50	12.90	12.8	0.16	0.13
10	10.30	12.60	13.10	12.30	10.60	13.90	11.10	14.30	13.05	12.70	12.4	-0.22	0.15
11a	10.60	12.95	13.50	12.60	10.88	14.38	11.39	14.78	13.43	12.97	12.7	0.13	0.14
11b	10.57	12.92	13.47	12.59	10.86	14.34	11.37	14.74	13.42	12.93	12.7	0.10	0.14
12	10.80	13.10	13.60	12.80	11.10	14.50	11.60	15.00	13.50	13.10	12.9	0.29	0.13
15	10.90	13.20	13.70	12.90	11.20	14.50	11.70	15.00	13.50	13.10	13.0	0.35	0.17
17a	10.80	13.20	13.60	12.80	11.10	14.50	11.65	14.85	13.60	13.20	12.9	0.31	0.15
17b	10.80	13.10	13.60	12.80	11.10	14.40	11.65	14.80	13.60	13.20	12.9	0.29	0.14
18	10.50	12.70	13.30	12.40	10.70	14.10	11.20	14.50	13.10	12.70	12.5	-0.10	0.15
19	10.90	13.17	13.69	12.87	11.18	14.57	11.69	15.04	13.64	13.10	13.0	0.37	0.13
25	10.60	12.90	13.50	12.60	10.90	14.30	11.40	14.80	13.40	12.90	12.7	0.11	0.13
26	10.80	13.20	13.70	12.80	11.10	14.60	11.70	15.20	13.60	13.30	13.0	0.38	0.14
27a	10.64	12.76	13.33	12.53	10.95	14.23	11.42	14.65	13.28	12.77	12.7	0.04	0.14
27b	10.72	12.80	13.34	12.61	11.00	14.17	11.44	14.62	13.27	12.78	12.7	0.06	0.16
30a	10.30	12.70	13.20	12.40	10.60	14.00	12.30	14.40	13.10	12.70	12.6	-0.05	0.38
30b	10.42	12.68	13.20	12.38	10.75	14.03	11.20	14.50	13.16	12.60	12.5	-0.13	0.14
30c	10.43	12.64	13.17	12.33	10.71	13.98	11.17	14.46	13.14	12.56	12.5	-0.16	0.14
30d	10.32	12.57	13.13	12.28	10.62	13.97	11.12	14.42	13.09	12.55	12.4	-0.21	0.13
30e	10.31	12.55	13.09	12.30	10.61	13.97	11.07	14.39	13.04	12.52	12.4	-0.23	0.13
30f	10.30	12.54	13.08	12.24	10.62	13.92	11.08	14.41	13.02	12.50	12.4	-0.25	0.13
30h	10.38	12.56	13.13	12.30	10.66	13.94	11.12	14.42	13.11	12.54	12.4	-0.20	0.13
30i	10.30	12.52	13.08	12.21	10.59	13.91	11.09	14.38	13.04	12.54	12.4	-0.25	0.12

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb-Apr 2023

<b>30k</b>	10.30	12.55	13.03	12.24	10.61	13.91	11.11	14.38	13.03	12.51	12.4	-0.25	0.13
<b>30l</b>	10.46	12.65	13.17	12.35	10.75	13.99	11.22	14.44	13.11	12.57	12.5	-0.15	0.15
<b>33</b>	11.00	13.30	13.80	13.00	11.20	14.60	11.70	15.00	13.70	13.20	13.1	0.43	0.17
<b>35a</b>	10.80	13.10	13.60	12.90	11.10	14.40	11.70	14.90	13.60	13.20	12.9	0.31	0.14
<b>35b</b>	10.90	13.10	13.60	12.80	11.10	14.40	11.70	14.80	13.60	13.20	12.9	0.30	0.14
<b>35c</b>	10.90	13.10	13.60	12.80	11.10	14.40	11.70	14.80	13.60	13.20	12.9	0.30	0.14
<b>35d</b>	10.80	13.10	13.50	12.80	11.10	14.40	11.50	14.90	13.60	13.20	12.9	0.27	0.13
<b>36</b>	10.60	12.60	13.00	12.20	10.70	13.90	11.20	14.20	13.00	12.70	12.4	-0.21	0.19
<b>56</b>	10.90	13.10	13.70	12.80	11.20	14.50	11.60	15.00	13.50	13.10	12.9	0.32	0.15
<b>61</b>	10.90	13.20	13.80	12.90	11.20	14.60	11.70	15.10	13.70	13.20	13.0	0.41	0.13
<b>64</b>	10.99	13.14	13.72	12.89	11.30	14.59	11.74	14.96	13.63	13.18	13.0	0.40	0.13
<b>66</b>	9.40	9.80	11.20	10.90	9.80	14.30	10.30	14.80	13.40	12.80	11.7	-0.95	0.96
<b>67</b>	10.60	12.90	13.50	12.60	10.90	14.30	11.50	14.70	13.40	12.90	12.7	0.11	0.14
<b>68</b>	10.20	12.40	12.90	12.20	10.50	13.80	11.00	14.40	12.90	12.50	12.3	-0.34	0.11
<b>73</b>	10.83	13.10	13.65	12.85	11.00	14.45	11.60	14.80	13.70	13.20	12.9	0.30	0.11
<b>77a</b>	10.90	13.10	13.60	12.80	11.00	14.30	11.80	14.70	13.60	13.10	12.9	0.27	0.19
<b>79a</b>	9.40	9.80	11.10	10.90	9.80	14.40	10.40	14.90	13.40	12.90	11.7	-0.92	1.00
<b>79b</b>	9.30	9.70	11.00	10.90	9.70	14.20	10.40	14.70	13.30	12.80	11.6	-1.02	0.97
<b>79c</b>	9.30	9.70	11.00	10.90	9.70	14.30	10.30	14.80	13.40	12.90	11.6	-0.99	1.01
<b>80</b>	9.61	9.97	11.62	11.18	10.06	14.59	10.63	15.06	13.61	13.11	11.9	-0.67	0.96
<b>82</b>	9.50	10.10	11.63	11.30	10.00	14.60	10.60	15.03	13.60	13.17	12.0	-0.66	0.93
<b>85</b>	9.30	9.90	11.00	11.00	9.70	14.20	10.40	14.70	13.30	12.90	11.6	-0.98	0.94
<b>91a</b>	10.90	13.20	13.70	12.90	11.20	14.60	11.70	15.10	13.70	13.20	13.0	0.40	0.12
<b>91b</b>	10.90	13.20	13.80	12.90	11.20	14.60	11.70	15.10	13.70	13.20	13.0	0.41	0.13
<b>94a</b>	10.70	13.00	13.50	12.70	11.00	14.40	11.50	14.90	13.50	13.00	12.8	0.20	0.12
<b>94b</b>	10.60	12.90	13.50	12.60	11.00	14.40	11.50	14.90	13.40	12.70	12.8	0.13	0.17
<b>98</b>	10.00	12.20	12.90	11.90	10.30	13.70	10.80	14.10	12.70	12.20	12.1	-0.54	0.14
<b>100</b>	12.10	12.60	12.40	13.00	12.40	12.00	12.20	12.10	13.20	13.00	12.5	-0.12	1.43
<b>101</b>	10.94	13.18	13.70	12.87	11.23	14.53	11.69	15.02	13.58	13.09	13.0	0.37	0.15
<b>Average</b>	10.53	12.54	13.16	12.44	10.83	14.27	11.36	14.72	13.40	12.93	12.62	0.00	0.27
<b>Std</b>	0.52	1.05	0.79	0.60	0.48	0.40	0.45	0.45	0.26	0.27	0.42	0.42	0.32

<b>Min</b>	9.3	9.7	11.0	10.9	9.7	12.0	10.3	12.1	12.7	12.2	11.6	-1.0	0.1
<b>Max</b>	12.1	13.3	13.8	13.0	12.4	14.8	12.3	15.3	13.8	13.3	13.1	0.5	1.4

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

<b>Lab Code</b>	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>B4</b>	<b>B5</b>	<b>B6</b>	<b>B7</b>	<b>B8</b>	<b>B9</b>	<b>B10</b>	<b>Mean</b>	<b>Dev</b>	<b>SDD</b>
1	13.98	14.95	11.83	12.22	11.95	12.70	11.60	13.37	13.31	13.02	12.9	0.18	0.12
2	14.19	14.57	11.78	12.16	11.89	12.65	11.67	13.36	13.21	12.89	12.8	0.12	0.11
4a	14.18	14.60	11.93	12.41	12.08	13.09	11.93	13.45	13.36	13.21	13.0	0.31	0.12
4b	14.07	14.46	11.86	12.18	11.95	12.64	11.64	13.30	13.18	13.07	12.8	0.12	0.11
5	14.35	14.70	11.90	12.25	12.00	12.65	11.65	13.35	13.20	12.95	12.9	0.19	0.16
8a	13.90	14.60	11.80	12.20	11.90	12.60	11.60	13.20	13.20	12.90	12.8	0.08	0.06
8b	14.00	14.50	11.70	12.20	11.90	12.60	11.50	13.30	13.20	12.90	12.8	0.07	0.09
10	13.60	14.25	12.00	12.40	12.00	12.70	11.80	13.40	13.30	13.00	12.8	0.13	0.19
11a	13.75	14.53	11.76	12.15	11.91	12.57	11.61	13.31	13.22	13.01	12.8	0.07	0.07
11b	13.74	14.55	11.70	12.09	11.86	12.49	11.51	13.28	13.21	12.94	12.7	0.02	0.07
12	14.00	14.60	11.80	12.20	11.90	12.60	11.60	13.40	13.20	13.00	12.8	0.12	0.08
15	14.10	14.70	11.90	12.30	12.00	12.80	11.80	13.40	13.20	13.00	12.9	0.21	0.07
17a	14.15	14.55	11.85	12.15	11.90	12.70	11.65	13.30	13.20	12.95	12.8	0.13	0.11
17b	14.30	14.40	11.80	12.10	12.00	12.80	11.60	13.20	13.15	12.90	12.8	0.11	0.18
18	14.10	14.70	11.80	12.10	11.80	12.80	11.60	13.20	13.10	12.80	12.8	0.09	0.14
19	14.05	14.69	11.88	12.30	11.95	12.71	11.74	13.41	13.37	13.03	12.9	0.20	0.05
25	14.00	14.40	11.80	12.30	11.90	12.70	11.60	13.20	13.10	12.80	12.8	0.07	0.11
26	14.00	14.60	11.90	12.20	11.90	12.60	11.60	13.30	13.30	13.00	12.8	0.13	0.09
27a	13.75	14.38	11.64	12.01	11.85	12.57	11.48	13.15	13.07	12.80	12.7	-0.04	0.09
27b	13.81	14.49	11.71	12.07	11.91	12.58	11.74	13.19	13.16	13.00	12.8	0.05	0.06
30a	14.10	14.40	11.80	12.10	11.90	12.60	11.60	13.40	13.20	12.90	12.8	0.09	0.12
30b	14.01	14.59	11.94	12.31	12.09	12.74	11.74	13.42	13.29	13.04	12.9	0.20	0.07
30c	13.59	14.25	11.41	11.75	11.54	12.28	11.41	12.90	12.77	12.56	12.4	-0.27	0.06
30d	13.73	14.27	11.49	11.85	11.58	12.33	11.29	12.94	12.83	12.65	12.5	-0.22	0.08

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<b>30e</b>	13.36	13.95	11.19	11.66	11.34	12.11	11.03	12.77	12.67	12.40	12.2	-0.46	0.06
<b>30f</b>	13.45	14.06	11.33	11.76	11.50	12.23	11.16	12.84	12.72	12.51	12.4	-0.36	0.06
<b>30h</b>	14.48	14.47	11.72	12.03	11.82	12.62	11.52	13.24	13.17	12.91	12.8	0.09	0.23
<b>30i</b>	13.59	14.11	11.44	11.82	11.54	12.31	11.29	12.93	12.84	12.55	12.4	-0.27	0.06
<b>30k</b>	13.42	14.04	11.20	11.66	11.36	12.03	11.12	12.70	12.56	12.34	12.2	-0.47	0.06
<b>30l</b>	14.37	14.92	11.72	12.11	11.89	12.56	11.59	13.17	13.09	12.85	12.8	0.11	0.22
<b>32</b>	14.10	14.50	11.80	12.10	11.80	12.60	11.60	13.30	13.10	12.90	12.8	0.07	0.11
<b>33</b>	14.30	14.60	12.00	12.20	12.00	12.80	11.70	13.40	13.30	13.00	12.9	0.22	0.14
<b>35a</b>	14.30	14.80	12.10	12.40	12.50	13.00	12.20	13.50	13.50	13.20	13.2	0.44	0.13
<b>35b</b>	14.10	14.50	11.90	12.30	12.10	12.90	12.00	13.40	13.40	13.10	13.0	0.26	0.11
<b>35c</b>	14.00	14.60	12.00	12.30	12.10	12.70	11.70	13.40	13.30	13.10	12.9	0.21	0.09
<b>35d</b>	14.30	14.70	12.00	12.40	12.10	13.10	11.90	13.50	13.40	13.10	13.1	0.34	0.12
<b>36</b>	13.10	13.90	11.70	12.00	11.70	12.30	11.40	12.90	13.00	12.70	12.5	-0.24	0.23
<b>56</b>	14.20	14.60	11.80	12.20	11.90	12.80	11.70	13.30	13.20	13.00	12.9	0.16	0.11
<b>61</b>	13.80	14.50	11.80	12.10	11.90	12.60	11.60	13.30	13.20	12.90	12.8	0.06	0.06
<b>64</b>	13.91	14.61	11.75	12.12	11.88	12.63	11.59	13.29	13.11	12.90	12.8	0.07	0.06
<b>68</b>	14.70	14.30	11.70	12.00	11.80	12.50	11.60	13.20	13.00	12.70	12.8	0.04	0.32
<b>77a</b>	13.90	14.40	11.80	12.20	12.00	12.60	11.80	13.20	13.20	13.00	12.8	0.10	0.09
<b>79a</b>	9.90	14.30	9.40	11.70	10.60	11.20	N/A	12.40	12.70	11.80	11.6	-1.16	1.15
<b>79c</b>	10.30	14.20	9.30	11.70	10.50	11.10	N/A	11.70	12.60	11.40	11.4	-1.29	1.01
<b>80</b>	14.15	14.88	11.89	12.34	11.94	12.84	11.79	13.41	13.31	12.98	13.0	0.24	0.09
<b>82</b>	14.18	14.65	11.95	12.35	12.00	12.80	11.90	13.45	13.35	13.10	13.0	0.26	0.07
<b>84</b>	9.60	14.20	9.30	11.60	10.50	11.20	N/A	12.30	12.70	11.50	11.4	-1.28	1.21
<b>85</b>	13.90	14.40	11.60	12.00	11.90	12.50	11.80	13.20	13.10	12.90	12.7	0.02	0.10
<b>91a</b>	14.05	14.70	11.80	12.20	12.20	12.65	11.65	13.35	13.40	13.10	12.9	0.20	0.11
<b>91b</b>	14.57	14.86	11.94	12.33	12.03	12.79	11.72	13.45	13.35	13.06	13.0	0.30	0.19
<b>94a</b>	14.10	14.50	11.60	12.00	11.80	12.60	11.50	13.10	13.00	12.70	12.7	-0.02	0.14
<b>94b</b>	14.00	14.60	11.70	12.10	11.80	12.60	11.50	13.20	13.10	12.90	12.8	0.04	0.09
<b>98</b>	13.80	14.40	11.70	12.10	11.80	12.60	11.60	13.30	13.30	12.90	12.8	0.04	0.07
<b>101</b>	14.10	14.60	11.93	12.24	11.96	12.68	11.72	13.36	13.22	12.96	12.9	0.16	0.08
<b>Average</b>	13.77	14.49	11.63	12.11	11.81	12.55	11.62	13.19	13.13	12.83	12.71	0.00	0.17

<b>Std</b>	0.99	0.23	0.59	0.21	0.37	0.39	0.21	0.33	0.22	0.36	0.36	0.36	0.24
<b>Min</b>	9.6	13.9	9.3	11.6	10.5	11.1	11.0	11.7	12.6	11.4	11.4	-1.3	0.1
<b>Max</b>	14.7	15.0	12.1	12.4	12.5	13.1	12.2	13.5	13.5	13.2	13.2	0.4	1.2

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

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

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1a	12.04	12.57	10.93	13.05	12.52	11.12	11.01	11.14	15.11	11.08	12.06	0.08	0.07
1b	12.03	12.57	10.73	12.99	12.55	11.04	10.90	10.93	15.10	11.04	11.99	0.01	0.07
2	12.00	12.54	10.82	13.15	12.52	11.07	10.98	10.89	14.92	10.96	11.99	0.01	0.04
4a	11.98	12.44	10.81	13.03	12.47	11.07	11.01	10.94	14.97	10.95	11.97	-0.01	0.03
4b	12.11	12.55	10.88	13.03	12.41	11.05	11.10	10.86	14.91	10.97	11.99	0.01	0.08
5	12.03	12.52	10.93	13.09	12.59	11.01	11.04	10.86	14.93	11.01	12.00	0.02	0.06
8a	12.00	12.47	10.72	12.95	12.58	11.04	10.93	10.97	14.97	11.04	11.97	-0.01	0.06
8b	11.99	12.50	10.80	13.08	12.55	11.13	11.01	10.93	15.09	11.06	12.01	0.03	0.04
10	12.12	12.65	10.77	13.12	12.46	10.99	10.99	10.88	14.92	10.93	11.98	0.01	0.08
11a	12.09	12.54	10.79	13.09	12.56	11.05	11.11	10.88	15.08	10.90	12.01	0.03	0.06
11b	11.97	12.61	10.93	13.06	12.54	11.13	11.10	11.10	15.07	10.93	12.04	0.07	0.08
11d	11.94	12.42	10.86	13.11	12.53	11.00	10.95	10.90	15.10	10.85	11.97	-0.01	0.08
11e	11.92	12.50	10.89	13.01	12.49	10.95	11.02	10.88	15.04	11.00	11.97	-0.01	0.06
12	11.90	12.54	10.73	13.17	12.44	11.07	10.82	10.86	14.92	10.93	11.94	-0.04	0.08
15	11.98	12.48	10.77	13.14	12.55	11.00	11.04	10.87	14.97	11.11	11.99	0.01	0.05
17a	11.96	12.57	10.78	13.12	12.40	11.09	10.89	10.87	14.89	10.96	11.95	-0.03	0.07
17b	12.11	12.59	10.82	13.12	12.54	11.12	10.97	10.96	14.91	11.01	12.02	0.04	0.06
18	12.05	12.50	10.79	13.05	12.41	11.06	10.99	10.82	15.03	11.06	11.98	0.00	0.06
19	11.98	12.47	10.74	13.04	12.53	10.95	10.93	10.92	14.89	10.95	11.94	-0.04	0.04
25	11.88	12.51	10.61	13.07	12.51	11.24	10.83	11.14	15.10	10.91	11.98	0.00	0.14
26	11.99	12.59	10.69	13.11	12.51	11.10	11.10	10.88	15.12	11.03	12.01	0.03	0.07
27a	12.02	12.65	11.01	13.06	12.66	10.98	11.15	11.03	15.15	10.88	12.06	0.08	0.11
27b	12.10	12.49	10.94	13.19	12.56	11.08	11.07	10.97	14.96	10.79	12.01	0.04	0.10
30a	11.97	12.60	10.90	13.11	12.54	11.12	11.01	10.95	14.98	11.13	12.03	0.05	0.05
30b	11.93	12.39	10.75	13.06	12.58	10.88	11.11	10.86	14.84	10.98	11.94	-0.04	0.08
30c	12.09	12.41	10.75	13.05	12.50	11.03	11.03	10.91	15.05	11.10	11.99	0.02	0.06
30d	11.92	12.41	10.81	13.01	12.52	10.89	10.99	10.80	14.92	10.93	11.92	-0.06	0.05

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30e	11.93	12.53	10.62	13.08	12.54	10.95	11.04	10.81	15.06	11.02	11.96	-0.02	0.08
30f	11.94	12.53	10.80	13.03	12.52	11.09	11.05	10.95	14.85	11.17	11.99	0.01	0.08
30h	12.08	12.36	10.99	12.91	12.60	11.00	11.11	10.97	14.84	11.05	11.99	0.01	0.12
30i	12.00	12.47	10.79	13.01	12.56	10.99	11.12	10.77	15.06	10.91	11.97	-0.01	0.08
30k	11.98	12.47	10.93	13.12	12.68	11.05	10.91	11.01	14.98	11.28	12.04	0.06	0.11
30l	11.93	12.46	10.70	13.13	12.63	10.99	11.11	10.97	15.06	11.03	12.00	0.03	0.07
33	12.07	12.53	10.73	13.06	12.51	11.02	10.99	10.93	14.89	11.08	11.98	0.00	0.06
35a	11.95	12.59	10.71	13.20	12.49	11.12	11.05	10.97	15.14	11.12	12.03	0.06	0.08
35b	11.94	12.50	10.81	13.13	12.52	11.00	10.97	10.91	14.92	11.07	11.98	0.00	0.04
35a	11.96	12.48	10.88	13.10	12.52	11.07	11.04	10.91	15.04	10.98	12.00	0.02	0.04
35d	12.02	12.54	10.98	13.09	12.58	11.10	11.01	10.94	14.91	10.96	12.01	0.03	0.07
36	11.98	12.51	10.65	13.12	12.58	11.05	11.15	10.86	15.02	10.90	11.98	0.00	0.08
56	11.99	12.47	10.74	12.96	12.46	11.06	10.99	10.88	14.87	10.98	11.94	-0.04	0.04
61	11.98	12.49	10.68	13.07	12.28	10.89	11.05	10.91	14.62	11.02	11.90	-0.08	0.13
64	12.00	12.58	10.85	13.06	12.57	11.14	11.08	10.97	14.98	11.03	12.03	0.05	0.04
66	11.91	12.29	10.76	12.95	12.35	11.03	10.97	10.75	14.85	10.99	11.89	-0.09	0.07
67	12.00	12.47	10.79	13.17	12.55	10.92	11.17	10.91	15.02	10.85	11.99	0.01	0.09
68	11.79	12.52	10.64	13.02	12.62	11.06	10.79	10.72	14.96	10.81	11.89	-0.09	0.11
73	11.97	12.54	10.91	13.11	12.46	11.24	10.93	11.04	15.02	10.98	12.02	0.04	0.11
77a	12.05	12.51	10.87	13.19	12.51	11.11	10.84	10.94	15.22	10.95	12.02	0.04	0.11
79a	11.96	12.59	11.01	13.02	12.59	10.99	11.08	10.96	14.88	10.93	12.00	0.02	0.10
79b	11.94	12.32	10.70	12.99	12.38	11.04	10.89	11.12	14.83	10.83	11.91	-0.07	0.11
79c	11.97	12.37	10.70	13.02	12.57	11.11	10.98	11.00	14.75	11.01	11.95	-0.03	0.10
80	11.82	12.23	10.65	12.89	12.47	10.95	10.93	10.85	14.99	10.95	11.87	-0.10	0.08
82	11.93	12.34	10.71	13.02	12.35	10.97	10.80	10.86	14.96	10.96	11.89	-0.09	0.06
85	11.80	12.30	10.63	12.97	12.39	10.80	11.01	10.83	15.07	10.86	11.87	-0.11	0.10
91a	12.07	12.57	10.59	13.01	12.47	10.89	10.96	10.89	15.03	10.90	11.94	-0.04	0.09
91b	11.96	12.49	10.82	13.10	12.52	11.00	10.94	10.85	14.99	11.04	11.97	-0.01	0.04
94a	11.93	12.49	10.87	13.07	12.51	10.93	10.97	10.89	15.02	11.02	11.97	-0.01	0.05
94b	11.77	12.65	10.70	13.08	12.53	11.13	11.04	10.79	14.99	10.89	11.96	-0.02	0.11
98	12.03	12.55	10.69	13.17	12.42	10.90	11.08	10.85	14.88	10.95	11.95	-0.03	0.09
100	12.11	12.53	10.93	12.87	12.65	11.15	11.06	11.26	15.07	11.18	12.08	0.10	0.13

101	12.07	12.42	10.87	13.02	12.61	11.15	10.99	10.91	15.00	11.08	12.01	0.04	0.07
<b>Average</b>	11.98	12.50	10.79	13.06	12.52	11.04	11.00	10.92	14.98	10.99	11.98	0.00	0.08
<b>Std</b>	0.08	0.09	0.11	0.07	0.08	0.09	0.09	0.10	0.11	0.09	0.05	0.05	0.03
<b>Min</b>	11.8	12.2	10.6	12.9	12.3	10.8	10.8	10.7	14.6	10.8	11.9	-0.1	0.0
<b>Max</b>	12.1	12.7	11.0	13.2	12.7	11.2	11.2	11.3	15.2	11.3	12.1	0.1	0.1

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

Lab Code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Mean	Dev	SDD
1a	11.00	9.51	11.71	11.45	9.02	12.05	12.30	11.80	11.57	9.86	11.0	0.03	0.06
1b	10.75	9.59	11.77	11.53	9.23	12.01	12.41	11.88	11.54	9.95	11.1	0.06	0.11
2	11.00	9.40	11.85	11.37	9.07	11.77	12.43	11.63	11.45	10.02	11.0	0.00	0.10
4a	11.22	9.72	11.55	11.60	9.08	11.70	12.08	11.76	11.56	9.74	11.0	0.00	0.18
4b	10.98	9.53	11.86	11.48	9.11	12.03	12.40	11.85	11.56	9.71	11.1	0.05	0.09
5	10.94	9.42	11.73	11.38	9.04	11.86	12.25	11.62	11.46	9.92	11.0	-0.04	0.05
8a	11.08	9.46	11.68	11.31	9.02	11.92	12.31	11.72	11.44	9.91	11.0	-0.02	0.06
8b	11.03	9.60	11.68	11.38	9.20	11.82	12.33	11.83	11.46	9.86	11.0	0.02	0.07
10	11.06	9.33	11.89	11.40	9.09	11.74	12.43	11.66	11.65	9.79	11.0	0.00	0.12
11a	11.16	9.39	11.89	11.26	9.12	11.95	12.23	11.84	11.52	10.15	11.1	0.05	0.13
11b	11.64	9.54	11.87	11.56	9.12	11.83	12.28	11.65	11.57	9.87	11.1	0.09	0.21
11d	10.70	9.35	11.65	11.45	9.01	11.80	12.36	11.73	11.52	9.84	10.9	-0.06	0.10
11e	11.19	9.55	11.81	11.43	9.22	11.82	12.29	11.86	11.47	9.90	11.1	0.05	0.08
12	10.89	9.42	11.62	11.29	9.09	11.93	12.17	11.68	11.31	9.68	10.9	-0.09	0.08
15	11.39	9.74	11.61	11.48	9.07	12.07	12.28	11.61	11.60	9.99	11.1	0.08	0.17
17a	11.01	9.36	11.83	11.24	8.99	11.79	12.34	11.67	11.48	9.76	10.9	-0.05	0.09
17b	10.86	9.26	11.74	11.52	8.96	11.95	12.38	11.88	11.42	9.85	11.0	-0.02	0.11
18	10.90	9.65	11.81	11.49	9.25	11.89	12.40	11.76	11.51	9.97	11.1	0.06	0.08
19	10.71	9.35	11.73	11.35	9.07	12.08	12.31	11.72	11.49	9.91	11.0	-0.03	0.12
25	10.89	9.31	11.91	11.48	9.00	11.82	12.19	11.94	11.43	9.69	11.0	-0.03	0.13
26	11.07	9.61	11.69	11.43	9.23	11.91	12.22	11.62	11.57	9.94	11.0	0.03	0.09
27a	11.45	9.48	11.89	11.56	9.18	11.97	12.51	12.07	11.66	9.32	11.1	0.11	0.27
27b	11.31	9.47	11.91	11.69	9.20	12.17	12.34	11.87	11.72	9.90	11.2	0.16	0.12
30a	11.18	9.57	11.75	11.30	9.01	11.93	12.28	11.82	11.51	9.88	11.0	0.02	0.09
30b	10.86	9.37	11.81	11.41	8.87	11.65	12.11	11.82	11.47	9.95	10.9	-0.07	0.11
30c	10.96	9.54	11.77	11.46	9.07	11.98	12.17	11.77	11.45	10.12	11.0	0.03	0.09
30d	10.82	9.34	11.31	11.58	9.14	11.89	12.27	11.63	11.48	10.05	11.0	-0.05	0.18

<b>30e</b>	10.80	9.50	11.61	11.25	9.05	11.82	12.48	11.74	11.47	9.92	11.0	-0.04	0.11
<b>30f</b>	11.11	9.50	11.91	11.59	9.04	11.62	12.30	11.87	11.78	10.19	11.1	0.09	0.16
<b>30h</b>	11.06	9.74	11.80	11.46	9.12	11.74	12.44	11.97	11.49	9.79	11.1	0.06	0.13
<b>30i</b>	10.91	9.42	11.88	11.52	9.14	11.72	12.30	11.84	11.60	10.02	11.0	0.03	0.10
<b>30k</b>	10.88	9.65	11.78	11.40	9.11	11.85	12.43	11.76	11.61	9.98	11.0	0.04	0.09
<b>30l</b>	10.83	9.52	11.70	11.45	9.15	11.81	12.24	11.80	11.53	9.85	11.0	-0.01	0.07
<b>32</b>	11.16	9.41	11.78	11.33	9.10	11.98	12.34	11.65	11.49	9.98	11.0	0.02	0.09
<b>33</b>	11.01	9.45	11.56	11.36	9.39	11.93	12.32	11.77	11.51	9.93	11.0	0.02	0.12
<b>35a</b>	11.02	9.55	11.65	11.30	9.08	11.79	12.01	11.74	11.34	9.91	10.9	-0.06	0.11
<b>35b</b>	10.74	9.51	11.87	11.33	9.06	11.80	12.06	11.76	11.51	9.98	11.0	-0.04	0.13
<b>35a</b>	10.96	9.52	11.80	11.50	9.06	12.04	12.43	11.76	11.55	9.88	11.1	0.05	0.07
<b>35d</b>	11.19	9.45	11.78	11.41	9.04	12.01	12.28	11.82	11.43	9.88	11.0	0.03	0.08
<b>36</b>	10.74	9.58	11.74	11.38	9.08	11.91	12.23	11.98	11.66	9.79	11.0	0.01	0.13
<b>56</b>	10.70	9.19	11.82	11.39	9.13	11.91	12.42	11.82	11.48	9.82	11.0	-0.03	0.14
<b>61</b>	11.10	9.48	11.65	11.43	9.01	11.78	12.41	11.65	11.38	9.70	11.0	-0.04	0.10
<b>64</b>	10.94	9.38	11.71	11.31	9.12	11.67	12.28	11.88	11.47	9.90	11.0	-0.03	0.09
<b>68</b>	11.22	9.20	11.74	11.23	8.79	12.14	12.10	11.70	11.38	9.60	10.9	-0.09	0.20
<b>77a</b>	11.26	9.76	11.39	11.73	9.10	12.10	12.14	11.90	11.42	9.90	11.1	0.07	0.22
<b>79a</b>	10.99	9.16	11.42	11.43	8.99	11.83	12.23	11.73	11.53	10.02	10.9	-0.07	0.14
<b>79c</b>	10.63	9.32	11.53	11.51	9.04	11.86	12.23	11.74	11.35	9.89	10.9	-0.09	0.13
<b>80</b>	10.79	9.56	11.79	11.38	9.13	12.02	12.31	11.71	11.55	10.11	11.0	0.03	0.11
<b>82</b>	10.81	9.28	11.46	11.28	8.98	11.75	12.18	11.70	11.49	9.76	10.9	-0.13	0.07
<b>84</b>	11.03	9.52	11.77	11.18	8.98	11.61	12.23	11.75	11.59	9.90	11.0	-0.04	0.12
<b>85</b>	11.05	9.61	11.59	11.39	8.91	12.05	12.18	11.74	11.41	10.06	11.0	0.00	0.13
<b>91a</b>	10.99	9.46	11.81	11.27	9.00	11.83	12.31	11.76	11.44	9.92	11.0	-0.02	0.06
<b>91b</b>	10.87	9.25	11.70	11.33	9.08	11.89	12.53	11.69	11.44	9.85	11.0	-0.04	0.12
<b>94a</b>	10.91	9.39	11.83	11.48	9.10	11.98	12.26	11.76	11.44	9.88	11.0	0.00	0.06
<b>94b</b>	10.60	9.21	11.73	11.43	9.07	11.90	12.32	11.77	11.55	9.86	10.9	-0.06	0.14
<b>98</b>	10.97	9.39	11.82	11.26	8.82	11.68	12.01	11.76	11.43	9.98	10.9	-0.09	0.13
<b>101</b>	11.00	9.41	11.82	11.43	9.23	11.89	12.39	11.74	11.45	9.99	11.0	0.03	0.07
<b>Average</b>	10.99	9.46	11.73	11.41	9.08	11.88	12.29	11.77	11.50	9.89	11.00	0.00	0.11
<b>Std</b>	0.20	0.14	0.13	0.11	0.10	0.13	0.12	0.10	0.09	0.14	0.06	0.06	0.04

<b>Min</b>	10.6	9.2	11.3	11.2	8.8	11.6	12.0	11.6	11.3	9.3	10.9	-0.1	0.0
<b>Max</b>	11.6	9.8	11.9	11.7	9.4	12.2	12.5	12.1	11.8	10.2	11.2	0.2	0.3

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

Lab Code	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Mean	Dev	SDD
1a	10.59	12.86	13.44	12.60	10.84	14.30	11.36	14.71	13.40	12.91	12.7	0.13	0.11
1b	10.67	12.87	13.45	12.61	10.92	14.28	11.42	14.70	13.34	12.91	12.7	0.15	0.12
2	10.69	12.95	13.50	12.64	10.95	14.35	11.46	14.79	13.40	12.99	12.8	0.20	0.11
4a	10.55	12.87	13.44	12.57	10.86	14.32	11.40	14.77	13.41	12.96	12.7	0.15	0.10
4b	10.64	12.91	13.42	12.58	10.89	14.29	11.43	14.74	13.38	12.92	12.7	0.15	0.11
5	10.64	12.88	13.45	12.60	10.90	14.25	11.39	14.69	13.33	12.88	12.7	0.13	0.13
8a	10.67	12.93	13.49	12.62	10.91	14.29	11.44	14.73	13.37	12.93	12.7	0.17	0.13
8b	10.63	12.87	13.43	12.57	10.87	14.22	11.38	14.67	13.37	12.87	12.7	0.12	0.12
10	10.73	13.05	13.58	12.73	11.03	14.42	11.58	14.87	13.47	13.11	12.9	0.29	0.12
11a	10.60	12.95	13.50	12.60	10.88	14.38	11.39	14.78	13.43	12.97	12.7	0.18	0.12
11b	10.57	12.92	13.47	12.59	10.86	14.34	11.37	14.74	13.42	12.93	12.7	0.15	0.12
11d	10.62	12.88	13.36	12.52	10.87	14.19	11.38	13.34	13.26	12.75	12.5	-0.05	0.47
11e	10.59	12.86	13.32	12.52	10.85	14.17	11.36	14.49	13.27	12.77	12.6	0.05	0.15
12	10.69	13.01	13.53	12.68	10.98	14.42	11.47	14.86	13.40	13.03	12.8	0.24	0.12
15	10.69	12.99	13.50	12.64	10.96	14.30	11.47	14.72	13.31	12.96	12.8	0.18	0.15
17a	10.60	12.92	13.44	12.57	10.88	14.32	11.39	14.69	13.38	12.93	12.7	0.14	0.12
17b	10.58	12.86	13.39	12.52	10.87	14.23	11.39	14.62	13.27	12.86	12.7	0.09	0.13
18	10.67	12.92	13.49	12.59	10.93	14.31	11.45	14.71	13.38	12.88	12.7	0.16	0.13
19	10.65	12.93	13.45	12.62	10.92	14.31	11.43	14.74	13.38	12.91	12.7	0.16	0.12
25	10.65	12.95	13.52	12.63	10.91	14.31	11.44	14.77	13.42	12.96	12.8	0.19	0.12
26	10.65	12.93	13.45	12.61	10.93	14.29	11.45	14.71	13.36	12.90	12.7	0.16	0.13
27a	10.66	12.79	13.33	12.55	10.94	14.24	11.43	14.62	13.29	12.80	12.7	0.09	0.12
27b	10.72	12.80	13.37	12.60	10.97	14.15	11.45	14.58	13.26	12.81	12.7	0.10	0.16
30a	10.64	12.94	13.48	12.62	10.94	14.33	11.47	14.75	13.38	12.97	12.8	0.18	0.12
30b	10.65	12.90	13.41	12.59	10.92	14.22	11.41	14.66	13.35	12.84	12.7	0.12	0.14
30c	10.63	12.87	13.39	12.55	10.90	14.18	11.40	14.62	13.33	12.84	12.7	0.10	0.13
30d	10.64	12.90	13.46	12.58	10.93	14.26	11.42	14.68	13.37	12.87	12.7	0.14	0.13
30e	10.63	12.88	13.39	12.57	10.89	14.27	11.38	14.66	13.33	12.88	12.7	0.12	0.12

<b>30f</b>	10.63	12.87	13.39	12.56	10.90	14.23	11.40	14.68	13.32	12.86	12.7	0.11	0.12
<b>30h</b>	10.59	12.79	13.34	12.51	10.84	14.14	11.34	14.59	13.29	12.79	12.6	0.05	0.12
<b>30i</b>	10.62	12.86	13.39	12.54	10.88	14.21	11.41	14.65	13.35	12.87	12.7	0.11	0.12
<b>30k</b>	10.64	12.88	13.36	12.55	10.90	14.23	11.42	14.64	13.33	12.88	12.7	0.11	0.12
<b>30l</b>	10.67	12.88	13.38	12.56	10.92	14.19	11.42	14.61	13.29	12.83	12.7	0.11	0.15
<b>33</b>	10.62	12.92	13.48	12.61	10.90	14.35	11.43	14.73	13.34	12.92	12.7	0.16	0.12
<b>35a</b>	10.63	12.89	13.43	12.58	10.90	14.26	11.40	14.69	13.34	12.89	12.7	0.13	0.12
<b>35b</b>	10.62	12.87	13.38	12.55	10.90	14.22	11.39	14.66	13.30	12.85	12.7	0.10	0.13
<b>35a</b>	10.60	12.84	13.34	12.53	10.88	14.19	11.36	14.64	13.27	12.82	12.6	0.08	0.13
<b>35d</b>	10.58	12.85	13.33	12.50	10.87	14.19	11.37	14.66	13.29	12.85	12.6	0.08	0.12
<b>36</b>	10.69	12.90	13.42	12.57	10.90	14.25	11.45	14.59	13.37	12.93	12.7	0.14	0.13
<b>56</b>	10.71	13.00	13.50	12.64	10.98	14.33	11.48	14.76	13.33	12.95	12.8	0.20	0.14
<b>61</b>	10.64	12.91	13.46	12.64	10.92	14.35	11.44	14.76	13.37	12.98	12.7	0.18	0.11
<b>64</b>	10.64	12.82	13.37	12.52	10.92	14.24	11.40	14.58	13.28	12.85	12.7	0.09	0.13
<b>66</b>	9.36	9.81	11.20	10.86	9.80	14.29	10.34	14.77	13.36	12.91	11.7	-0.90	0.97
<b>67</b>	10.53	12.57	13.28	12.24	10.77	11.17	11.14	13.98	12.92	12.56	12.1	-0.45	0.95
<b>68</b>	10.52	12.82	13.34	12.52	10.82	14.20	11.39	14.74	13.25	12.93	12.7	0.08	0.11
<b>73</b>	10.57	12.87	13.45	12.59	10.85	14.29	11.39	14.69	13.42	12.90	12.7	0.13	0.11
<b>77a</b>	10.51	12.72	13.22	12.50	10.89	14.01	11.37	14.36	13.09	12.70	12.5	-0.03	0.18
<b>79a</b>	9.41	9.78	11.06	10.91	9.73	14.39	10.41	14.82	13.44	12.99	11.7	-0.88	1.03
<b>79b</b>	9.34	9.71	10.99	10.85	9.69	14.23	10.39	14.67	13.33	12.92	11.6	-0.96	1.00
<b>79c</b>	9.29	9.69	11.01	10.86	9.63	14.31	10.32	14.80	13.38	12.97	11.6	-0.95	1.04
<b>80</b>	9.30	9.64	11.32	10.88	9.71	14.31	10.33	14.73	13.33	12.88	11.6	-0.93	0.99
<b>82</b>	9.29	9.85	11.38	11.01	9.69	14.37	10.32	14.75	13.37	12.95	11.7	-0.87	0.95
<b>85</b>	9.34	9.85	11.00	11.01	9.63	14.27	10.42	14.70	13.31	12.94	11.6	-0.92	0.97
<b>91a</b>	10.65	12.93	13.47	12.64	10.93	14.32	11.45	14.75	13.37	12.95	12.7	0.17	0.12
<b>91b</b>	10.62	12.91	13.45	12.59	10.90	14.29	11.42	14.73	13.35	12.93	12.7	0.15	0.12
<b>94a</b>	10.63	12.92	13.46	12.59	10.92	14.29	11.41	14.75	13.39	12.92	12.7	0.16	0.12
<b>94b</b>	10.62	12.89	13.41	12.56	10.91	14.28	11.41	14.72	13.35	12.93	12.7	0.14	0.11
<b>98</b>	10.57	12.83	13.48	12.55	10.86	14.32	11.39	14.75	13.30	12.90	12.7	0.13	0.12
<b>100</b>	10.67	12.90	13.44	12.58	10.89	14.23	11.38	14.63	13.38	12.88	12.7	0.13	0.13
<b>101</b>	10.69	12.95	13.45	12.63	10.97	14.29	11.44	14.72	13.36	12.89	12.7	0.17	0.14

<b>Average</b>	10.48	12.52	13.16	12.38	10.76	14.22	11.29	14.66	13.34	12.89	12.57	0.00	0.25
<b>Std</b>	0.42	1.01	0.75	0.54	0.39	0.41	0.34	0.21	0.08	0.08	0.35	0.35	0.30
<b>Min</b>	9.3	9.6	11.0	10.8	9.6	11.2	10.3	13.3	12.9	12.6	11.6	-1.0	0.1
<b>Max</b>	10.7	13.0	13.6	12.7	11.0	14.4	11.6	14.9	13.5	13.1	12.9	0.3	1.0

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-Apr 2023

<b>Lab Code</b>	<b>B1</b>	<b>B2</b>	<b>B3</b>	<b>B4</b>	<b>B5</b>	<b>B6</b>	<b>B7</b>	<b>B8</b>	<b>B9</b>	<b>B10</b>	<b>Mean</b>	<b>Dev</b>	<b>SDD</b>
<b>1a</b>	13.78	14.68	11.72	12.12	11.84	12.56	11.49	13.26	13.20	12.91	12.8	0.07	0.07
<b>1b</b>	13.93	14.52	11.74	12.13	11.89	12.54	11.56	13.31	13.23	13.00	12.8	0.10	0.08
<b>2</b>	13.92	14.56	11.78	12.17	11.91	12.55	11.57	13.33	13.24	12.94	12.8	0.12	0.07
<b>4a</b>	13.71	14.44	11.66	12.12	11.85	12.55	11.49	13.26	13.18	12.97	12.7	0.04	0.05
<b>4b</b>	13.85	14.48	11.72	12.11	11.87	12.54	11.48	13.30	13.21	13.02	12.8	0.08	0.08
<b>5</b>	13.90	14.50	11.68	12.12	11.90	12.54	11.52	13.24	13.16	12.88	12.7	0.06	0.08
<b>8a</b>	13.94	14.58	11.76	12.13	11.88	12.58	11.55	13.29	13.25	12.93	12.8	0.11	0.08
<b>8b</b>	13.92	14.52	11.76	12.14	11.89	12.54	11.52	13.26	13.26	12.91	12.8	0.09	0.08
<b>10</b>	13.83	14.54	11.80	12.20	11.98	12.64	11.57	13.34	13.28	13.01	12.8	0.14	0.05
<b>11a</b>	13.75	14.53	11.76	12.15	11.91	12.57	11.61	13.31	13.22	13.01	12.8	0.10	0.04
<b>11b</b>	13.74	14.55	11.70	12.09	11.86	12.49	11.51	13.28	13.21	12.94	12.7	0.06	0.04
<b>11d</b>	13.69	14.42	11.65	12.06	11.85	12.47	11.48	13.18	13.14	12.88	12.7	0.00	0.04
<b>11e</b>	13.74	14.47	11.67	12.09	11.85	12.49	11.44	13.16	13.16	12.85	12.7	0.01	0.06
<b>12</b>	13.88	14.53	11.83	12.19	11.93	12.59	11.57	13.36	13.26	13.08	12.8	0.14	0.07
<b>15</b>	13.91	14.53	11.78	12.18	11.92	12.61	11.57	13.32	13.19	12.91	12.8	0.11	0.07
<b>17a</b>	13.77	14.47	11.72	12.10	11.84	12.48	11.47	13.25	13.16	12.92	12.7	0.04	0.06
<b>17b</b>	13.74	14.34	11.66	12.04	11.82	12.48	11.42	13.16	13.09	12.87	12.7	-0.02	0.08
<b>18</b>	14.00	14.60	11.75	12.15	11.91	12.57	11.56	13.24	13.17	12.89	12.8	0.10	0.10
<b>19</b>	13.91	14.60	11.75	12.17	11.89	12.60	11.60	13.31	13.25	12.99	12.8	0.13	0.06
<b>25</b>	13.79	14.46	11.74	12.16	11.91	12.61	11.57	13.29	13.21	12.91	12.8	0.08	0.05
<b>26</b>	13.84	14.50	11.73	12.12	11.90	12.54	11.54	13.23	13.20	12.94	12.8	0.07	0.06
<b>27a</b>	13.81	14.37	11.66	12.05	11.85	12.54	11.57	13.15	13.08	12.91	12.7	0.02	0.08
<b>27b</b>	13.96	14.44	11.73	12.07	11.91	12.53	11.65	13.18	13.17	12.94	12.8	0.08	0.10
<b>30a</b>	13.79	14.42	11.72	12.11	11.87	12.48	11.51	13.25	13.17	12.91	12.7	0.04	0.06
<b>30b</b>	13.78	14.42	11.74	12.11	11.92	12.47	11.52	13.24	13.14	12.88	12.7	0.04	0.07
<b>30c</b>	13.90	14.54	11.71	12.07	11.91	12.54	11.64	13.24	13.14	12.90	12.8	0.08	0.08
<b>30d</b>	13.92	14.57	12.15	11.78	11.92	12.60	11.58	13.26	13.19	12.99	12.8	0.12	0.21

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<b>30e</b>	13.85	14.48	11.72	12.15	11.90	12.60	11.52	13.29	13.21	12.96	12.8	0.09	0.06
<b>30f</b>	13.92	14.51	11.74	12.17	11.93	12.63	11.56	13.28	13.18	12.96	12.8	0.11	0.08
<b>30h</b>	13.88	14.51	11.70	12.06	11.87	12.59	11.50	13.24	13.16	12.93	12.7	0.06	0.08
<b>30i</b>	13.83	14.44	11.74	12.13	11.88	12.57	11.58	13.25	13.18	12.91	12.7	0.07	0.06
<b>30k</b>	13.82	14.57	11.69	12.14	11.90	12.52	11.57	13.24	13.12	12.90	12.7	0.07	0.06
<b>30l</b>	13.86	14.53	11.71	12.12	11.89	12.51	11.56	13.20	13.14	12.88	12.7	0.06	0.07
<b>32</b>	14.08	14.48	11.73	12.12	11.88	12.58	11.52	13.26	13.15	12.93	12.8	0.09	0.13
<b>33</b>	13.85	14.46	11.73	12.10	11.88	12.55	11.50	13.27	13.17	12.92	12.7	0.06	0.07
<b>35a</b>	13.81	14.41	11.71	12.08	11.85	12.51	11.48	13.20	13.16	12.84	12.7	0.02	0.07
<b>35b</b>	13.73	14.39	11.67	12.09	11.86	12.51	11.60	13.17	13.17	12.85	12.7	0.02	0.05
<b>35a</b>	13.74	14.38	11.65	12.06	11.83	12.45	11.47	13.15	13.08	12.82	12.7	-0.02	0.06
<b>35d</b>	13.69	14.35	11.64	12.03	11.79	12.50	11.48	13.16	13.10	12.79	12.7	-0.03	0.06
<b>36</b>	13.78	14.49	11.76	12.14	11.93	12.55	11.56	13.26	13.17	12.91	12.8	0.07	0.05
<b>56</b>	14.00	14.59	11.80	12.21	11.97	12.65	11.60	13.37	13.26	13.02	12.8	0.17	0.08
<b>61</b>	13.70	14.53	11.76	12.12	11.90	12.53	11.52	13.34	13.19	12.91	12.7	0.07	0.05
<b>64</b>	13.91	14.54	11.75	12.14	11.94	12.59	11.54	13.29	13.17	12.94	12.8	0.10	0.08
<b>68</b>	14.16	14.31	11.64	11.97	11.78	12.34	11.48	13.14	13.07	12.74	12.7	-0.02	0.19
<b>77a</b>	13.60	14.20	11.60	11.98	11.82	12.42	11.48	13.06	13.00	12.83	12.6	-0.08	0.09
<b>79a</b>	9.85	14.30	9.29	11.70	10.55	11.12	11.61	12.36	12.73	11.53	11.5	-1.18	1.16
<b>79c</b>	10.07	14.12	9.20	11.63	10.46	10.99	11.61	12.27	12.63	11.44	11.4	-1.24	1.08
<b>80</b>	13.95	14.61	11.75	12.18	11.84	12.66	11.58	13.31	13.24	12.92	12.8	0.12	0.08
<b>82</b>	13.88	14.49	11.72	12.16	11.87	12.56	11.56	13.29	13.23	12.97	12.8	0.09	0.06
<b>84</b>	9.73	14.20	9.24	11.65	10.49	11.05	11.61	12.32	12.76	11.52	11.5	-1.22	1.18
<b>85</b>	13.83	14.41	11.66	12.03	11.87	12.44	11.48	13.24	13.14	12.91	12.7	0.02	0.08
<b>91a</b>	13.85	14.51	11.72	12.13	11.91	12.50	11.51	13.28	13.24	12.91	12.8	0.08	0.06
<b>91b</b>	14.02	14.56	11.76	12.15	11.91	12.55	11.53	13.29	13.20	12.94	12.8	0.11	0.10
<b>94a</b>	13.99	14.58	11.73	12.15	11.89	12.56	11.54	13.28	13.21	12.92	12.8	0.10	0.09
<b>94b</b>	13.83	14.48	11.72	12.08	11.85	12.50	11.49	13.23	13.16	12.89	12.7	0.04	0.07
<b>98</b>	13.73	14.46	11.66	12.12	11.83	12.46	11.55	13.22	13.22	12.89	12.7	0.03	0.03
<b>101</b>	13.99	14.52	11.79	12.15	11.91	12.61	11.58	13.32	13.19	12.93	12.8	0.12	0.10
<b>Average</b>	13.64	14.47	11.60	12.09	11.81	12.46	11.54	13.20	13.15	12.84	12.68	0.00	0.13
<b>Std</b>	0.90	0.11	0.56	0.12	0.31	0.34	0.05	0.22	0.12	0.33	0.29	0.29	0.24

<b>Min</b>	9.7	14.1	9.2	11.6	10.5	11.0	11.4	12.3	12.6	11.4	11.4	-1.2	0.0
<b>Max</b>	14.2	14.7	12.1	12.2	12.0	12.7	11.7	13.4	13.3	13.1	12.8	0.2	1.2

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	47.90	47.10	50.50	48.90	50.50	47.80	48.80	49.00	48.10	48.90	48.8	-0.24	0.70
2	47.93	48.35	51.45	49.73	50.80	46.30	49.27	49.37	48.86	49.28	49.1	0.14	0.35
4a	48.92	48.81	50.49	49.85	49.91	47.85	49.38	49.09	49.32	49.59	49.3	0.33	0.52
4b	49.60	48.80	50.60	49.60	50.50	47.60	49.50	49.30	49.30	49.70	49.5	0.46	0.47
5	49.00	49.20	51.10	49.70	50.80	46.70	49.50	49.20	49.30	50.00	49.5	0.46	0.23
8a	49.30	49.30	52.90	49.70	51.80	47.50	50.30	49.80	49.70	49.50	50.0	0.99	0.50
8b	49.40	49.70	52.20	49.60	51.80	47.40	49.50	49.60	49.90	49.80	49.9	0.90	0.40
11a	49.20	49.04	51.35	49.48	50.42	47.07	49.11	48.91	49.31	49.97	49.4	0.40	0.26
11b	49.06	49.13	51.04	49.88	50.45	46.59	49.23	48.75	49.76	49.94	49.4	0.39	0.34
12	49.40	49.40	51.60	49.90	50.50	46.80	49.70	49.30	49.50	50.80	49.7	0.70	0.37
15a	49.12	49.01	51.21	49.45	50.66	47.14	49.78	49.67	49.67	50.00	49.6	0.58	0.27
15b	49.23	49.13	51.49	49.89	50.40	50.77	47.10	49.95	49.48	49.92	49.7	0.75	1.49
17a	49.05	50.00	52.10	51.10	51.75	47.20	49.60	49.85	50.35	49.60	50.1	1.07	0.52
17b	48.45	48.90	51.95	49.40	51.30	45.90	48.50	49.00	49.50	49.20	49.2	0.22	0.55
18	47.70	48.90	51.90	50.20	50.70	46.90	49.30	49.40	49.00	49.70	49.4	0.38	0.44
19	49.00	48.80	51.10	49.50	51.00	46.50	49.30	49.00	49.20	50.10	49.4	0.36	0.28
25	48.80	48.50	50.90	49.10	50.90	47.20	48.50	49.20	48.50	49.20	49.1	0.09	0.44
27a	48.60	49.41	51.34	50.15	50.94	48.55	48.86	49.17	49.85	49.65	49.7	0.66	0.44
27b	47.67	50.12	52.20	50.92	51.22	47.24	49.21	49.22	49.82	48.90	49.7	0.66	0.80
30a	47.20	47.40	50.10	47.70	49.30	44.70	47.70	47.40	47.80	47.10	47.6	-1.35	0.43
30d	47.12	46.68	49.91	48.30	49.31	44.84	47.93	47.57	47.16	47.90	47.7	-1.32	0.31
30e	46.23	46.16	48.37	46.66	47.63	43.49	45.99	46.30	46.70	46.63	46.4	-2.57	0.32
30f	46.37	46.16	48.63	46.75	47.82	44.06	46.32	46.40	47.23	46.91	46.7	-2.33	0.30
30k	45.61	45.73	48.68	46.47	48.77	44.77	47.55	47.41	46.63	47.14	46.9	-2.11	0.57
31	49.72	48.67	52.97	49.78	51.90	45.07	50.05	48.59	49.00	50.24	49.6	0.61	0.99
33	49.90	49.20	53.50	50.60	52.20	45.60	50.90	48.80	49.50	51.40	50.2	1.17	1.04

<b>35a</b>	48.40	48.30	50.00	49.30	50.00	47.00	48.50	48.70	48.10	49.00	48.7	-0.26	0.45
<b>35b</b>	48.50	49.00	51.20	49.30	51.10	46.70	49.60	48.90	49.20	49.40	49.3	0.30	0.29
<b>35c</b>	49.00	49.10	51.00	49.60	50.40	46.20	49.30	49.10	49.30	49.50	49.3	0.26	0.31
<b>35d</b>	48.00	48.10	49.80	48.80	50.60	46.30	48.50	48.30	48.50	48.60	48.6	-0.44	0.41
<b>35e</b>	48.10	48.40	51.90	48.30	50.60	46.00	49.60	48.30	49.30	49.70	49.0	0.03	0.57
<b>35f</b>	48.60	48.90	51.60	48.70	50.40	45.90	49.90	48.30	49.60	49.90	49.2	0.19	0.56
<b>36</b>	48.72	48.73	51.42	50.15	50.83	47.07	49.72	49.67	49.38	50.15	49.6	0.59	0.22
<b>56</b>	49.90	49.60	51.60	50.60	51.30	47.50	50.10	49.70	50.10	50.50	50.1	1.10	0.27
<b>61</b>	48.66	47.54	52.12	50.53	51.97	47.31	49.74	49.73	49.74	50.26	49.8	0.77	0.68
<b>64</b>	48.22	48.31	51.20	49.90	50.39	46.85	49.27	49.13	48.64	49.66	49.2	0.17	0.26
<b>67</b>	45.30	46.40	48.20	47.00	47.40	44.60	47.00	46.00	46.70	46.70	46.5	-2.46	0.42
<b>68</b>	48.29	47.95	51.06	49.21	50.59	46.66	49.58	49.20	48.53	50.05	49.1	0.12	0.38
<b>77a</b>	47.36	49.12	50.93	48.71	49.70	46.22	49.71	47.88	49.34	49.46	48.8	-0.15	0.63
<b>79a</b>	48.20	47.70	51.30	49.10	42.00	46.50	N/A	49.10	48.40	49.30	48.0	-1.03	2.72
<b>79b</b>	48.50	47.80	51.90	49.60	50.20	46.20	49.20	49.00	48.50	49.90	49.1	0.09	0.43
<b>79c</b>	46.74	45.65	49.35	47.50	48.37	45.65	46.96	47.07	46.52	47.07	47.1	-1.90	0.51
<b>80</b>	46.87	47.41	51.25	49.80	51.16	46.04	48.69	49.25	48.42	48.91	48.8	-0.21	0.73
<b>82</b>	48.37	48.90	51.10	49.15	50.03	46.65	48.97	48.73	48.97	50.00	49.1	0.10	0.27
<b>85</b>	47.39	47.17	50.43	48.59	49.02	45.65	47.93	47.61	48.15	48.37	48.0	-0.96	0.21
<b>91a</b>	48.90	48.80	51.40	49.90	51.30	47.40	49.80	50.00	49.20	49.70	49.6	0.65	0.33
<b>91b</b>	49.00	48.70	51.60	49.70	50.90	46.30	48.30	49.00	49.20	49.90	49.3	0.27	0.43
<b>91c</b>	49.30	49.60	52.20	49.70	50.20	46.55	50.90	47.80	50.20	50.70	49.7	0.72	0.85
<b>94a</b>	48.80	48.50	50.90	49.20	50.70	46.70	49.40	49.00	49.30	50.00	49.3	0.26	0.26
<b>94b</b>	49.00	49.30	51.20	49.70	50.10	46.80	49.40	48.90	49.30	50.20	49.4	0.40	0.33
<b>98</b>	48.50	47.60	51.20	49.70	50.00	46.50	49.40	48.90	48.60	49.60	49.0	0.01	0.37
<b>Average</b>	48.4	48.4	51.1	49.3	50.2	46.5	49.0	48.8	48.9	49.4	49.0	0.0	0.5
<b>Std</b>	1.05	1.09	1.10	1.03	1.58	1.17	1.05	0.94	0.95	1.08	0.94	0.94	0.40
<b>Min</b>	45.3	45.7	48.2	46.5	42.0	43.5	46.0	46.0	46.5	46.6	46.4	-2.6	0.2
<b>Max</b>	49.9	50.1	53.5	51.1	52.2	50.8	50.9	50.0	50.4	51.4	50.2	1.2	2.7

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

Lab Code	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Dev	SDD
1	5.75	4.41	5.31	5.22	6.68	5.16	4.20	6.39	4.11	4.88	5.2	-0.37	0.25
2	6.48	4.39	5.93	5.42	6.69	5.74	4.60	6.55	4.43	5.32	5.6	-0.02	0.13
4a	6.40	4.22	5.59	5.28	6.76	5.74	4.69	6.67	4.41	5.34	5.5	-0.07	0.20
4b	6.69	4.77	6.04	5.39	6.58	5.33	4.62	6.64	4.62	5.27	5.6	0.02	0.14
5	6.60	4.60	5.80	5.50	6.50	5.40	4.90	6.20	4.60	5.60	5.6	-0.01	0.15
8a	6.50	4.50	5.60	5.30	6.40	5.10	4.70	6.50	4.30	5.30	5.4	-0.16	0.14
8b	6.50	4.30	5.30	5.30	6.40	5.40	4.50	6.40	4.30	5.10	5.4	-0.23	0.16
11a	6.81	4.16	5.94	5.23	6.71	5.35	4.68	6.54	4.32	5.40	5.5	-0.06	0.22
11b	6.74	4.42	5.85	5.35	6.47	5.37	4.62	6.45	4.36	5.62	5.5	-0.05	0.16
12	6.40	4.40	6.10	5.30	6.30	5.30	4.50	6.30	4.50	5.40	5.5	-0.13	0.15
15a	6.60	4.70	5.80	5.40	6.50	5.40	4.80	6.10	4.80	5.70	5.6	0.00	0.20
15b	6.25	4.85	5.90	5.50	5.75	6.05	5.20	5.00	4.70	5.55	5.5	-0.10	0.62
17a	6.40	4.40	5.85	5.40	7.00	5.80	4.70	6.85	4.65	5.35	5.6	0.06	0.21
17b	6.30	4.65	5.75	5.40	7.15	5.80	4.95	7.00	4.50	5.30	5.7	0.10	0.27
18	6.20	4.00	5.40	5.00	6.40	5.30	4.20	6.20	4.20	5.10	5.2	-0.38	0.14
19	6.63	4.55	5.86	5.56	6.47	5.35	4.80	6.44	4.52	5.34	5.6	-0.03	0.10
25	6.40	4.80	5.60	5.20	6.50	5.40	4.40	6.10	4.70	5.30	5.4	-0.14	0.18
27a	6.70	5.71	6.57	6.31	7.02	6.25	4.86	6.81	5.44	5.76	6.1	0.56	0.18
27b	6.75	5.56	6.57	6.20	6.74	6.25	5.11	6.76	5.34	5.66	6.1	0.52	0.28
30a	6.20	4.80	5.80	5.50	7.30	6.00	4.90	7.50	4.70	5.60	5.8	0.25	0.38
30d	6.49	4.40	5.94	5.62	6.68	5.72	4.80	6.95	4.52	5.32	5.6	0.07	0.18
30e	6.82	4.89	6.51	5.92	6.76	5.72	5.42	6.95	4.98	6.03	6.0	0.42	0.19
30f	6.69	4.55	6.32	5.73	6.72	5.41	5.17	6.41	4.79	5.59	5.7	0.16	0.20
30k	7.03	5.24	6.65	6.44	7.39	6.38	5.00	7.13	4.97	5.71	6.2	0.62	0.24
33	6.60	4.90	5.60	5.50	6.80	5.70	4.50	6.30	5.00	5.50	5.6	0.06	0.23

WORLD GRAIN NETWORK: Results of the inter-laboratory study conducted in Feb-Apr 2023

<b>35a</b>	6.90	5.40	6.50	5.90	7.40	6.20	5.50	7.30	5.20	5.70	6.2	0.62	0.18
<b>35b</b>	6.50	4.70	6.30	5.40	6.50	5.30	4.80	6.50	4.70	5.50	5.6	0.04	0.17
<b>35c</b>	6.40	4.70	5.90	5.50	6.60	5.40	4.90	6.30	4.60	5.40	5.6	-0.01	0.11
<b>35d</b>	7.00	5.30	6.70	6.10	7.60	6.50	5.60	7.40	5.30	6.00	6.4	0.77	0.17
<b>35e</b>	5.80	4.20	4.60	4.60	5.50	4.80	4.10	5.40	4.30	4.90	4.8	-0.76	0.32
<b>35f</b>	5.80	4.10	4.80	4.50	5.40	4.70	4.00	5.40	4.10	4.90	4.8	-0.81	0.26
<b>36</b>	6.71	4.94	6.36	5.72	6.64	5.31	4.96	6.30	4.85	5.67	5.7	0.17	0.23
<b>56</b>	6.60	4.60	5.90	5.30	6.30	5.10	4.70	6.10	4.50	5.50	5.5	-0.12	0.20
<b>61</b>	6.50	4.50	5.80	5.60	6.30	5.10	4.50	6.50	4.30	5.30	5.4	-0.14	0.17
<b>64</b>	6.40	4.50	5.80	5.30	6.50	5.60	4.70	6.60	4.50	5.40	5.5	-0.05	0.08
<b>67</b>	6.50	4.30	5.80	5.10	6.40	5.00	4.30	6.30	4.00	5.20	5.3	-0.29	0.19
<b>68</b>	6.60	4.70	5.80	5.50	6.70	5.70	4.20	6.50	4.80	5.50	5.6	0.02	0.21
<b>79a</b>	6.40	4.60	5.80	5.80	6.60	5.50	N/A	6.50	4.50	5.10	5.6	0.07	0.17
<b>79b</b>	6.00	4.50	5.90	5.30	6.40	5.40	4.80	6.20	4.50	5.00	5.4	-0.18	0.18
<b>79c</b>	6.50	4.40	5.80	5.40	6.60	5.40	4.60	6.50	4.20	5.30	5.5	-0.11	0.12
<b>80</b>	6.57	4.27	5.96	5.23	6.68	5.46	4.35	6.53	4.00	5.06	5.4	-0.17	0.24
<b>82</b>	6.67	4.65	5.93	5.55	6.90	5.70	4.83	6.73	4.73	5.67	5.7	0.16	0.09
<b>85</b>	5.50	4.50	5.60	5.30	6.30	5.60	4.40	6.70	4.70	5.50	5.4	-0.17	0.34
<b>91a</b>	6.45	4.40	5.65	5.55	6.50	5.50	4.70	6.75	4.45	5.30	5.5	-0.05	0.14
<b>91b</b>	6.75	4.57	5.91	5.31	6.50	5.36	5.01	6.49	4.56	5.42	5.6	0.01	0.16
<b>91c</b>	6.70	4.70	5.70	5.45	6.60	5.40	4.60	6.60	4.65	5.55	5.6	0.02	0.13
<b>94a</b>	6.60	4.60	5.90	5.30	6.50	5.40	4.80	6.40	4.50	5.70	5.6	-0.01	0.14
<b>94b</b>	6.50	4.60	6.00	5.60	6.70	5.60	4.90	6.60	4.70	5.40	5.7	0.08	0.07
<b>98</b>	6.40	4.30	5.80	5.20	6.60	5.40	4.30	6.60	4.40	5.10	5.4	-0.17	0.16
<b>Average</b>	6.5	4.6	5.9	5.5	6.6	5.5	4.7	6.5	4.6	5.4	5.6	0.0	0.2
<b>Std</b>	0.31	0.36	0.41	0.35	0.40	0.38	0.35	0.45	0.32	0.26	0.30	0.30	0.09
<b>Min</b>	5.5	4.0	4.6	4.5	5.4	4.7	4.0	5.0	4.0	4.9	4.8	-0.8	0.1

Max	7.0	5.7	6.7	6.4	7.6	6.5	5.6	7.5	5.4	6.0	6.4	0.8	0.6
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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	49.08	48.51	51.11	49.41	50.58	46.86	49.84	49.26	49.36	50.06	49.4	0.05	0.27
1b	48.51	48.22	50.89	49.35	50.68	46.70	48.75	48.95	48.91	49.71	49.1	-0.29	0.25
2	49.02	49.13	51.40	50.01	50.91	46.80	49.29	49.46	49.75	49.51	49.5	0.17	0.24
4a	49.19	49.12	51.41	49.58	50.49	46.78	49.31	48.84	49.99	49.78	49.4	0.09	0.22
4b	49.42	48.88	50.87	49.40	50.66	46.94	49.32	49.30	49.29	49.75	49.4	0.02	0.21
5	49.15	49.11	51.30	49.80	50.67	46.82	49.27	49.23	49.57	49.80	49.5	0.11	0.09
8a	48.86	49.05	50.96	49.79	50.49	46.75	49.35	49.21	49.11	49.37	49.3	-0.07	0.23
8b	48.64	48.47	51.19	49.25	50.56	46.85	48.63	49.45	49.07	49.56	49.2	-0.19	0.29
11a	49.20	49.04	51.35	49.48	50.42	47.07	49.11	48.91	49.31	49.97	49.4	0.02	0.16
11b	49.06	49.13	51.04	49.88	50.45	46.59	49.23	48.75	49.76	49.94	49.4	0.02	0.24
11d	49.09	48.84	51.29	49.35	50.53	46.72	49.02	48.90	49.68	49.54	49.3	-0.07	0.16
11e	49.23	48.96	51.32	50.13	50.85	47.11	49.72	49.34	49.29	49.86	49.6	0.22	0.22
12	49.12	49.31	51.52	49.72	50.79	46.52	49.06	49.12	49.33	50.31	49.5	0.12	0.24
15a	49.03	48.65	51.12	49.22	50.64	47.08	49.29	49.44	49.34	49.36	49.3	-0.05	0.26
15b	49.02	49.10	51.32	49.55	50.52	46.91	49.63	49.04	49.27	49.79	49.4	0.05	0.16
17a	49.11	49.44	51.24	50.03	50.40	46.95	49.01	49.26	49.62	49.74	49.5	0.12	0.26
17b	49.69	49.65	52.00	49.67	50.71	46.63	49.21	49.04	49.81	50.38	49.7	0.32	0.34
18	48.56	49.07	51.53	49.19	50.34	46.71	48.40	49.02	49.70	49.65	49.2	-0.14	0.36
19	48.70	48.97	51.20	49.36	50.71	46.52	49.24	49.03	49.05	49.67	49.2	-0.12	0.17
25	49.69	49.25	51.49	49.49	50.75	46.65	48.73	49.10	48.93	50.03	49.4	0.05	0.35
27a	49.00	48.32	51.18	48.92	50.06	46.14	48.50	48.18	49.25	50.05	49.0	-0.40	0.36
27b	48.40	49.16	50.69	48.97	50.09	45.93	49.15	49.40	49.78	49.16	49.1	-0.29	0.47
30a	49.72	49.10	51.75	49.69	50.79	46.82	49.77	48.83	49.79	49.70	49.6	0.23	0.29
30d	49.67	49.38	51.17	49.47	50.80	46.74	49.90	49.25	49.50	49.89	49.6	0.21	0.27
30e	48.70	48.46	51.01	49.18	50.36	46.55	48.67	48.81	49.34	49.12	49.0	-0.34	0.19
30f	48.97	48.70	51.30	49.42	50.50	47.06	49.04	49.18	49.85	49.52	49.4	-0.01	0.23

<b>30k</b>	48.21	48.13	49.99	48.20	50.45	46.67	49.55	48.87	49.25	49.58	48.9	-0.47	0.55
<b>31</b>	49.10	48.74	51.20	49.58	50.72	46.66	49.42	48.73	49.41	49.66	49.3	-0.04	0.15
<b>33</b>	48.74	48.60	51.82	49.41	50.46	46.39	49.37	48.59	48.62	50.10	49.2	-0.15	0.40
<b>35a</b>	49.43	49.44	50.97	49.82	50.49	47.02	49.09	48.99	49.49	49.63	49.4	0.08	0.27
<b>35b</b>	48.79	48.88	51.04	49.67	51.07	46.99	49.62	48.78	48.94	49.70	49.3	-0.01	0.31
<b>35c</b>	49.10	49.00	50.92	49.61	50.32	46.77	49.38	49.09	49.02	49.82	49.3	-0.06	0.20
<b>35d</b>	48.92	48.91	51.05	49.51	50.61	46.57	49.42	49.14	49.32	49.89	49.3	-0.03	0.13
<b>36</b>	48.54	48.77	51.16	49.62	50.55	46.67	49.39	49.44	49.29	49.92	49.3	-0.03	0.24
<b>56</b>	49.41	48.88	51.44	50.23	50.47	47.00	49.32	48.98	49.46	49.91	49.5	0.15	0.24
<b>61</b>	49.72	48.33	51.46	50.00	50.91	46.79	49.68	48.58	50.01	50.07	49.6	0.19	0.42
<b>64</b>	48.86	48.85	51.52	49.71	50.48	46.73	49.08	48.74	49.49	50.02	49.3	-0.01	0.19
<b>67</b>	49.60	49.23	51.38	49.82	50.64	47.41	49.67	48.94	49.48	50.53	49.7	0.31	0.27
<b>68</b>	48.64	48.79	51.19	49.55	50.54	46.57	49.48	49.28	49.31	50.15	49.3	-0.01	0.23
<b>79a</b>	49.71	48.88	51.70	49.23	50.94	47.13	49.11	48.96	49.62	49.87	49.5	0.15	0.30
<b>79b</b>	49.16	48.95	51.84	49.32	50.55	46.43	49.41	48.96	49.40	50.20	49.4	0.06	0.28
<b>79c</b>	49.53	48.28	51.27	49.54	50.64	46.65	49.16	49.57	49.45	49.71	49.4	0.02	0.32
<b>80</b>	48.90	48.80	51.12	49.82	50.82	47.04	49.09	49.37	49.52	49.75	49.4	0.06	0.20
<b>82</b>	48.94	49.38	51.10	49.42	50.27	46.84	49.10	48.75	49.58	50.16	49.4	-0.01	0.27
<b>85</b>	49.30	49.27	51.30	49.50	50.19	46.97	49.18	48.64	49.82	49.82	49.4	0.04	0.28
<b>91a</b>	49.19	49.16	51.03	49.68	50.88	46.98	49.48	49.33	49.42	49.64	49.5	0.12	0.18
<b>91b</b>	49.13	48.73	51.36	49.64	50.73	46.51	48.67	49.01	48.92	49.91	49.3	-0.10	0.26
<b>94a</b>	48.74	48.48	51.08	49.18	50.71	46.85	49.30	49.43	49.11	49.67	49.3	-0.11	0.26
<b>94b</b>	48.59	49.13	50.82	49.53	51.06	46.72	49.46	49.13	49.51	49.78	49.4	0.01	0.29
<b>98</b>	49.15	48.63	51.53	49.78	50.84	47.06	48.65	49.00	49.24	49.92	49.4	0.02	0.29
<b>Average</b>	49.1	48.9	51.2	49.5	50.6	46.8	49.2	49.1	49.4	49.8	49.4	0.0	0.3
<b>Std</b>	0.37	0.35	0.33	0.34	0.23	0.26	0.35	0.28	0.30	0.28	0.17	0.17	0.08
<b>Min</b>	48.2	48.1	50.0	48.2	50.1	45.9	48.4	48.2	48.6	49.1	48.9	-0.5	0.1
<b>Max</b>	49.7	49.6	52.0	50.2	51.1	47.4	49.9	49.6	50.0	50.5	49.7	0.3	0.5

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

<b>Lab Code</b>	<b>R1</b>	<b>R2</b>	<b>R3</b>	<b>R4</b>	<b>R5</b>	<b>R6</b>	<b>R7</b>	<b>R8</b>	<b>R9</b>	<b>R10</b>	<b>Mean</b>	<b>Dev</b>	<b>SDD</b>
<b>1a</b>	6.47	4.38	5.81	5.41	6.54	5.35	4.88	6.30	4.56	5.39	5.5	-0.07	0.09
<b>1b</b>	6.63	4.82	5.96	5.63	6.58	5.26	5.08	6.33	4.70	5.55	5.7	0.07	0.11
<b>2</b>	6.67	4.62	5.98	5.54	6.46	5.39	4.96	6.32	4.73	5.24	5.6	0.01	0.11
<b>4a</b>	6.27	4.43	5.41	5.17	6.28	5.33	4.60	6.42	4.47	5.23	5.4	-0.22	0.14
<b>4b</b>	6.70	4.85	6.11	5.42	6.70	5.31	4.73	6.40	4.65	5.34	5.6	0.04	0.13
<b>5</b>	6.62	4.63	5.92	5.60	6.51	5.34	5.01	6.19	4.60	5.61	5.6	0.02	0.11
<b>8a</b>	6.68	4.95	5.95	5.56	6.52	5.27	5.15	6.61	4.62	5.59	5.7	0.11	0.14
<b>8b</b>	6.93	4.69	5.80	5.80	6.79	5.70	4.83	6.42	5.41	5.56	5.8	0.21	0.26
<b>11a</b>	6.81	4.16	5.94	5.23	6.71	5.35	4.68	6.54	4.32	5.40	5.5	-0.07	0.24
<b>11b</b>	6.74	4.42	5.85	5.35	6.47	5.37	4.62	6.45	4.36	5.62	5.5	-0.06	0.15
<b>11d</b>	6.18	4.81	5.71	5.39	6.28	5.20	4.76	6.08	4.52	5.43	5.4	-0.15	0.15
<b>11e</b>	6.16	4.67	5.75	5.25	6.30	5.13	4.77	6.02	4.70	5.36	5.4	-0.17	0.15
<b>12</b>	6.41	4.28	6.02	5.23	6.22	5.22	4.54	6.47	4.29	5.42	5.4	-0.18	0.17
<b>15a</b>	6.57	4.65	5.93	5.55	6.58	5.53	5.09	6.11	4.86	5.70	5.7	0.07	0.16
<b>15b</b>	6.55	4.92	6.09	5.70	6.21	5.31	5.20	6.14	4.87	5.61	5.7	0.08	0.22
<b>17a</b>	6.50	4.12	5.96	5.25	6.55	5.29	4.77	6.34	4.54	5.35	5.5	-0.12	0.16
<b>17b</b>	6.56	4.37	5.77	5.42	6.50	5.25	4.90	6.25	4.48	5.42	5.5	-0.09	0.10
<b>18</b>	6.74	4.66	5.94	5.65	6.38	5.30	5.14	6.52	4.52	5.36	5.6	0.04	0.15
<b>19</b>	6.67	4.59	5.91	5.58	6.58	5.38	4.70	6.56	4.61	5.54	5.6	0.03	0.10
<b>25</b>	6.66	4.51	5.78	5.32	6.66	5.54	4.54	6.15	4.43	5.46	5.5	-0.08	0.16
<b>27a</b>	6.66	6.09	6.37	6.58	6.97	6.51	4.80	6.96	5.31	5.47	6.2	0.59	0.51
<b>27b</b>	6.64	5.88	6.74	6.39	6.75	6.46	5.42	6.64	5.59	5.65	6.2	0.63	0.42
<b>30a</b>	6.48	4.48	5.77	5.19	6.30	5.29	4.71	6.50	4.33	5.55	5.5	-0.13	0.13
<b>30d</b>	6.54	4.68	5.76	5.54	6.09	4.84	5.22	6.25	4.44	5.37	5.5	-0.11	0.26
<b>30e</b>	6.61	4.73	6.20	5.62	6.51	5.34	4.99	6.32	4.90	5.66	5.7	0.10	0.12
<b>30f</b>	6.78	4.72	6.17	5.69	6.58	5.27	4.93	6.36	4.87	5.63	5.7	0.12	0.12
<b>30k</b>	6.60	4.96	6.19	5.77	6.42	5.34	4.86	6.34	4.81	5.52	5.7	0.09	0.15

31	6.66	4.56	6.00	5.61	6.46	5.47	5.03	6.31	4.61	5.48	5.6	0.04	0.10
33	6.79	4.85	5.80	5.38	6.64	5.57	4.67	6.39	4.60	5.37	5.6	0.02	0.15
35a	6.52	4.37	5.75	5.24	6.41	5.40	4.70	6.47	4.49	5.40	5.5	-0.11	0.11
35b	6.50	4.76	6.04	5.34	6.51	5.31	4.79	6.36	4.75	5.63	5.6	0.01	0.10
35c	6.42	4.80	5.93	5.42	6.50	5.26	4.99	6.03	4.67	5.40	5.5	-0.04	0.15
35d	6.78	4.75	6.09	5.54	6.65	5.59	4.94	6.42	4.84	5.62	5.7	0.14	0.06
36	6.74	4.93	6.29	5.75	6.65	5.31	5.00	6.28	4.87	5.69	5.7	0.16	0.15
56	6.79	4.64	6.10	5.52	6.65	5.44	4.95	6.42	4.79	5.62	5.7	0.11	0.07
61	6.67	4.50	6.02	5.34	6.56	5.37	4.60	6.61	4.41	5.36	5.5	-0.04	0.16
64	6.44	4.66	5.78	5.14	6.38	5.42	4.89	6.40	4.52	5.38	5.5	-0.08	0.11
67	6.52	4.60	5.77	4.93	6.30	5.01	4.95	6.28	4.43	5.36	5.4	-0.17	0.18
68	6.71	4.61	5.94	5.57	6.86	5.65	4.44	6.86	4.74	5.71	5.7	0.12	0.24
79a	6.50	4.72	5.92	5.73	6.52	5.31	4.68	6.11	4.77	5.55	5.6	-0.01	0.15
79b	6.18	4.38	5.46	5.06	6.24	5.18	4.74	6.06	4.40	5.01	5.3	-0.31	0.12
79c	6.64	4.40	5.79	5.27	6.38	5.45	4.60	6.48	4.23	5.45	5.5	-0.12	0.16
80	6.75	4.85	6.18	5.56	6.53	5.39	4.96	6.36	4.59	5.57	5.7	0.09	0.10
82	6.54	4.31	5.70	5.25	6.56	5.41	4.55	6.51	4.34	5.43	5.5	-0.13	0.17
85	5.64	4.14	5.63	4.97	6.07	5.54	4.63	6.66	4.45	5.56	5.3	-0.26	0.36
91a	6.63	4.68	5.88	5.60	6.54	5.42	4.97	6.51	4.63	5.52	5.6	0.05	0.06
91b	6.86	4.54	6.09	5.41	6.60	5.39	5.17	6.50	4.73	5.53	5.7	0.10	0.14
94a	6.70	4.63	5.96	5.42	6.65	5.48	4.84	6.47	4.62	5.73	5.6	0.06	0.09
94b	6.30	4.48	5.66	5.21	6.34	5.26	4.64	6.45	4.37	5.49	5.4	-0.17	0.11
98	6.32	4.34	5.52	4.97	6.58	5.22	4.62	6.44	4.36	5.43	5.4	-0.21	0.18
<b>Average</b>	6.6	4.7	5.9	5.5	6.5	5.4	4.8	6.4	4.6	5.5	5.6	0.0	0.2
<b>Std</b>	0.22	0.35	0.23	0.30	0.18	0.27	0.21	0.19	0.27	0.14	0.17	0.17	0.08
<b>Min</b>	5.6	4.1	5.4	4.9	6.1	4.8	4.4	6.0	4.2	5.0	5.3	-0.3	0.1
<b>Max</b>	6.9	6.1	6.7	6.6	7.0	6.5	5.4	7.0	5.6	5.7	6.2	0.6	0.5

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