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Article Title

Data on agronomic traits, biochemical composition of lipids, proteins and polysaccharides and rheological measurement in a brown mustard seed collection.

Authors

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Abstract

The data were collected from a brown mustard seeds collection of 18 accessions during two years and in three distinct sites of production in France. The 18 accessions of mustard seeds were selected to be representative of genetic, agronomical and technological variabilities. All accessions were produced in the “*Bourgogne*” area. This article describes agronomical data (PMG, yield), genotyping data, global composition of mustard seeds (lipids, proteins and polysaccharides) and fine composition of the previous macronutrients potentially involved in the technological properties (fatty acids, storage proteins and osidic composition of polysaccharides). Additional data regarding the potential rheological property of each accessions were also reported. These data can be reused by food industries, breeders and geneticists in order to understand pedoclimatic effects (year and location) and the relation between mustard seed composition and the end-uses properties (paste mustard quality).

Keywords

Mustard seed, agronomic traits, biochemical composition, microsatellite genotyping, pedoclimatic variation, technological quality trait

Specifications Table

| | |
|---------------------------------------|---|
| Subject | Agricultural and Biological Sciences |
| Specific subject area | Food Science |
| Type of data | Tables Figures |
| How data were acquired | <p>Genotyping: DNA extraction followed by PCR analysis (2720 Thermal Cycler, Applied Biosystems) using 14 microsatellites markers.</p> <p>Total lipids, proteins and fatty acid composition: Near Infra-Red Spectroscopy (NIR-6500 analysis system SYS II, FOSS®, calibration software: WINISI V4.10.0. 15326; acquisition software: ISISCAN version 2.85).</p> <p>Storage protein composition: Solid-liquid extraction with salt buffer followed by gel filtration chromatography analysis (Superdex 75 Increase, GE Healthcare).</p> <p>Polysaccharide composition: alcohol extraction followed by acid hydrolysis. Alditol acetate derivatization and gas chromatography analysis (TRACE GC ULTRA™, THERMO) for neutral sugars & colorimetric measurement for acidic sugars.</p> <p>Rheological data: seed grinding and soaking in a verjuice-like solution and rheological measurement using a Botswick consistometer (24 cm, ENDECOTTS).</p> <p>Granulometry measurement: seed grinding followed by laser diffraction particle size Analyzer LA-960 HORIBA</p> |
| Data format | Raw data Analyzed data |
| Parameters for data collection | <p>Eighteen accessions of mustard seeds were grown in the French area "Bourgogne" in three different locations:</p> <p>Fauverney (47°15'20.14" N and 5°09'20.34" E, clay loam soil), Châlon-sur-Saône (46°43'59.07" N and 4°46'14.20" E, white silt/sandy soil)</p> |

| | |
|---------------------------------------|---|
| | and Barges (47°12'49.47" N and 5°01'52.46" E, clay loam soil) for two years in the Fauverney plot (2017 & 2018). |
| Description of data collection | The biochemical composition of 18 mustard seeds accessions has been determined, considering the lipid, protein and cell wall polysaccharide content, the main fatty acids content, the storage protein content and the osidic composition of cell wall polysaccharides. Genotyping using chosen microsatellites markers and agronomical traits such as yield and 1000-grain weight were also reported. The rheological properties of each accessions were measured using Bostwick consistometer. The particle size distribution after seed milling were acquired by laser diffraction particle size analyzer. |
| Data source location | Biopolymers-Interaction-Assemblies (BIA) research unit from French National Research Institute for Agriculture, Food and the Environment (INRAE), FRANCE |
| Data accessibility | Data describes in this paper are accessible in the INRAE Dataverse repository and accessible as 3 Excel files. Repository name: Dataverse INRAE Data identification number: doi: https://doi.org/10.15454/YJ33JC , <i>Direct URL to data (only for revision):</i> https://data.inrae.fr/privateurl.xhtml?token=9d6a937b-54f1-4c22-8254-f7841c0c371c |
| Related research article | None |

Value of the Data

- The data are useful to compare the environmental and the year effects on the biochemical composition of mustard seeds, since the accessions were grown in three distinct locations and under two years.
- Data provided in this article can be used by food industries, breeders and geneticists in order to understand the relation between mustard seed composition and the end-uses properties (paste mustard quality).
- These data provide a complete biochemical description of brown seed mustard and can allow new understandings towards macro constituent's relationship.
- These data increase the existing knowledge regarding brown seed mustard

Data Description

This article provides 8 tables and 2 figures of the raw and analysed data^[6] corresponding to genotyping, agronomic traits, physico-chemical characterizations of mustard seed accessions (18 genotypes) grown under three different locations and for two years.

Table 1 provides averaged values of agronomics traits, *i.e.* yields (Qx/Ha) and 1000-grain weight (g). Table 2 provides genotyping data using the 20 microsatellite markers identified and selected^[1-3] and allowing the characterization of the genetic diversity of the mustard seed collection and the selection of the 18 genotypes. The genetic diversity of the initial mustard seed collection (40 genotypes) was represented by the Neighbour Joining method (Figure 1). Table 3 provides content of dry matters (% of seed weight), amounts of sinigrin ($\mu\text{mol/g DM}$) and total amounts of lipids and proteins. Table 4, 5 and 6 provides respectively amounts of fatty acids, storage proteins and cell wall polysaccharides. Table 7 provides rheological behaviour of each genotype subjected to coarse gridding and soaking in a verjuice-like buffer and Table 8 provides granulometric data after coarse gridding performed before rheological measurements. For each trait, the values provided correspond to the mean calculated for the 18 genotypes, three plots and 2 years of harvest in one plot, *i.e.* 72 independent values. For biochemical and rheological measurement, the values provided correspond to 2 or 3 replicates per genotype. These data will be comprehensively discussed in a scientific article.

Experimental Design, Materials and Methods

1. Raw materials and agronomical traits

Eighteen accessions of mustard seeds were grown in the French area "Bourgogne" in three different locations: Fauverney (47°15'20.14" N and 5°09'20.34" E, clay loam soil), Châlon-sur-Saône (46°43'59.07" N and 4°46'14.20" E, white silt/sandy soil) and Barges (47°12'49.47" N and 5°01'52.46" E, clay loam soil) for two years in the Fauverney plot (2017 & 2018). The mustard seeds were sown using an experimental seeder (Hege) on 6 plots (20 m² per plot) and harvested at crop maturity using an experimental harvester (Aldrup). Samples were cleaned to remove broken seeds, dust and other undesirable matter before yield and 1000-grain weight (Contador, Pfeuffer) measurements.

Table 1: Agronomic traits (yield and 1000-grain weight) of the seed mustard collection grown in three locations (Ch: Châlon-sur-Saône; Bg: Barges; Fv: Fauverney) and two years (2017 & 2018).

| Year | location | Name | Yield [Qtz/Ha] | 1000-grain weight [g] | Year | location | Name | Yield [Qtz/Ha] | 1000-grain weight [g] |
|------|----------|-----------|----------------|-----------------------|------|----------|-----------|----------------|-----------------------|
| 2018 | Ch | Brown | 15,4 | 2,8 | 2018 | Fv | Brown | 19,2 | 2,5 |
| 2018 | Ch | BZ7/3 | 18,1 | 2,6 | 2018 | Fv | BZ7/3 | 24,3 | 3,0 |
| 2018 | Ch | CA119/3 | 19,3 | 3,1 | 2018 | Fv | CA119/3 | 25,0 | 3,0 |
| 2018 | Ch | CA98/1 | 18,5 | 2,8 | 2018 | Fv | CA98/1 | 24,1 | 3,3 |
| 2018 | Ch | CH25/1 | 20,2 | 2,5 | 2018 | Fv | CH25/1 | 23,5 | 2,8 |
| 2018 | Ch | CH7/1 | 19,5 | 2,5 | 2018 | Fv | CH7/1 | 21,1 | 2,7 |
| 2018 | Ch | CI114/2 | 26,9 | 3,0 | 2018 | Fv | CI114/2 | 32,4 | 2,9 |
| 2018 | Ch | CI2/3 | 22,4 | 2,6 | 2018 | Fv | CI2/3 | 20,6 | 2,9 |
| 2018 | Ch | CJ35/2 | 23,0 | 2,8 | 2018 | Fv | CJ35/2 | 23,7 | 3,0 |
| 2018 | Ch | CK17/1 | 18,6 | 2,6 | 2018 | Fv | CK17/1 | 26,0 | 2,5 |
| 2018 | Ch | DA1/2 | 22,0 | 2,8 | 2018 | Fv | DA1/2 | 24,5 | 3,3 |
| 2018 | Ch | DD84/3 | 21,1 | 2,8 | 2018 | Fv | DD84/3 | 27,0 | 2,8 |
| 2018 | Ch | DN107/1 | 23,9 | 2,7 | 2018 | Fv | DN107/1 | 23,7 | 2,7 |
| 2018 | Ch | DN76/3 | 21,1 | 2,8 | 2018 | Fv | DN76/3 | 21,3 | 3,0 |
| 2018 | Ch | DP32/1 | 20,2 | 2,7 | 2018 | Fv | DP32/1 | 21,1 | 2,8 |
| 2018 | Ch | DW7/1 | 23,1 | 2,4 | 2018 | Fv | DW7/1 | 24,4 | 2,6 |
| 2018 | Ch | Espérance | 17,2 | 3,1 | 2018 | Fv | Espérance | 20,2 | 3,1 |
| 2018 | Ch | Etamine | 23,6 | 2,5 | 2018 | Fv | Etamine | 27,5 | 2,6 |
| 2018 | Bg | Brown | 17,9 | 2,7 | 2017 | Fv | Brown | 24,0 | 2,3 |
| 2018 | Bg | BZ7/3 | 24,5 | 2,9 | 2017 | Fv | BZ7/3 | 23,0 | 3,0 |
| 2018 | Bg | CA119/3 | 27,0 | 3,1 | 2017 | Fv | CA119/3 | 22,8 | 3,0 |
| 2018 | Bg | CA98/1 | 25,2 | 3,0 | 2017 | Fv | CA98/1 | 26,1 | 3,3 |
| 2018 | Bg | CH25/1 | 22,7 | 2,6 | 2017 | Fv | CH25/1 | 28,5 | 2,9 |
| 2018 | Bg | CH7/1 | 20,1 | 2,5 | 2017 | Fv | CH7/1 | 24,6 | 2,5 |
| 2018 | Bg | CI114/2 | 30,2 | 3,0 | 2017 | Fv | CI114/2 | 27,1 | 2,9 |
| 2018 | Bg | CI2/3 | 21,5 | 2,7 | 2017 | Fv | CI2/3 | 26,7 | 2,9 |
| 2018 | Bg | CJ35/2 | 24,2 | 2,8 | 2017 | Fv | CJ35/2 | 25,0 | 3,2 |
| 2018 | Bg | CK17/1 | 26,1 | 2,4 | 2017 | Fv | CK17/1 | 21,6 | 2,5 |
| 2018 | Bg | DA1/2 | 22,4 | 2,9 | 2017 | Fv | DA1/2 | 28,7 | 3,1 |
| 2018 | Bg | DD84/3 | 25,3 | 2,8 | 2017 | Fv | DD84/3 | 23,7 | 2,7 |
| 2018 | Bg | DN107/1 | 25,9 | 2,6 | 2017 | Fv | DN107/1 | 25,7 | 2,8 |
| 2018 | Bg | DN76/3 | 23,6 | 2,8 | 2017 | Fv | DN76/3 | 24,5 | 3,0 |
| 2018 | Bg | DP32/1 | 22,2 | 2,7 | 2017 | Fv | DP32/1 | 23,2 | 2,8 |
| 2018 | Bg | DW7/1 | 24,3 | 2,3 | 2017 | Fv | DW7/1 | 26,9 | 2,7 |
| 2018 | Bg | Espérance | 23,6 | 3,0 | 2017 | Fv | Espérance | 15,9 | 3,0 |
| 2018 | Bg | Etamine | 28,4 | 2,7 | 2017 | Fv | Etamine | 23,3 | 2,6 |

2. Genotyping

2.1. DNA extraction

Genomic DNA was extracted as follow Punches of 8 mm diameter from young leaves were crushed, in 1.5 mL tubes, in 150 µL of an extraction buffer (EDTA 25 mM, Tris-HCl 200 mM,

NaCl 250 mM , SDS 0.5%, pH8). The contents were centrifuged at 13 000 *g* for 5 min. The supernatant was transferred to a fresh tube and warmed 10 min at 95°C, and then, centrifuged again at 13 000 *g* for 5 min. The supernatant was transferred in a fresh tube and diluted in UHQ water to get a final concentration of 10 ng/μL. Total genomic DNA concentration and nucleic acids/proteins ratio were estimated by using an Eppendorf 6131 biophotometer.

2.2. PCR assay and capillary electrophoresis

Twenty microsatellites markers (SSR) were chosen^[1-3] (Table 2).

DNA extract (5 μL of 10 ng/μL) from each plant was added to 20 μL of a master mix [2.5 μL 10x reaction buffer (NEB), 0.5 μL 25 mM dNTPs (NEB), 0.5 μL 10 mM Primer 1, 0.5 μL 10 mM Primer 2, 0.15 μL 5U/μL Taq DNA polymerase (NEB) and 15.85 μL UHQ water] . Forward primers are 6-FAM-labeled at the 5' end. PCRs were conducted with a 2720 Thermal Cycler (Applied Biosystems) with the following program: one cycle of 5 min at 95°C, 35 cycles of 30 s at 95°C, 30 s at 52 °C, 1 min at 68°C and a final extension step of 10 min at 68°C. PCR products were screened by capillary electrophoresis using the ABI 3730 XL (Applied Biosystems) of the GENTYANE Genotyping and Sequencing platform (Clermond-Ferrand, France). Electrophoregrams (Figure 1) were analysed with the Gene-Mapper software (Applied Biosystems).

Table 2: Description of the primers of the microsatellite markers used in the genetic diversity study

| SSR name | Forward Primer (5'-3') | Reverse Primer (5'-3') | References, Code * | Number of different amplified fragments |
|-----------|--------------------------|------------------------|--|---|
| SSR_Bj_1 | CCGTTGGGCCAATTGATGTC | TCACACGCTCCACTGTTACC | Singh et al. 2016, <i>BjSSR-133</i> | 2 |
| SSR_Bj_2 | CTGGCTCGAACTCCGTC | CAAACGTGCTGAGAAACGCA | Singh et al. 2016, <i>BjSSR-1645</i> | 0 |
| SSR_Bj_3 | CGGTCCGAAACCTCTTGATT | AGCCCTTCGGATCTCCTCTT | Singh et al. 2016, <i>BjSSR-1938</i> | 5 |
| SSR_Bj_4 | ACTCTCCGGATGGGAAAAGC | AGAAGGAAGCAAAGCTGAGACT | Singh et al. 2016, <i>BjSSR-2242</i> | 0 |
| SSR_Bj_5 | GCTTCTAGTTCCATTGCTGC | CCGCTGCAGCCATTTTCTT | Singh et al. 2016, <i>BjSSR-2349</i> | 3 |
| SSR_Bj_6 | GCATGAGCTTATTTTCTTTGATGA | TGGGCTTCTCGTCCAGTTC | Singh et al. 2016, <i>BjSSR-2490</i> | 3 |
| SSR_Bj_7 | TGGAGGCACTTCTCAGCTG | TGCCGCTCTTCATCGTGAG | Singh et al. 2016, <i>BjSSR-278</i> | 1 |
| SSR_Bj_8 | CGTCGATAGCTTCCACC | CTCCCGTGTCTCTTGTCC | Singh et al. 2016, <i>BjSSR-578</i> | 2 |
| SSR_Bj_9 | CCGGTTTGTCTCTCTCCC | TCTCCCTTTGCTCACACAC | Singh et al. 2016, <i>BjSSR-678</i> | 0 |
| SSR_Bj_10 | GTCTTCTCTCTGTGCGACC | AGTCAGCTTCTCTGTGGGA | Chen et al. 2013, <i>sN9875</i> | 3 |
| SSR_Bj_11 | AAGGAGCAAACAAGCGAT | GCACAAGCACTTACGGTGA | Chen et al. 2013, <i>sN2025</i> | 3 |
| SSR_Bj_12 | TTCTTGGTGTCTCTGCAAA | GAGCTATGGCAATCCTCTG | Chen et al. 2013, <i>sR12156</i> | 7 |
| SSR_Bj_13 | CAGATGAGACAACACAGGAAACA | ACTCAATACGTTTTTCGCGG | Chen et al. 2013, <i>sS1702</i> | 0 |
| SSR_Bj_14 | AATTAAGGGACCACGCAACA | CCAGAACCCTCTTGATCACTT | Chen et al. 2013, <i>sS2066</i> | 0 |
| SSR_Bj_15 | CTAAGAAGGAACCGGAAGG | AACCGGAATCAGAACACACA | Chen et al. 2013, <i>sN3514F</i> | 0 |
| SSR_Bj_16 | CAGCTGGTATCCTCGGTTT | CCTCAGGTGGACAGAGAAGC | Chen et al. 2013, <i>sR9477</i> | 6 |
| SSR_Bj_17 | CATGGTTAAAACAATGGCCC | CAAGAAACACCATATTCTCA | Chen et al. 2013, <i>No10-A08</i> | 0 |
| SSR_Bj_18 | AAGGAGATTGTTTTGGGGC | AAGACTAATAACACACGGCG | Sudan and Khajuria 2016, <i>BniB.Ni2-B01.1</i> | 1 |
| SSR_Bj_19 | TTATCTGCTTGTCTGGGGC | AAGGAAATCGTCTCACTTGG | Sudan and Khajuria 2016, <i>BniB.Ni2-E12.5</i> | 4 |
| SSR_Bj_20 | CACAGGAAACCGTGGCTAGA | AACCCAACCTCAACGTCTTG | Sudan and Khajuria. 2016, <i>SSRα3-D02B</i> | 0 |

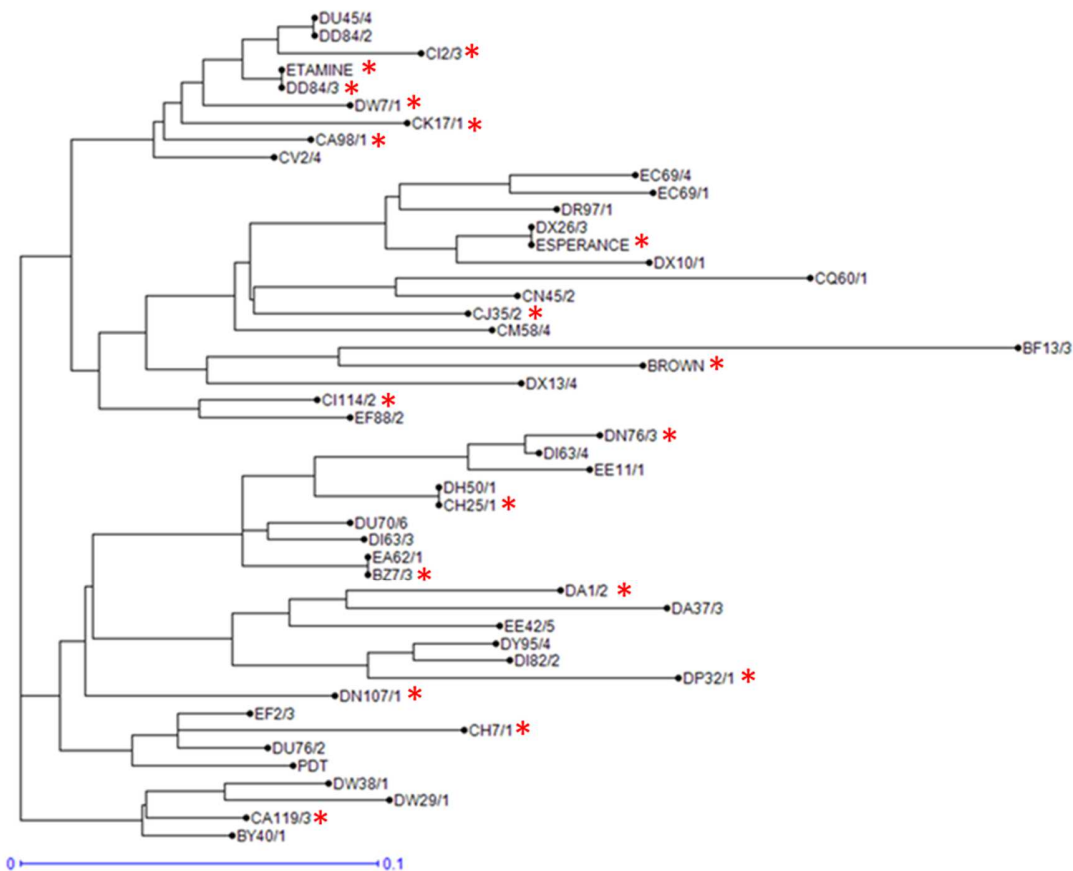


Figure 1: Dendrogram of the genetic diversity within the 48 genotypes. The 18 selected genotypes for further biochemical and rheological characterisation were indicated by a red asterisk. Darwin software, unpondered Neighbor joining method.

3. Near Infra-Red spectroscopy analysis

The quantitative mustard seeds biochemical parameters such as dry matter, fat (total lipids), proteins, Fatty Acids and Glucosinolates (*i.e.* sinigrin) were predicted using Near-infrared Spectroscopy (NIRSystems 6500-FOSS®). The mustard seeds were introduced in ¼ cup cell. The values were calculated on an average of 32 scans.

The validation of the instrument measurement was done using calibrated mustard seed samples. The references values of these calibrated samples were analysed with a reference laboratory method: Dry Matter (desiccation 4h/103°C), Protein (N, Kjeldahl method, NF EN ISO 5983-2), Fat (Soxhlet extraction method, NF V03 908), Fatty Acids (ISO/ Total FAT (NF EN ISO 12966-2/12966-4), Glucosinolates (NF V03 918-3).

Table 3: Average values of dry matter (DM), sinigrin, total lipids (Oil) and proteins (Prot) measured using NIR spectroscopy.

| Year | Location | Name | Dry matter [% seed weight] | Sinigrin [$\mu\text{mol/g DM}$] | Oil.NIRS ([% DM]) | PROT.NIRS [% DM] | Year | Location | Name | Dry matter [% seed weight] | Sinigrin [$\mu\text{mol/g DM}$] | Oil.NIRS ([% DM]) | PROT.NIRS [% DM] |
|------|----------|-----------|----------------------------|-----------------------------------|-------------------|------------------|------|----------|-----------|----------------------------|-----------------------------------|-------------------|------------------|
| 2018 | Ch | Brown | 94,6 | 109,8 | 36,1 | 27,8 | 2018 | Fv | Brown | 93,9 | 104,3 | 35,5 | 28,0 |
| 2018 | Ch | BZ7/3 | 94,3 | 100,5 | 36,6 | 28,3 | 2018 | Fv | BZ7/3 | 93,6 | 107,0 | 36,0 | 28,3 |
| 2018 | Ch | CA119/3 | 94,3 | 103,6 | 34,7 | 28,9 | 2018 | Fv | CA119/3 | 93,6 | 104,1 | 35,9 | 28,6 |
| 2018 | Ch | CA98/1 | 94,4 | 127,0 | 35,2 | 29,7 | 2018 | Fv | CA98/1 | 93,5 | 120,0 | 36,4 | 29,0 |
| 2018 | Ch | CH25/1 | 94,8 | 90,8 | 42,7 | 24,5 | 2018 | Fv | CH25/1 | 94,5 | 96,2 | 42,4 | 24,5 |
| 2018 | Ch | CH7/1 | 94,4 | 105,4 | 41,1 | 23,8 | 2018 | Fv | CH7/1 | 94,0 | 108,8 | 41,2 | 24,0 |
| 2018 | Ch | CI114/2 | 94,4 | 103,5 | 39,9 | 24,5 | 2018 | Fv | CI114/2 | 93,9 | 100,0 | 39,0 | 25,0 |
| 2018 | Ch | CI2/3 | 94,8 | 94,4 | 43,2 | 24,5 | 2018 | Fv | CI2/3 | 94,1 | 98,7 | 40,1 | 25,4 |
| 2018 | Ch | CJ35/2 | 94,2 | 111,6 | 36,4 | 26,7 | 2018 | Fv | CJ35/2 | 93,7 | 113,0 | 36,2 | 27,4 |
| 2018 | Ch | CK17/1 | 94,8 | 94,0 | 37,0 | 25,8 | 2018 | Fv | CK17/1 | 94,0 | 93,9 | 37,1 | 25,8 |
| 2018 | Ch | DA1/2 | 94,8 | 79,6 | 37,2 | 24,3 | 2018 | Fv | DA1/2 | 94,1 | 80,0 | 39,2 | 23,7 |
| 2018 | Ch | DD84/3 | 94,6 | 110,8 | 36,6 | 28,0 | 2018 | Fv | DD84/3 | 93,8 | 115,1 | 35,7 | 28,9 |
| 2018 | Ch | DN107/1 | 94,1 | 99,3 | 36,3 | 24,9 | 2018 | Fv | DN107/1 | 93,8 | 97,3 | 36,4 | 24,8 |
| 2018 | Ch | DN76/3 | 94,6 | 85,5 | 37,8 | 22,6 | 2018 | Fv | DN76/3 | 94,1 | 84,1 | 37,9 | 22,7 |
| 2018 | Ch | DP32/1 | 94,9 | 83,0 | 40,9 | 25,2 | 2018 | Fv | DP32/1 | 94,2 | 88,8 | 38,9 | 26,3 |
| 2018 | Ch | DW7/1 | 94,9 | 105,2 | 39,1 | 25,3 | 2018 | Fv | DW7/1 | 94,3 | 109,4 | 38,1 | 26,2 |
| 2018 | Ch | Espérance | 94,5 | 106,5 | 35,3 | 27,3 | 2018 | Fv | Espérance | 93,9 | 105,9 | 37,0 | 26,7 |
| 2018 | Ch | Etamine | 94,4 | 102,4 | 37,8 | 25,3 | 2018 | Fv | Etamine | 93,9 | 101,1 | 37,4 | 26,1 |
| 2018 | Bg | Brown | 94,0 | 103,1 | 37,2 | 26,9 | 2017 | Fv | Brown | 94,7 | 112,3 | 38,2 | 27,7 |
| 2018 | Bg | BZ7/3 | 94,2 | 100,6 | 39,3 | 25,2 | 2017 | Fv | BZ7/3 | 94,3 | 102,3 | 40,1 | 26,2 |
| 2018 | Bg | CA119/3 | 93,9 | 103,5 | 36,3 | 27,8 | 2017 | Fv | CA119/3 | 94,4 | 107,5 | 38,7 | 27,5 |
| 2018 | Bg | CA98/1 | 94,2 | 122,3 | 36,9 | 28,4 | 2017 | Fv | CA98/1 | 94,3 | 115,3 | 39,8 | 26,4 |
| 2018 | Bg | CH25/1 | 94,7 | 93,9 | 42,3 | 24,2 | 2017 | Fv | CH25/1 | 95,1 | 85,8 | 45,5 | 23,6 |
| 2018 | Bg | CH7/1 | 94,3 | 100,5 | 41,9 | 22,8 | 2017 | Fv | CH7/1 | 94,4 | 102,5 | 43,3 | 22,5 |
| 2018 | Bg | CI114/2 | 94,3 | 98,0 | 40,1 | 23,9 | 2017 | Fv | CI114/2 | 94,5 | 105,5 | 41,1 | 24,5 |
| 2018 | Bg | CI2/3 | 94,5 | 94,7 | 42,0 | 23,4 | 2017 | Fv | CI2/3 | 94,9 | 91,4 | 45,6 | 22,2 |
| 2018 | Bg | CJ35/2 | 94,0 | 105,2 | 37,7 | 26,1 | 2017 | Fv | CJ35/2 | 94,8 | 105,0 | 39,4 | 26,2 |
| 2018 | Bg | CK17/1 | 94,5 | 96,0 | 38,1 | 25,0 | 2017 | Fv | CK17/1 | 94,6 | 91,4 | 41,2 | 23,8 |
| 2018 | Bg | DA1/2 | 94,3 | 75,8 | 38,6 | 22,8 | 2017 | Fv | DA1/2 | 94,9 | 72,1 | 43,5 | 20,5 |
| 2018 | Bg | DD84/3 | 94,2 | 112,8 | 37,8 | 26,7 | 2017 | Fv | DD84/3 | 94,6 | 110,9 | 39,5 | 26,7 |
| 2018 | Bg | DN107/1 | 94,4 | 92,6 | 38,2 | 22,7 | 2017 | Fv | DN107/1 | 94,3 | 99,5 | 40,2 | 23,2 |
| 2018 | Bg | DN76/3 | 94,1 | 79,3 | 38,4 | 22,0 | 2017 | Fv | DN76/3 | 94,3 | 84,8 | 40,9 | 21,7 |
| 2018 | Bg | DP32/1 | 94,7 | 77,4 | 41,4 | 24,2 | 2017 | Fv | DP32/1 | 95,5 | 74,9 | 46,6 | 21,6 |
| 2018 | Bg | DW7/1 | 94,4 | 102,1 | 38,8 | 24,5 | 2017 | Fv | DW7/1 | 94,7 | 98,8 | 42,9 | 23,1 |
| 2018 | Bg | Espérance | 94,3 | 100,9 | 39,4 | 23,5 | 2017 | Fv | Espérance | 94,2 | 99,9 | 39,4 | 25,4 |
| 2018 | Bg | Etamine | 94,4 | 95,7 | 41,4 | 22,3 | 2017 | Fv | Etamine | 95,2 | 97,7 | 41,6 | 22,8 |

Table 4: Average values of fatty acids measured using NIR spectroscopy.

| Year | Location | Name | C16:0.NIRS [% DM] | C18:0.NIRS [% DM] | C18:1.NIRS [% DM] | C18:2.NIRS [% DM] | C18:3.NIRS [% DM] | C20:1.NIRS [% DM] | C22:1.NIRS [% DM] | Year | Location | Name | C16:0.NIRS [% DM] | C18:0.NIRS [% DM] | C18:1.NIRS [% DM] | C18:2.NIRS [% DM] | C18:3.NIRS [% DM] | C20:1.NIRS [% DM] | C22:1.NIRS [% DM] |
|------|----------|-----------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|------|----------|-----------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| 2018 | Ch | Brown | 1,2 | 0,5 | 6,8 | 8,2 | 4,5 | 4,3 | 7,8 | 2018 | Fv | Brown | 1,2 | 0,5 | 6,8 | 8,3 | 4,3 | 4,3 | 7,6 |
| 2018 | Ch | BZ7/3 | 1,3 | 0,5 | 7,0 | 8,1 | 4,2 | 4,4 | 8,8 | 2018 | Fv | BZ7/3 | 1,3 | 0,6 | 7,7 | 8,5 | 3,9 | 4,4 | 7,9 |
| 2018 | Ch | CA119/3 | 1,4 | 0,6 | 7,7 | 9,5 | 4,4 | 4,1 | 5,8 | 2018 | Fv | CA119/3 | 1,4 | 0,6 | 7,7 | 9,5 | 4,3 | 4,3 | 6,7 |
| 2018 | Ch | CA98/1 | 1,4 | 0,6 | 8,2 | 9,5 | 4,3 | 4,2 | 5,1 | 2018 | Fv | CA98/1 | 1,3 | 0,6 | 8,4 | 9,3 | 4,4 | 4,4 | 6,1 |
| 2018 | Ch | CH25/1 | 1,3 | 0,4 | 4,8 | 7,3 | 4,7 | 5,2 | 16,6 | 2018 | Fv | CH25/1 | 1,3 | 0,5 | 5,5 | 7,2 | 4,5 | 5,2 | 15,9 |
| 2018 | Ch | CH7/1 | 1,1 | 0,5 | 4,6 | 6,9 | 4,7 | 5,1 | 15,2 | 2018 | Fv | CH7/1 | 1,1 | 0,5 | 4,6 | 6,9 | 4,6 | 5,1 | 15,4 |
| 2018 | Ch | CI114/2 | 1,2 | 0,6 | 8,6 | 9,1 | 5,0 | 4,9 | 8,0 | 2018 | Fv | CI114/2 | 1,3 | 0,6 | 8,0 | 9,0 | 4,7 | 4,8 | 8,1 |
| 2018 | Ch | CI2/3 | 1,4 | 0,5 | 5,5 | 7,3 | 4,9 | 5,3 | 15,3 | 2018 | Fv | CI2/3 | 1,4 | 0,5 | 5,4 | 7,1 | 4,3 | 4,9 | 13,9 |
| 2018 | Ch | CJ35/2 | 1,3 | 0,6 | 9,4 | 9,7 | 4,8 | 4,4 | 2,5 | 2018 | Fv | CJ35/2 | 1,3 | 0,6 | 9,2 | 9,9 | 4,9 | 4,4 | 2,8 |
| 2018 | Ch | CK17/1 | 1,5 | 0,7 | 11,5 | 11,4 | 5,2 | 4,4 | -0,3 | 2018 | Fv | CK17/1 | 1,5 | 0,7 | 11,2 | 11,3 | 5,1 | 4,4 | 0,0 |
| 2018 | Ch | DA1/2 | 1,4 | 0,6 | 7,8 | 8,7 | 3,9 | 4,5 | 8,3 | 2018 | Fv | DA1/2 | 1,4 | 0,6 | 8,7 | 9,1 | 4,1 | 4,8 | 8,4 |
| 2018 | Ch | DD84/3 | 1,2 | 0,6 | 8,0 | 8,8 | 4,3 | 4,4 | 7,0 | 2018 | Fv | DD84/3 | 1,2 | 0,5 | 8,0 | 8,6 | 4,2 | 4,3 | 6,9 |
| 2018 | Ch | DN107/1 | 1,6 | 0,7 | 12,1 | 12,1 | 4,4 | 4,3 | 0,0 | 2018 | Fv | DN107/1 | 1,6 | 0,8 | 12,8 | 11,8 | 4,1 | 4,4 | 0,0 |
| 2018 | Ch | DN76/3 | 1,6 | 0,8 | 12,7 | 11,8 | 4,1 | 4,6 | 0,0 | 2018 | Fv | DN76/3 | 1,5 | 0,8 | 12,6 | 11,6 | 4,2 | 4,6 | 0,3 |
| 2018 | Ch | DP32/1 | 1,4 | 0,4 | 5,8 | 7,4 | 4,4 | 5,0 | 13,9 | 2018 | Fv | DP32/1 | 1,4 | 0,5 | 5,8 | 7,5 | 4,1 | 4,7 | 13,2 |
| 2018 | Ch | DW7/1 | 1,3 | 0,6 | 8,2 | 8,9 | 4,5 | 4,7 | 8,0 | 2018 | Fv | DW7/1 | 1,3 | 0,6 | 7,6 | 8,6 | 4,3 | 4,7 | 8,5 |
| 2018 | Ch | Espérance | 1,3 | 0,6 | 8,5 | 8,8 | 3,7 | 4,3 | 5,3 | 2018 | Fv | Espérance | 1,2 | 0,6 | 8,9 | 8,9 | 3,8 | 4,5 | 5,7 |
| 2018 | Ch | Etamine | 1,3 | 0,6 | 8,0 | 8,6 | 4,5 | 4,5 | 7,4 | 2018 | Fv | Etamine | 1,3 | 0,6 | 7,6 | 8,5 | 4,3 | 4,5 | 8,4 |
| 2018 | Bg | Brown | 1,3 | 0,6 | 7,2 | 8,5 | 4,6 | 4,5 | 7,7 | 2017 | Fv | Brown | 1,1 | 0,5 | 7,9 | 8,1 | 4,8 | 4,7 | 7,8 |
| 2018 | Bg | BZ7/3 | 1,3 | 0,6 | 7,9 | 8,3 | 4,5 | 4,9 | 9,2 | 2017 | Fv | BZ7/3 | 1,2 | 0,6 | 8,5 | 8,3 | 4,4 | 5,1 | 9,3 |
| 2018 | Bg | CA119/3 | 1,4 | 0,6 | 8,3 | 9,6 | 4,5 | 4,4 | 6,0 | 2017 | Fv | CA119/3 | 1,3 | 0,6 | 9,0 | 9,0 | 4,6 | 4,8 | 6,4 |
| 2018 | Bg | CA98/1 | 1,4 | 0,6 | 8,0 | 9,6 | 4,5 | 4,5 | 5,9 | 2017 | Fv | CA98/1 | 1,3 | 0,6 | 9,3 | 9,1 | 4,7 | 5,0 | 6,5 |
| 2018 | Bg | CH25/1 | 1,3 | 0,4 | 5,1 | 7,2 | 4,9 | 5,2 | 16,2 | 2017 | Fv | CH25/1 | 1,2 | 0,5 | 5,8 | 6,9 | 4,9 | 5,8 | 18,1 |
| 2018 | Bg | CH7/1 | 1,2 | 0,5 | 4,4 | 7,0 | 5,0 | 5,2 | 16,0 | 2017 | Fv | CH7/1 | 1,1 | 0,5 | 5,2 | 6,7 | 4,7 | 5,6 | 16,0 |
| 2018 | Bg | CI114/2 | 1,3 | 0,6 | 8,0 | 8,9 | 5,0 | 4,9 | 8,5 | 2017 | Fv | CI114/2 | 1,2 | 0,6 | 8,7 | 8,8 | 5,1 | 5,2 | 8,0 |
| 2018 | Bg | CI2/3 | 1,4 | 0,5 | 5,3 | 7,4 | 4,9 | 5,1 | 15,0 | 2017 | Fv | CI2/3 | 1,2 | 0,5 | 6,0 | 7,1 | 5,0 | 5,7 | 16,6 |
| 2018 | Bg | CJ35/2 | 1,3 | 0,6 | 8,9 | 9,8 | 5,0 | 4,6 | 3,7 | 2017 | Fv | CJ35/2 | 1,3 | 0,6 | 9,7 | 9,8 | 5,5 | 4,9 | 3,8 |
| 2018 | Bg | CK17/1 | 1,6 | 0,7 | 11,4 | 11,4 | 5,4 | 4,6 | 0,2 | 2017 | Fv | CK17/1 | 1,5 | 0,8 | 12,8 | 11,6 | 5,4 | 5,2 | 0,3 |
| 2018 | Bg | DA1/2 | 1,4 | 0,6 | 7,9 | 9,0 | 4,3 | 4,7 | 8,8 | 2017 | Fv | DA1/2 | 1,4 | 0,6 | 9,1 | 9,1 | 4,6 | 5,5 | 10,3 |
| 2018 | Bg | DD84/3 | 1,3 | 0,6 | 8,6 | 8,7 | 4,3 | 4,6 | 7,1 | 2017 | Fv | DD84/3 | 1,1 | 0,6 | 8,8 | 8,7 | 4,5 | 4,9 | 7,9 |
| 2018 | Bg | DN107/1 | 1,6 | 0,8 | 12,6 | 12,0 | 4,6 | 4,7 | 0,0 | 2017 | Fv | DN107/1 | 1,5 | 0,8 | 13,9 | 12,1 | 4,9 | 5,0 | 0,0 |
| 2018 | Bg | DN76/3 | 1,6 | 0,8 | 12,7 | 11,8 | 4,3 | 4,7 | 0,0 | 2017 | Fv | DN76/3 | 1,5 | 0,8 | 14,1 | 12,2 | 4,5 | 5,1 | 0,0 |
| 2018 | Bg | DP32/1 | 1,4 | 0,5 | 5,4 | 7,4 | 4,5 | 5,1 | 14,9 | 2017 | Fv | DP32/1 | 1,2 | 0,5 | 6,1 | 7,2 | 4,8 | 5,8 | 17,8 |
| 2018 | Bg | DW7/1 | 1,3 | 0,7 | 8,0 | 8,9 | 4,5 | 4,8 | 8,0 | 2017 | Fv | DW7/1 | 1,2 | 0,6 | 9,4 | 9,0 | 4,8 | 5,4 | 9,6 |
| 2018 | Bg | Espérance | 1,3 | 0,7 | 9,7 | 9,6 | 4,2 | 4,9 | 5,3 | 2017 | Fv | Espérance | 1,3 | 0,7 | 10,1 | 9,4 | 3,9 | 5,0 | 4,8 |
| 2018 | Bg | Etamine | 1,4 | 0,6 | 8,2 | 9,0 | 4,7 | 5,0 | 8,9 | 2017 | Fv | Etamine | 1,3 | 0,7 | 8,9 | 8,7 | 4,5 | 5,2 | 8,1 |

4. Sample preparations

Prior to biochemical analyses, 10 g of each cultivars were milled with an IKA M20 grinding system (IKA®-Werke GmbH & Co., KG, Germany) during 2 * 10 sec. Then, each mill was dried at 40°C overnight under vacuum over P2O5, weighted and defatted using an accelerated solvent extractor (ASE™350, Thermo Scientific™ Dionex™). Briefly, 1 g of dried mill per 22 mL stainless steel cell was flushed with hexane during 3 minutes at 20 °C (flow 2 mL.min-1). Partially defatted mill was recovered, dried and ground into fine powder using FastPrep-24 instrument (MP Biochemicals, CA) at a speed of 6.5 m/s for 60 s. Partially dried defatted mill was transferred in 22 mL stainless steel cell of the ASE® 350, weighted and flushed with hexane during 3 min at room temperature (flow 2 mL.min-1). Lipids content were determined as the yield of extraction using initial and final dry weight. Defatted mills were gridding before biochemical analyses (seed storage protein and cell wall polysaccharides composition).

5. Biochemical analyses

5.1. Seed storage protein composition

Seed storage proteins were extracted from defatted mill in Tris buffer 50 mM pH 8.5 containing NaCl 750 mM, EDTA 5 mM, sodium bisulfite 15 mM (ratio 1/10 w/w). Pigments were removed by desalting chromatography (PD Miditrap G-25, GE Healthcare). Depigmented extracts were injected onto size exclusion chromatography (Superdex75 Increase, GE Healthcare) with refractometer detection. The column was calibrated with increasing quantity of 12S and 2S standards produced as previously

described^[4]. Quantification of 12S and 2S was calculated from linear regression between peak area and standard quantity for each protein. The 12S and 2S contents were determined in triplicates in independent experiments.

Table 5: Average values of storage proteins measured after extraction and gel filtration analyses.

| Year | Location | Name | 12S.GF [% DM] | 2S.GF [% DM] | ratio 12S/2S | Year | Location | Name | 12S.GF [% DM] | 2S.GF [% DM] | ratio 12S/2S |
|------|----------|-----------|---------------|--------------|--------------|------|----------|-----------|---------------|--------------|--------------|
| 2018 | Ch | Brown | 6,0 | 7,4 | 0,81 | 2018 | Fv | Brown | 5,2 | 6,1 | 0,86 |
| 2018 | Ch | BZ7/3 | 6,4 | 7,7 | 0,84 | 2018 | Fv | BZ7/3 | 5,9 | 7,2 | 0,82 |
| 2018 | Ch | CA119/3 | 6,1 | 7,3 | 0,83 | 2018 | Fv | CA119/3 | 5,0 | 5,8 | 0,85 |
| 2018 | Ch | CA98/1 | 5,6 | 7,0 | 0,80 | 2018 | Fv | CA98/1 | 4,8 | 6,0 | 0,80 |
| 2018 | Ch | CH25/1 | 4,1 | 7,0 | 0,58 | 2018 | Fv | CH25/1 | 3,6 | 6,6 | 0,54 |
| 2018 | Ch | CH7/1 | 5,1 | 7,2 | 0,71 | 2018 | Fv | CH7/1 | 5,3 | 7,3 | 0,73 |
| 2018 | Ch | CI114/2 | 4,7 | 6,3 | 0,74 | 2018 | Fv | CI114/2 | 4,9 | 7,0 | 0,70 |
| 2018 | Ch | CI2/3 | 5,0 | 7,5 | 0,66 | 2018 | Fv | CI2/3 | 3,5 | 5,7 | 0,62 |
| 2018 | Ch | CJ35/2 | 6,5 | 8,5 | 0,77 | 2018 | Fv | CJ35/2 | 5,8 | 8,1 | 0,73 |
| 2018 | Ch | CK17/1 | 5,5 | 8,5 | 0,65 | 2018 | Fv | CK17/1 | 3,2 | 4,9 | 0,64 |
| 2018 | Ch | DA1/2 | 5,1 | 6,5 | 0,78 | 2018 | Fv | DA1/2 | 3,0 | 4,1 | 0,72 |
| 2018 | Ch | DD84/3 | 6,6 | 7,0 | 0,94 | 2018 | Fv | DD84/3 | 5,8 | 7,0 | 0,82 |
| 2018 | Ch | DN107/1 | 5,5 | 7,1 | 0,78 | 2018 | Fv | DN107/1 | 4,7 | 6,9 | 0,68 |
| 2018 | Ch | DN76/3 | 5,3 | 6,4 | 0,83 | 2018 | Fv | DN76/3 | 3,2 | 4,3 | 0,74 |
| 2018 | Ch | DP32/1 | 4,9 | 6,7 | 0,73 | 2018 | Fv | DP32/1 | 3,3 | 4,7 | 0,70 |
| 2018 | Ch | DW7/1 | 5,0 | 7,3 | 0,69 | 2018 | Fv | DW7/1 | 4,3 | 6,0 | 0,71 |
| 2018 | Ch | Espérance | 4,7 | 6,7 | 0,70 | 2018 | Fv | Espérance | 4,9 | 7,2 | 0,67 |
| 2018 | Ch | Etamine | 5,1 | 6,9 | 0,74 | 2018 | Fv | Etamine | 4,7 | 6,6 | 0,71 |
| 2018 | Bg | Brown | 5,3 | 6,0 | 0,89 | 2017 | Fv | Brown | 5,2 | 6,3 | 0,83 |
| 2018 | Bg | BZ7/3 | 5,0 | 6,8 | 0,73 | 2017 | Fv | BZ7/3 | 4,4 | 5,3 | 0,83 |
| 2018 | Bg | CA119/3 | 5,8 | 7,2 | 0,80 | 2017 | Fv | CA119/3 | 6,1 | 7,4 | 0,82 |
| 2018 | Bg | CA98/1 | 6,3 | 7,8 | 0,81 | 2017 | Fv | CA98/1 | 5,2 | 6,2 | 0,83 |
| 2018 | Bg | CH25/1 | 4,1 | 6,0 | 0,68 | 2017 | Fv | CH25/1 | 3,2 | 5,1 | 0,63 |
| 2018 | Bg | CH7/1 | 4,0 | 6,1 | 0,66 | 2017 | Fv | CH7/1 | 3,5 | 5,3 | 0,65 |
| 2018 | Bg | CI114/2 | 6,3 | 8,5 | 0,75 | 2017 | Fv | CI114/2 | 4,5 | 4,4 | 1,02 |
| 2018 | Bg | CI2/3 | 4,5 | 6,5 | 0,69 | 2017 | Fv | CI2/3 | 4,3 | 6,8 | 0,63 |
| 2018 | Bg | CJ35/2 | 7,2 | 9,4 | 0,76 | 2017 | Fv | CJ35/2 | 6,0 | 7,2 | 0,83 |
| 2018 | Bg | CK17/1 | 5,6 | 8,4 | 0,67 | 2017 | Fv | CK17/1 | 4,7 | 7,3 | 0,65 |
| 2018 | Bg | DA1/2 | 5,2 | 6,9 | 0,75 | 2017 | Fv | DA1/2 | 4,5 | 6,3 | 0,72 |
| 2018 | Bg | DD84/3 | 6,6 | 7,7 | 0,86 | 2017 | Fv | DD84/3 | 5,7 | 6,1 | 0,96 |
| 2018 | Bg | DN107/1 | 5,1 | 7,5 | 0,68 | 2017 | Fv | DN107/1 | 4,3 | 6,4 | 0,67 |
| 2018 | Bg | DN76/3 | 5,6 | 7,2 | 0,78 | 2017 | Fv | DN76/3 | 4,6 | 6,0 | 0,77 |
| 2018 | Bg | DP32/1 | 4,7 | 6,4 | 0,74 | 2017 | Fv | DP32/1 | 3,6 | 5,5 | 0,67 |
| 2018 | Bg | DW7/1 | 3,3 | 4,0 | 0,82 | 2017 | Fv | DW7/1 | 4,4 | 6,8 | 0,66 |
| 2018 | Bg | Espérance | 4,4 | 6,7 | 0,66 | 2017 | Fv | Espérance | 4,9 | 6,8 | 0,72 |
| 2018 | Bg | Etamine | 4,2 | 6,0 | 0,70 | 2017 | Fv | Etamine | 4,5 | 6,1 | 0,73 |

5.2. Cell wall polysaccharides composition

Cell wall polysaccharides were extracted as Alcohol Insoluble Residues (AIRs) using the ASE[®] 350 (Thermo Scientific™ Dionex™). Approximately 200 mg of defatted dried mill prepared as described above were transferred in 22 mL cells of the ASE[®] 350, weighted and AIRs were extracted using 80%

ethanol at 100°C during 15 min (flow 2 mL.min⁻¹). Cells of the ASE[®] 350 containing AIRs were dried at 40°C overnight under vacuum over P2O5 before weighing in order to determine the yield of extraction. AIRs were grinded before compositional analyses.

Identification and quantification of cell wall sugars were performed by gas-liquid chromatography (GC) or using the methoxydiphenyl colorimetric method after sulfuric acid degradation as described previously^[5].

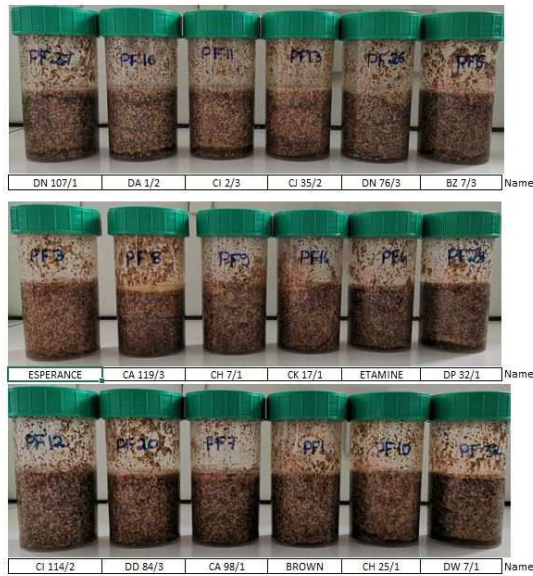
Table 6: Average values of cell wall polysaccharides: total amount (PS) and amount of each monosaccharide subunit of PS (Rha: rhamnose; Ara: arabinose; Xyl: xylose; Man: mannose; Gal: galactose; Glc: glucose; UA: uronic acids).

| Year | Location | Name | PS.GC [% DM] | Rha.GC [% DM] | Ara.GC [% DM] | Xyl.GC [% DM] | Man.GC [% DM] | Gal.GC [% DM] | Glc.GC [% DM] | UA.GC [% DM] | Year | Location | Name | PS.GC [% DM] | Rha.GC [% DM] | Ara.GC [% DM] | Xyl.GC [% DM] | Man.GC [% DM] | Gal.GC [% DM] | Glc.GC [% DM] | UA.GC [% DM] |
|------|----------|-----------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|--------------|------|----------|-----------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|--------------|
| 2018 | Ch | Brown | 16,5 | 0,2 | 3,2 | 1,1 | 0,4 | 1,8 | 4,9 | 4,9 | 2018 | Fv | Brown | 15,4 | 0,3 | 3,0 | 1,1 | 0,4 | 1,7 | 4,8 | 4,0 |
| 2018 | Ch | BZ7/3 | 18,4 | 0,3 | 3,3 | 1,2 | 0,4 | 2,1 | 5,7 | 5,3 | 2018 | Fv | BZ7/3 | 13,1 | 0,2 | 2,6 | 0,9 | 0,4 | 1,5 | 3,9 | 3,6 |
| 2018 | Ch | CA119/3 | 15,7 | 0,3 | 3,3 | 1,2 | 0,4 | 1,5 | 4,3 | 4,7 | 2018 | Fv | CA119/3 | 13,0 | 0,2 | 2,7 | 0,9 | 0,4 | 1,4 | 3,9 | 3,4 |
| 2018 | Ch | CA98/1 | 17,7 | 0,3 | 3,3 | 1,2 | 0,4 | 2,2 | 5,3 | 5,0 | 2018 | Fv | CA98/1 | 13,0 | 0,2 | 2,6 | 0,9 | 0,4 | 1,5 | 3,8 | 3,5 |
| 2018 | Ch | CH25/1 | 16,2 | 0,3 | 3,6 | 1,3 | 0,4 | 1,7 | 4,5 | 4,2 | 2018 | Fv | CH25/1 | 13,0 | 0,2 | 3,0 | 1,0 | 0,3 | 1,4 | 3,8 | 3,2 |
| 2018 | Ch | CH7/1 | 14,2 | 0,1 | 2,9 | 0,9 | 0,3 | 1,4 | 3,8 | 4,8 | 2018 | Fv | CH7/1 | 12,9 | 0,2 | 2,7 | 0,9 | 0,4 | 1,4 | 3,7 | 3,6 |
| 2018 | Ch | CI114/2 | 17,3 | 0,3 | 3,6 | 1,3 | 0,4 | 1,9 | 5,1 | 4,6 | 2018 | Fv | CI114/2 | 13,9 | 0,3 | 2,8 | 1,0 | 0,5 | 1,5 | 4,2 | 3,5 |
| 2018 | Ch | CI2/3 | 14,1 | 0,3 | 3,2 | 1,1 | 0,2 | 1,3 | 4,0 | 4,0 | 2018 | Fv | CI2/3 | 11,1 | 0,2 | 2,5 | 0,8 | 0,3 | 1,2 | 3,2 | 2,9 |
| 2018 | Ch | CJ35/2 | 21,4 | 0,4 | 4,8 | 1,6 | 0,6 | 2,6 | 6,1 | 5,2 | 2018 | Fv | CJ35/2 | 14,0 | 0,3 | 3,0 | 1,1 | 0,4 | 1,7 | 4,1 | 3,5 |
| 2018 | Ch | CK17/1 | 16,8 | 0,2 | 3,4 | 1,1 | 0,4 | 1,7 | 4,9 | 5,1 | 2018 | Fv | CK17/1 | 14,0 | 0,3 | 3,1 | 1,1 | 0,4 | 1,4 | 4,1 | 3,6 |
| 2018 | Ch | DA1/2 | 17,4 | 0,3 | 3,7 | 1,2 | 0,4 | 1,8 | 4,9 | 5,1 | 2018 | Fv | DA1/2 | 14,3 | 0,3 | 3,2 | 1,0 | 0,3 | 1,6 | 4,2 | 3,6 |
| 2018 | Ch | DD84/3 | 15,9 | 0,3 | 3,1 | 1,2 | 0,4 | 1,7 | 4,7 | 4,5 | 2018 | Fv | DD84/3 | 14,2 | 0,3 | 2,9 | 1,0 | 0,4 | 1,5 | 4,4 | 3,7 |
| 2018 | Ch | DN107/1 | 17,7 | 0,3 | 3,4 | 1,2 | 0,4 | 1,9 | 5,2 | 5,3 | 2018 | Fv | DN107/1 | 16,1 | 0,3 | 3,4 | 1,2 | 0,5 | 1,7 | 4,8 | 4,2 |
| 2018 | Ch | DN76/3 | 19,0 | 0,3 | 3,8 | 1,3 | 0,4 | 2,0 | 5,6 | 5,5 | 2018 | Fv | DN76/3 | 15,8 | 0,3 | 3,4 | 1,2 | 0,4 | 1,7 | 4,6 | 4,1 |
| 2018 | Ch | DP32/1 | 14,8 | 0,3 | 3,3 | 1,1 | 0,3 | 1,5 | 4,4 | 3,9 | 2018 | Fv | DP32/1 | 12,6 | 0,3 | 2,8 | 0,9 | 0,3 | 1,3 | 3,7 | 3,2 |
| 2018 | Ch | DW7/1 | 16,4 | 0,5 | 3,4 | 1,3 | 0,1 | 1,5 | 5,1 | 4,5 | 2018 | Fv | DW7/1 | 13,3 | 0,3 | 2,8 | 0,9 | 0,4 | 1,6 | 3,9 | 3,4 |
| 2018 | Ch | Espérance | 18,6 | 0,2 | 3,5 | 1,2 | 0,4 | 2,1 | 5,5 | 5,6 | 2018 | Fv | Espérance | 15,4 | 0,2 | 3,1 | 1,1 | 0,5 | 1,7 | 4,5 | 4,2 |
| 2018 | Ch | Etamine | 17,3 | 0,2 | 3,5 | 1,1 | 0,3 | 1,8 | 5,1 | 5,3 | 2018 | Fv | Etamine | 12,3 | 0,2 | 2,6 | 0,8 | 0,3 | 1,3 | 3,7 | 3,4 |
| 2018 | Bg | Brown | 16,7 | 0,3 | 3,2 | 1,2 | 0,4 | 2,0 | 5,4 | 4,1 | 2017 | Fv | Brown | 15,1 | 0,3 | 3,1 | 1,1 | 0,5 | 1,6 | 4,7 | 3,7 |
| 2018 | Bg | BZ7/3 | 16,0 | 0,3 | 3,0 | 1,2 | 0,4 | 1,9 | 5,4 | 3,8 | 2017 | Fv | BZ7/3 | 13,5 | 0,2 | 2,8 | 1,1 | 0,4 | 1,5 | 4,1 | 3,3 |
| 2018 | Bg | CA119/3 | 14,4 | 0,2 | 2,9 | 1,1 | 0,4 | 1,5 | 4,3 | 3,9 | 2017 | Fv | CA119/3 | 13,3 | 0,2 | 2,8 | 1,0 | 0,4 | 1,5 | 4,0 | 3,2 |
| 2018 | Bg | CA98/1 | 15,4 | 0,2 | 2,9 | 1,1 | 0,4 | 1,8 | 5,0 | 3,9 | 2017 | Fv | CA98/1 | 12,9 | 0,2 | 2,7 | 1,0 | 0,4 | 1,5 | 3,9 | 3,2 |
| 2018 | Bg | CH25/1 | 14,7 | 0,2 | 3,1 | 1,1 | 0,3 | 1,7 | 4,5 | 3,8 | 2017 | Fv | CH25/1 | 12,9 | 0,3 | 2,8 | 1,0 | 0,4 | 1,4 | 3,8 | 3,2 |
| 2018 | Bg | CH7/1 | 15,4 | 0,3 | 3,0 | 1,0 | 0,4 | 1,6 | 4,9 | 4,0 | 2017 | Fv | CH7/1 | 13,0 | 0,2 | 2,9 | 1,0 | 0,3 | 1,4 | 3,9 | 3,1 |
| 2018 | Bg | CI114/2 | 14,7 | 0,3 | 3,2 | 1,1 | 0,3 | 1,7 | 4,3 | 3,6 | 2017 | Fv | CI114/2 | 14,6 | 0,3 | 3,1 | 1,1 | 0,5 | 1,6 | 4,4 | 3,5 |
| 2018 | Bg | CI2/3 | 13,0 | 0,2 | 2,9 | 0,9 | 0,3 | 1,4 | 3,8 | 3,5 | 2017 | Fv | CI2/3 | 11,7 | 0,2 | 2,7 | 0,9 | 0,3 | 1,2 | 3,6 | 2,9 |
| 2018 | Bg | CJ35/2 | 15,3 | 0,3 | 3,3 | 1,2 | 0,4 | 1,8 | 4,4 | 3,8 | 2017 | Fv | CJ35/2 | 14,3 | 0,2 | 3,1 | 1,1 | 0,5 | 1,7 | 4,2 | 3,4 |
| 2018 | Bg | CK17/1 | 14,8 | 0,2 | 3,3 | 1,2 | 0,4 | 1,6 | 4,5 | 3,8 | 2017 | Fv | CK17/1 | 15,2 | 0,3 | 3,3 | 1,2 | 0,5 | 1,7 | 4,7 | 3,6 |
| 2018 | Bg | DA1/2 | 18,0 | 0,4 | 4,0 | 1,3 | 0,4 | 1,9 | 5,4 | 4,5 | 2017 | Fv | DA1/2 | 16,4 | 0,4 | 3,7 | 1,2 | 0,4 | 1,7 | 4,9 | 4,0 |
| 2018 | Bg | DD84/3 | 16,4 | 0,3 | 3,4 | 1,2 | 0,4 | 1,8 | 5,0 | 4,3 | 2017 | Fv | DD84/3 | 14,6 | 0,2 | 3,1 | 1,1 | 0,5 | 1,6 | 4,4 | 3,6 |
| 2018 | Bg | DN107/1 | 16,8 | 0,3 | 3,8 | 1,4 | 0,4 | 1,9 | 5,0 | 4,0 | 2017 | Fv | DN107/1 | 15,1 | 0,3 | 3,3 | 1,2 | 0,5 | 1,6 | 4,4 | 3,7 |
| 2018 | Bg | DN76/3 | 17,5 | 0,3 | 3,7 | 1,3 | 0,4 | 1,8 | 5,4 | 4,4 | 2017 | Fv | DN76/3 | 16,4 | 0,3 | 3,5 | 1,2 | 0,6 | 1,8 | 5,0 | 4,0 |
| 2018 | Bg | DP32/1 | 14,0 | 0,2 | 3,0 | 1,0 | 0,3 | 1,6 | 4,4 | 3,5 | 2017 | Fv | DP32/1 | 12,2 | 0,2 | 2,8 | 0,9 | 0,4 | 1,2 | 3,7 | 2,9 |
| 2018 | Bg | DW7/1 | 15,6 | 0,2 | 3,3 | 1,1 | 0,3 | 1,7 | 4,6 | 4,2 | 2017 | Fv | DW7/1 | 14,3 | 0,3 | 3,1 | 1,1 | 0,5 | 1,7 | 4,2 | 3,4 |
| 2018 | Bg | Espérance | 16,6 | 0,6 | 3,7 | 1,1 | 0,5 | 1,8 | 4,8 | 4,2 | 2017 | Fv | Espérance | 16,2 | 0,3 | 3,4 | 1,2 | 0,5 | 1,9 | 4,8 | 4,1 |
| 2018 | Bg | Etamine | 14,7 | 0,2 | 3,1 | 1,1 | 0,3 | 1,5 | 4,4 | 4,1 | 2017 | Fv | Etamine | 14,5 | 0,2 | 3,0 | 1,0 | 0,4 | 1,5 | 4,6 | 3,8 |

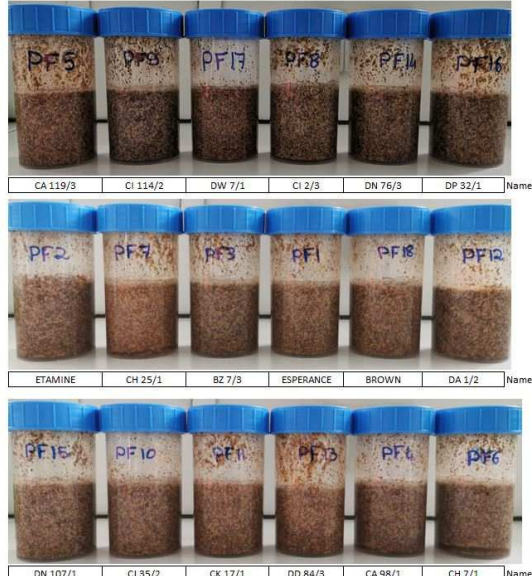
6. Rheological measurements

30 g of seeds were mixed 10 pulses in 15 seconds in a coffee grinder KRUPS F203 or in Tube Mill control IKA grinding system (IKA[®]-Werke GmbH & Co., KG, Germany) during 30 sec at 14000 rpm. Then, the grind was soaked 24h in 70 mL of a verjuice-like solution containing 8% Salt NaCl and 2% acetic acid. The totality of the mixture (100 mL) is transferred in a Bostwick Consistometer (Endecotts) to measure the distance (cm) of the sample flowing at 30 s and 60 s.

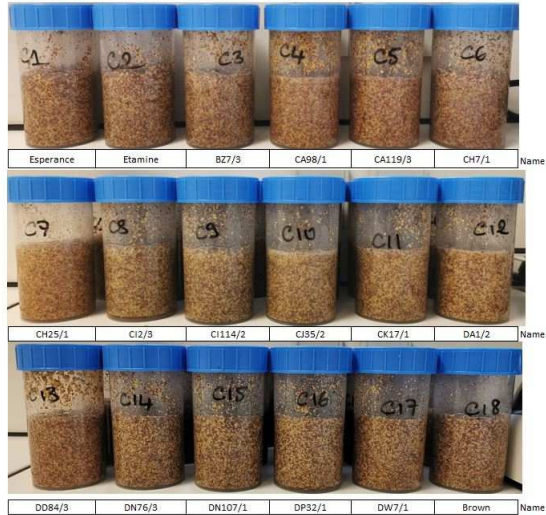
Fauverney 2017



Fauverney 2018



Chalon 2018



Barges 2018

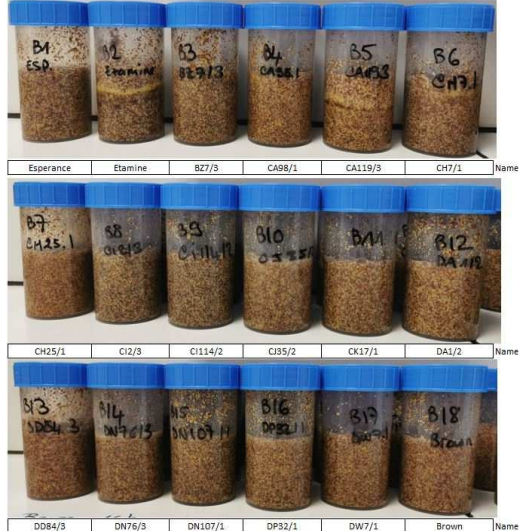


Figure 2: Appearance of grinded seeds soaked in verjuice-like solution for each location (Fauverney, Chalon, Barges) and year (2017, 2018)

Table 7: Average of flow in Bostwick consistometer of grinded seeds soaked in verjuice-like solution over a period of 30 seconds then 60 seconds

| Year | Location | Name | RheoN.30sec [cm] | RheoN.60sec [cm] | Year | Location | Name | RheoN.30sec [cm] | RheoN.60sec [cm] |
|------|----------|-----------|---------------------|---------------------|------|----------|-----------|---------------------|---------------------|
| 2018 | Ch | Brown | 10,3 | 10,5 | 2018 | Fv | Brown | 7,8 | 8,3 |
| 2018 | Ch | BZ7/3 | 13,5 | 14,0 | 2018 | Fv | BZ7/3 | 11,0 | 11,8 |
| 2018 | Ch | CA119/3 | 11,5 | 12,0 | 2018 | Fv | CA119/3 | 11,0 | 11,3 |
| 2018 | Ch | CA98/1 | 13,3 | 12,0 | 2018 | Fv | CA98/1 | 16,8 | 17,5 |
| 2018 | Ch | CH25/1 | 23,0 | 24,0 | 2018 | Fv | CH25/1 | 23,0 | 23,8 |
| 2018 | Ch | CH7/1 | 24,0 | 24,0 | 2018 | Fv | CH7/1 | 24,0 | 24,0 |
| 2018 | Ch | CI114/2 | 11,8 | 12,3 | 2018 | Fv | CI114/2 | 11,8 | 12,3 |
| 2018 | Ch | CI2/3 | 24,0 | 24,0 | 2018 | Fv | CI2/3 | 22,8 | 23,8 |
| 2018 | Ch | CJ35/2 | 18,0 | 19,0 | 2018 | Fv | CJ35/2 | 18,8 | 19,3 |
| 2018 | Ch | CK17/1 | 17,0 | 17,5 | 2018 | Fv | CK17/1 | 13,8 | 14,3 |
| 2018 | Ch | DA1/2 | 14,5 | 13,3 | 2018 | Fv | DA1/2 | 13,8 | 14,3 |
| 2018 | Ch | DD84/3 | 12,8 | 13,3 | 2018 | Fv | DD84/3 | 8,8 | 9,3 |
| 2018 | Ch | DN107/1 | 19,0 | 20,3 | 2018 | Fv | DN107/1 | 14,8 | 15,3 |
| 2018 | Ch | DN76/3 | 13,5 | 14,0 | 2018 | Fv | DN76/3 | 10,8 | 11,3 |
| 2018 | Ch | DP32/1 | 21,3 | 22,8 | 2018 | Fv | DP32/1 | 13,8 | 14,5 |
| 2018 | Ch | DW7/1 | 17,3 | 18,0 | 2018 | Fv | DW7/1 | 15,5 | 16,0 |
| 2018 | Ch | Espérance | 12,0 | 12,5 | 2018 | Fv | Espérance | 10,0 | 10,5 |
| 2018 | Ch | Etamine | 20,8 | 22,3 | 2018 | Fv | Etamine | 16,5 | 17,3 |
| 2018 | Bg | Brown | 11,5 | 12,0 | 2017 | Fv | Brown | 10,8 | 11,3 |
| 2018 | Bg | BZ7/3 | 15,5 | 16,3 | 2017 | Fv | BZ7/3 | 16,8 | 17,3 |
| 2018 | Bg | CA119/3 | 13,8 | 14,3 | 2017 | Fv | CA119/3 | 18,8 | 19,8 |
| 2018 | Bg | CA98/1 | 16,0 | 16,5 | 2017 | Fv | CA98/1 | 19,3 | 20,3 |
| 2018 | Bg | CH25/1 | 21,3 | 22,8 | 2017 | Fv | CH25/1 | 23,5 | 24,0 |
| 2018 | Bg | CH7/1 | 23,8 | 24,0 | 2017 | Fv | CH7/1 | 24,0 | 24,0 |
| 2018 | Bg | CI114/2 | 15,0 | 15,5 | 2017 | Fv | CI114/2 | 12,5 | 13,0 |
| 2018 | Bg | CI2/3 | 23,8 | 24,0 | 2017 | Fv | CI2/3 | 24,0 | 24,0 |
| 2018 | Bg | CJ35/2 | 21,0 | 22,0 | 2017 | Fv | CJ35/2 | 21,0 | 22,3 |
| 2018 | Bg | CK17/1 | 17,0 | 18,0 | 2017 | Fv | CK17/1 | 16,8 | 17,5 |
| 2018 | Bg | DA1/2 | 15,0 | 15,8 | 2017 | Fv | DA1/2 | 17,3 | 18,5 |
| 2018 | Bg | DD84/3 | 11,0 | 11,3 | 2017 | Fv | DD84/3 | 13,8 | 14,3 |
| 2018 | Bg | DN107/1 | 19,0 | 20,0 | 2017 | Fv | DN107/1 | 19,5 | 21,0 |
| 2018 | Bg | DN76/3 | 14,5 | 15,0 | 2017 | Fv | DN76/3 | 14,8 | 15,5 |
| 2018 | Bg | DP32/1 | 19,5 | 21,0 | 2017 | Fv | DP32/1 | 24,0 | 24,0 |
| 2018 | Bg | DW7/1 | 15,5 | 16,5 | 2017 | Fv | DW7/1 | 20,3 | 21,0 |
| 2018 | Bg | Espérance | 12,5 | 13,0 | 2017 | Fv | Espérance | 12,3 | 12,8 |
| 2018 | Bg | Etamine | 22,5 | 23,5 | 2017 | Fv | Etamine | 19,5 | 20,8 |

7. Particle size distribution

The particle size distribution of the grinded seeds for rheological measurements was determined by laser diffraction using a particle size analyzer Partica LA960 (Horiba). The refractive index used was 1.473 with water as dispersant. Each sample was measured in duplicate. The volume-weighted particle size distribution was calculated using the Mie theory by the LA960 Horiba analytical software. To compare the distribution of each accession, the D10, D50 and D90 values were used and the population proportion under 150µm.

Table 8: Average values of granulometric parameters: $D(v0,1)$, $D(v0,5)$, $D(v0,9)$ mean particle diameter in μm of 10%, 50% and 90% population and proportion of grinded seeds whose size is less than $150\mu\text{m}$

| Year | Location | Name | LG.D(v0,1) [μm] | LG.D(v0,5) [μm] | LG.D(v0,9) [μm] | LG.< 150 μm [%] | Year | Location | Name | LG.D(v0,1) [μm] | LG.D(v0,5) [μm] | LG.D(v0,9) [μm] | LG.< 150 μm [%] |
|------|----------|-----------|---------------------------------|---------------------------------|---------------------------------|-------------------------------|------|----------|-----------|---------------------------------|---------------------------------|---------------------------------|-------------------------------|
| 2018 | Ch | Brown | 42,8 | 520,3 | 1067,6 | 23,6 | 2018 | Fv | Brown | 41,4 | 506,9 | 1051,0 | 25,5 |
| 2018 | Ch | BZ7/3 | 41,3 | 522,7 | 1084,4 | 24,4 | 2018 | Fv | BZ7/3 | 42,2 | 496,5 | 1115,9 | 29,3 |
| 2018 | Ch | CA119/3 | 38,5 | 491,1 | 1080,9 | 26,6 | 2018 | Fv | CA119/3 | 40,3 | 498,7 | 1106,6 | 26,7 |
| 2018 | Ch | CA98/1 | 37,5 | 513,9 | 1083,4 | 26,4 | 2018 | Fv | CA98/1 | 41,3 | 540,6 | 1079,8 | 23,6 |
| 2018 | Ch | CH25/1 | 38,7 | 511,3 | 1087,8 | 26,1 | 2018 | Fv | CH25/1 | 42,0 | 476,4 | 1009,5 | 26,7 |
| 2018 | Ch | CH7/1 | 37,5 | 424,3 | 972,8 | 29,7 | 2018 | Fv | CH7/1 | 42,1 | 542,2 | 1077,5 | 25,3 |
| 2018 | Ch | CI114/2 | 43,8 | 494,9 | 1025,8 | 24,6 | 2018 | Fv | CI114/2 | 43,1 | 525,9 | 1097,2 | 25,1 |
| 2018 | Ch | CI2/3 | 40,0 | 490,2 | 995,9 | 26,1 | 2018 | Fv | CI2/3 | 41,4 | 506,6 | 1061,4 | 25,1 |
| 2018 | Ch | CJ35/2 | 40,0 | 476,8 | 1070,4 | 27,8 | 2018 | Fv | CJ35/2 | 44,0 | 597,5 | 1166,0 | 22,4 |
| 2018 | Ch | CK17/1 | 39,5 | 485,5 | 1043,0 | 25,0 | 2018 | Fv | CK17/1 | 45,5 | 580,4 | 1135,7 | 22,9 |
| 2018 | Ch | DA1/2 | 42,2 | 528,8 | 1133,1 | 25,0 | 2018 | Fv | DA1/2 | 40,6 | 507,5 | 1082,0 | 27,2 |
| 2018 | Ch | DD84/3 | 45,0 | 542,7 | 1100,2 | 22,7 | 2018 | Fv | DD84/3 | 44,8 | 549,9 | 1116,3 | 20,7 |
| 2018 | Ch | DN107/1 | 45,4 | 621,3 | 1185,2 | 20,5 | 2018 | Fv | DN107/1 | 43,3 | 573,4 | 1165,0 | 23,5 |
| 2018 | Ch | DN76/3 | 40,5 | 522,9 | 1111,2 | 26,5 | 2018 | Fv | DN76/3 | 44,6 | 583,3 | 1177,9 | 24,2 |
| 2018 | Ch | DP32/1 | 45,7 | 454,4 | 982,9 | 26,1 | 2018 | Fv | DP32/1 | 43,1 | 485,7 | 1066,3 | 25,8 |
| 2018 | Ch | DW7/1 | 44,2 | 542,5 | 1066,6 | 22,4 | 2018 | Fv | DW7/1 | 42,1 | 466,8 | 1023,5 | 30,5 |
| 2018 | Ch | Espérance | 44,5 | 567,3 | 1120,7 | 21,5 | 2018 | Fv | Espérance | 39,0 | 504,4 | 1090,1 | 26,3 |
| 2018 | Ch | Etamine | 42,8 | 545,9 | 1088,7 | 22,4 | 2018 | Fv | Etamine | 43,9 | 527,6 | 1056,8 | 23,9 |
| 2018 | Bg | Brown | 45,7 | 582,8 | 1141,8 | 21,5 | 2017 | Fv | Brown | 51,4 | 692,6 | 1077,2 | 21,0 |
| 2018 | Bg | BZ7/3 | 42,4 | 521,3 | 1102,2 | 27,4 | 2017 | Fv | BZ7/3 | 47,2 | 563,6 | 1224,1 | 27,4 |
| 2018 | Bg | CA119/3 | 43,3 | 565,4 | 1162,9 | 23,2 | 2017 | Fv | CA119/3 | 48,9 | 608,7 | 1296,1 | 25,9 |
| 2018 | Bg | CA98/1 | 39,8 | 521,8 | 1125,0 | 27,9 | 2017 | Fv | CA98/1 | 45,7 | 507,7 | 1205,2 | 30,6 |
| 2018 | Bg | CH25/1 | 39,4 | 530,9 | 1072,8 | 26,1 | 2017 | Fv | CH25/1 | 40,7 | 505,6 | 1130,9 | 29,6 |
| 2018 | Bg | CH7/1 | 37,9 | 461,1 | 977,6 | 28,9 | 2017 | Fv | CH7/1 | 39,8 | 477,5 | 1085,9 | 31,0 |
| 2018 | Bg | CI114/2 | 41,6 | 515,3 | 1068,1 | 25,6 | 2017 | Fv | CI114/2 | 47,9 | 536,3 | 1183,4 | 28,3 |
| 2018 | Bg | CI2/3 | 44,2 | 546,8 | 1097,8 | 23,3 | 2017 | Fv | CI2/3 | 47,2 | 462,1 | 1110,7 | 29,7 |
| 2018 | Bg | CJ35/2 | 40,2 | 534,1 | 1095,8 | 25,7 | 2017 | Fv | CJ35/2 | 44,5 | 547,6 | 1177,2 | 28,8 |
| 2018 | Bg | CK17/1 | 43,6 | 548,2 | 1116,0 | 24,6 | 2017 | Fv | CK17/1 | 47,2 | 591,2 | 1180,8 | 24,3 |
| 2018 | Bg | DA1/2 | 41,5 | 544,1 | 1141,1 | 24,8 | 2017 | Fv | DA1/2 | 43,0 | 500,9 | 1156,7 | 29,9 |
| 2018 | Bg | DD84/3 | 44,5 | 540,1 | 1086,8 | 23,9 | 2017 | Fv | DD84/3 | 46,1 | 533,1 | 1165,7 | 28,4 |
| 2018 | Bg | DN107/1 | 43,0 | 613,5 | 1189,3 | 23,6 | 2017 | Fv | DN107/1 | 47,8 | 543,5 | 1253,5 | 30,0 |
| 2018 | Bg | DN76/3 | 40,2 | 590,1 | 1208,9 | 24,4 | 2017 | Fv | DN76/3 | 48,5 | 608,1 | 1261,9 | 25,3 |
| 2018 | Bg | DP32/1 | 43,1 | 506,2 | 1067,3 | 24,6 | 2017 | Fv | DP32/1 | 45,4 | 486,9 | 1075,2 | 29,7 |
| 2018 | Bg | DW7/1 | 40,6 | 536,3 | 1079,2 | 24,4 | 2017 | Fv | DW7/1 | 47,2 | 532,1 | 1101,8 | 30,7 |
| 2018 | Bg | Espérance | 39,6 | 536,8 | 1103,7 | 23,8 | 2017 | Fv | Espérance | 49,4 | 614,4 | 1210,5 | 21,1 |
| 2018 | Bg | Etamine | 43,4 | 468,9 | 1005,8 | 29,5 | 2017 | Fv | Etamine | 51,8 | 607,9 | 1243,1 | 22,4 |

Credit Author Statement

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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