## Supplementary Material

The role of oxidative stress in determining the level of viability of black poplar (Populus nigra) seeds stored at different temperatures

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Table S1. Fatty acids composition in black poplar (Populus nigra L.) seeds
The percentage of palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2) and $\alpha$-linolenic acid (C18:3) determined using a GLC-10 FAME (Supelco) quantitative mix and heptadecanoic acid (17:0) as the internal standard

| Fatty acid |  | Content [\% $\pm$ s.e.] |
| :--- | :--- | :---: |
| C16:0 | Palmitic acid | $24.61 \pm 0.31$ |
| C18:0 | Steraic acid | $9.72 \pm 0.21$ |
| C18:1 | Oleic acid | $12.79 \pm 0.19$ |
| C18:2 | Linoleic acid | $35.82 \pm 0.19$ |
| C18:3 | $\alpha$-Linolenic acid | $17.21 \pm 0.17$ |

Table S2. Phospholipids: phosphatidylinositol (PI), phosphatidylcholine (PC), phosphatidylglycerol (PG), phosphatidylethanolamine (PE) and phosphatidic acid (PA) analyzed in black poplar (Populus nigra L.) seeds stored for 3 months, 1 year and 2 years at $\mathrm{LN},-20^{\circ} \mathrm{C},-10^{\circ} \mathrm{C},-3^{\circ} \mathrm{C}$ and $3^{\circ} \mathrm{C}$

Data represent the mean $\pm$ s.e. of six independent replicates. The Kruskal-Wallis test was used to compare storage temperature treatment. Data marked with the same letter are not statistically significant according to the multiple range test $(P \leq 0.05)$

|  | PI | PC | PG | PE | PA |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 3 months at: |  |  |  |  |  |
| LN | $29.51 \pm 2.55$ | $43.32 \pm 2.46$ | $21.06 \pm 4.00$ | $32.54 \pm 2.40$ | $36.89 \pm 2.14$ |
| $-20{ }^{\circ} \mathrm{C}$ | $28.58 \pm 1.52$ | $48.18 \pm 1.07$ | $19.38 \pm 1.53$ | $24.21 \pm 2.91$ | $23.07 \pm 3.05$ |
| $-10{ }^{\circ} \mathrm{C}$ | $20.91 \pm 2.45$ | $29.82 \pm 2.18$ | $9.44 \pm 0.15$ | $18.92 \pm 2.24$ | $15.43 \pm 2.28$ |
| $-3^{\circ} \mathrm{C}$ | $13.91 \pm 2.32$ | $25.67 \pm 2.39$ | $7.21 \pm 0.88$ | $16.34 \pm 0.92$ | $16.51 \pm 1.62$ |
| $+3^{\circ} \mathrm{C}$ | $25.61 \pm 2.89$ | $33.58 \pm 4.67$ | $15.39 \pm 0.65$ | $21.72 \pm 0.82$ | $17.11 \pm 0.90$ |
|  | $P=0.018$ | $P=0.022$ | $P=0.013$ | $P=0.283$ | $P=0.033$ |
| 1 year at: |  |  |  |  |  |
| LN | $19.52 \pm 0.41$ | $37.16 \pm 3.20$ | $16.71 \pm 1.18$ | $16.92 \pm 5.18$ | $24.00 \pm 1.92$ |
| $-20{ }^{\circ} \mathrm{C}$ | $16.45 \pm 1.14$ | $25.82 \pm 2.32$ | $13.96 \pm 2.67$ | $18.99 \pm 5.59$ | $23.09 \pm 0.79$ |
| $-10{ }^{\circ} \mathrm{C}$ | $12.49 \pm 4.03$ | $28.75 \pm 0.37$ | $12.76 \pm 0.53$ | $16.43 \pm 6.27$ | $23.66 \pm 0.40$ |
| $-3^{\circ} \mathrm{C}$ | $12.13 \pm 0.25$ | $12.96 \pm 1.27$ | $14.37 \pm 0.12$ | $23.45 \pm 1.72$ | $27.67 \pm 1.65$ |
| $+3{ }^{\circ} \mathrm{C}$ | $19.23 \pm 0.79$ | $17.96 \pm 2.93$ | $2.93 \pm 0.29$ | $15.07 \pm 1.74$ | $9.27 \pm 0.48$ |
|  | $P=0.081$ | $P=0.017$ | $P=0.454$ | $P=0.331$ | $P=0.062$ |
|  |  |  |  |  |  |
| LN | $14.81 \pm 2.01$ | $24.26 \pm 3.39$ | $9.58 \pm 0.74$ | $16.61 \pm 2.85$ | $12.90 \pm 2.10$ |
| $-20{ }^{\circ} \mathrm{C}$ | $18.93 \pm 2.52$ | $27.40 \pm 1.53$ | $16.66 \pm 2.88$ | $26.37 \pm 6.14$ | $19.50 \pm 2.43$ |
| $-10{ }^{\circ} \mathrm{C}$ | $18.36 \pm 3.03$ | $41.20 \pm 3.59$ | $16.15 \pm 2.57$ | $23.11 \pm 2.46$ | $20.51 \pm 1.33$ |
| $-3^{\circ} \mathrm{C}$ | $27.91 \pm 4.89$ | $30.77 \pm 9.88$ | $15.19 \pm 1.52$ | $21.69 \pm 5.02$ | $30.99 \pm 8.21$ |
| $+3{ }^{\circ} \mathrm{C}$ | $23.29 \pm 1.79$ | $39.54 \pm 2.30$ | $14.04 \pm 1.22$ | $38.82 \pm 9.41$ | $25.51 \pm 1.15$ |
|  | $P=0.011$ | $P=0.221673$ | $P=0.029$ | $P=0.092$ | $P=0.0051$ |

Table S3. Pearson correlation coefficient calculated between germination capacity of black poplar seeds (stored for 3 months, 1 year and 2 years; Suszka et al. 2014) and superoxide anionradical ( $\mathrm{O}_{2}^{-\bullet}$ ), hydrogen peroxide $\left(\mathrm{H}_{2} \mathrm{O}_{2}\right)$, protein carbonylation, electrolyte leakage, fatty acids including palmitic acid (C16:0), stearic acid ( $\mathrm{C} 18: 0$ ), oleic acid ( $\mathrm{C} 18: 1$ ), linoleic acid ( $\mathrm{C} 18: 2$ ) and $\alpha$-linolenic acid ( $\mathrm{C} 18: 3$ ), phospholipids including phosphatidylinositol (PI), phosphatidylcholine (PC), phosphatidylglycerol (PG), phosphatidylethanolamine ( PE ) and phosphatidic acid (PA), reduced (GSH) and oxidized (GSSG) form of glutathione and their redox potential ( $E_{G S S G / 2 G S H}$ ), reduced (AsA) and oxidized (DHA) form of ascorbate and their redox potential ( $E_{\text {AsA/DHA }}$ ), enzymes of the ascorbate-glutathione cycle including ascorbate peroxidase (APX), glutathione reductase (GR), dehydroascorbate reductase (DHAR) and monodehydroascorbate reductase (MDHAR)
$P$-value was calculated from the R-score at 0.05 significance level. Strong correlation coefficient is indicated with bolded type

|  | Germination |  |  |
| :---: | :---: | :---: | :---: |
|  | Seeds stored for 3 months | Seeds stored for 1 year | Seeds stored for 2 years |
| $\mathrm{O}_{2}{ }^{-}$ | $\begin{gathered} \mathrm{R}=0.4745 \\ P=0.061842 \end{gathered}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 8 8 8 3} \\ & P<0.00001 \end{aligned}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 9 3 7 3} \\ & P<0.00001 \end{aligned}$ |
| $\mathrm{H}_{2} \mathrm{O}_{2}$ | $\begin{gathered} \mathrm{R}=-0.4509 \\ P=0.091628 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathrm{R}=-0.3619 \\ P=0.185004 \end{gathered}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 7 8 5 5} \\ & P=0.00052 \\ & \hline \end{aligned}$ |
| Protein carbonylation | $\begin{gathered} \hline \mathrm{R}=-0.5218 \\ P=0.046431 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 9 2 2 7} \\ & P<0.00001 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathrm{R}=-0.5901 \\ P=0.020575 \\ \hline \end{gathered}$ |
| Electrolyte leakage | $\begin{gathered} \mathrm{R}=0.3847 \\ P=0.156814 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.7110 \\ P=0.002962 \\ \hline \end{gathered}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 9 7 6 1} \\ & P<0.00001 \\ & \hline \end{aligned}$ |
| C16:0 | $\begin{gathered} \mathrm{R}=-0.4005 \\ P=0.139055 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.7085 \\ p=0 \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 5 2 6} \\ P=0.001205 \\ \hline \end{gathered}$ |
| C18:0 | $\begin{gathered} \mathrm{R}=0.2425 \\ P=0.38385 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.4750 \\ P=0.073571 \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 7 6 6 9} \\ P=0.00085 \\ \hline \end{gathered}$ |
| C18:1 | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 8 3 5 8} \\ P=0.000104 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathrm{R}=0.7352 \\ P=0.00179 \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 5 0 0} \\ P=0.001284 \end{gathered}$ |
| C18:2 | $\begin{gathered} \mathrm{R}=-0.4904 \\ P=0.063465 \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 8 7 2 3} \\ P=0.000496 \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 9 7 1} \\ P=0.000373 \end{gathered}$ |
| C18:3 | $\begin{gathered} \hline \mathrm{R}=-0.6626 \\ P=0.222972 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 8 9 4 0} \\ P=6.2 \mathrm{E}-05 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 8 0 4} \\ P=0.000579 \\ \hline \end{gathered}$ |
| PI | $\begin{gathered} \hline \mathrm{R}=-0.1450 \\ P=0.606133 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.3011 \\ P=0.275473 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.7276 \\ P=0.002108 \\ \hline \end{gathered}$ |
| PC | $\begin{aligned} & \mathrm{R}=-0.4874 \\ & P=0.06535 \end{aligned}$ | $\begin{gathered} \mathrm{R}=0.7085 \\ P=0.003112 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6865 \\ P=0.004705 \\ \hline \end{gathered}$ |
| PG | $\begin{gathered} \mathrm{R}=-0.1405 \\ P=0.617472 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 8 8 3 1} \\ P=1.3 \mathrm{E}-05 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 8 5 5 8} \\ P=4.7 \mathrm{E}-05 \\ \hline \end{gathered}$ |
| PE | $\begin{gathered} \mathrm{R}=0.031 \\ P=0.91267 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 5 7 8} \\ P=0.001064 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.3908 \\ P=0.149788 \\ \hline \end{gathered}$ |
| PA | $\begin{gathered} \mathrm{R}=0.0012 \\ P=0.996614 \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 8 4 7 4} \\ P=6.7 \mathrm{E}-05 \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 8 2 3 2} \\ P=0.000163 \end{gathered}$ |
| GSH | $\begin{gathered} \mathrm{R}=0.7181 \\ P=0.002568 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6530 \\ P=0.008306 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.5712 \\ P=0.026137 \\ \hline \end{gathered}$ |
| GSSG | $\begin{gathered} \mathrm{R}=0.5037 \\ P=0.055582 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.4117 \\ P=0.127324 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.5226 \\ P=0.045645 \\ \hline \end{gathered}$ |
| $\mathbf{E}_{\text {GSSG/2GSH }}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 7 5 8 4} \\ P=0.001049 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.0871 \\ P=0.757581 \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.5265 \\ & P=0.04377 \\ & \hline \end{aligned}$ |
| AsA | $\begin{gathered} \mathrm{R}=0.0421 \\ P=0.881576 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.5586 \\ P=0.030432 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6831 \\ P=0.005001 \\ \hline \end{gathered}$ |
| DHA | $\begin{gathered} \mathrm{R}=0.2803 \\ P=0.31156 \\ \hline \end{gathered}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 8 8 6 2} \\ & P=1.1 \mathrm{E}-05 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathrm{R}=-0.6236 \\ P=0.012989 \\ \hline \end{gathered}$ |
| $\mathbf{E}_{\text {DHA/AsA }}$ | $\begin{gathered} \mathrm{R}=0.5830 \\ P=0.022546 \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 7 6 1 1} \\ P=0.000982 \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 8 1 2 9} \\ P=0.000229 \end{gathered}$ |
| APX | $\begin{gathered} \mathrm{R}=0.5373 \\ P=0.038875 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=-\mathbf{0 . 8 2 3 0} \\ P=0.000164 \\ \hline \end{gathered}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 8 9 6 2} \\ & P<0.00001 \\ & \hline \end{aligned}$ |
| GR | $\begin{gathered} \mathrm{R}=-0.5211 \\ P=0.046381 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-\mathbf{0 . 8 6 0 6} \\ & D=38 \mathrm{E}_{2} \mathrm{O} \end{aligned}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 8 3 6 3} \\ P=0.000102 \\ \hline \end{gathered}$ |
| DHAR | $\begin{gathered} \mathrm{R}=0.5544 \\ P=0.031976 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=-\mathbf{0 . 7 7 0 2} \\ P=0.000781 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=-\mathbf{0 . 8 3 3 3} \\ P=0.000114 \end{gathered}$ |
| MDHAR | $\begin{gathered} \mathrm{R}=0.5634 \\ P=0.028737 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 8 0 6 0} \\ P=0.000285 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 8 1 8 2} \\ P=0.000193 \\ \hline \end{gathered}$ |

Table S4. Pearson correlation coefficient calculated between the ROS content: (a) superoxide anionradical $\left(\mathrm{O}_{2}{ }^{-\bullet}\right)$, (b) hydrogen peroxide $\left(\mathrm{H}_{2} \mathrm{O}_{2}\right)$ and parameters that are thought to be affected by ROS: protein carbonylation, electrolyte leakage, fatty acids including palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2) and $\alpha$-linolenic acid (C18:3), phospholipids including phosphatidylinositol (PI), phosphatidylcholine (PC), phosphatidylglycerol (PG), phosphatidylethanolamine (PE) and phosphatidic acid (PA), reduced (GSH) and oxidized (GSSG) form of glutathione and their redox potential ( $\mathrm{E}_{\mathrm{GSSG} / 2 \mathrm{GSH}}$ ), reduced (AsA) and oxidized (DHA) form of ascorbate and their redox potential ( $\mathrm{E}_{\mathrm{AsA} / \mathrm{DHA}}$ ), enzymes of the ascorbateglutathione cycle including ascorbate peroxidase (APX), glutathione reductase (GR), dehydroascorbate reductase (DHAR) and monodehydroascorbate reductase (MDHAR)
$P$-value was calculated from the R-score at 0.05 significance level. Strong correlation coefficient is indicated with bolded type

| No. | Table S4a | $\mathrm{O}_{2}{ }^{-}$ |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Seeds stored for 3 months | Seeds stored for 1 year | seeds stored for 2 years |
| 1. | Protein carbonylation | $\begin{gathered} \mathrm{R}=-0.1027 \\ P=0.715698 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6692 \\ P=0.006364 \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 9 5 1} \\ P=0.000396 \\ \hline \end{gathered}$ |
| 2. | Electrolyte leakage | $\begin{gathered} \mathrm{R}=0.4698 \\ P=0.07723 \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.4171 \\ P=0.121918 \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 8 8 4 2} \\ P=1.2 \mathrm{E}-05 \\ \hline \end{gathered}$ |
| 3. | C16:0 | $\begin{gathered} \mathrm{R}=0.1754 \\ P=0.531797 \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 7 6 5 1} \\ P=0.000889 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 8 2 7 2} \\ P=0.000142 \\ \hline \end{gathered}$ |
| 4. | C18:0 | $\begin{gathered} \mathbf{R}=\mathbf{0 . 9 5 9 5} \\ P<0.00001 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.7011 \\ & P=0.00359 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 7 5 4 9} \\ P=0.001024 \\ \hline \end{gathered}$ |
| 5. | C18:1 | $\begin{gathered} \mathrm{R}=-0.3239 \\ P=238909 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 8 5 9 1} \\ & P=4.1 \mathrm{E}-05 \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 7 5 4 4} \\ & P=001155 \\ & \hline \end{aligned}$ |
| 6. | C18:2 | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 9 8 1 6} \\ P<0.00001 \end{gathered}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 8 6 5 2} \\ & P=3.1 \mathrm{E}-05 \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=\mathbf{- 0 . 8 2 1 6} \\ & P=0 \end{aligned}$ |
| 7. | C18:3 | $\begin{gathered} \mathrm{R}=-0.1459 \\ P=0.603975 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.6339 \\ P=0.011161 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 8 1 0 0} \\ P=0.000252 \\ \hline \end{gathered}$ |
| 8. | PI | $\begin{gathered} \mathrm{R}=-0.6690 \\ P=0.006386 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.0267 \\ P=0.924749 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.1804 \\ P=0.519975 \\ \hline \end{gathered}$ |
| 9. | PC | $\begin{gathered} \hline \mathbf{R}=-\mathbf{0 . 8 0 6 8} \\ P=0.000278 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathrm{R}=-0.5855 \\ P=0.021837 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.5788 \\ P=0.023778 \\ \hline \end{gathered}$ |
| 10. | PG | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 8 1 0 1} \\ P=0.000251 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-\mathbf{0 . 9 8 6 0} \\ P<0.00001 \end{gathered}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 9 0 1 3} \\ & P<0.00001 \\ & \hline \end{aligned}$ |
| 11. | PE | $\begin{gathered} \mathrm{R}=-0.6217 \\ P=0.1335 \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.4661 \\ & P=0.079912 \end{aligned}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 7 7 4 5} \\ & P=0.000699 \end{aligned}$ |
| 12. | PA | $\begin{aligned} & \hline \mathrm{R}=-0.6161 \\ & P=0.01446 \\ & \hline \end{aligned}$ | $\begin{aligned} & \mathrm{R}=-0.6171 \\ & P=0.014256 \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 9 1 4 8} \\ & P<0.00001 \\ & \hline \end{aligned}$ |
| 13. | GSH | $\begin{gathered} \mathrm{R}=-0.1311 \\ P=0.641418 \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.0868 \\ P=0.758393 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.4500 \\ P=0.092357 \end{gathered}$ |
| 14. | GSSG | $\begin{gathered} \mathrm{R}=0.2477 \\ P=0.373413 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.3345 \\ P=0.222991 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.0205 \\ P=0.942192 \end{gathered}$ |
| 15. | $\mathbf{E}_{\text {GSSG/2GSH }}$ | $\begin{gathered} \mathrm{R}=0.0382 \\ P=0.892485 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=\mathbf{0 . 8 1 2 3} \\ P=0.000234 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 8 7 5} \\ P=0.000491 \\ \hline \end{gathered}$ |
| 16. | AsA | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 8 3 6 6} \\ & P=0.000101 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathrm{R}=0.2706 \\ P=0.329326 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.0314 \\ & P=0.911547 \\ & \hline \end{aligned}$ |
| 17. | DHA | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 9 1 3 1} \\ P<0.00001 \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 9 6 0 1} \\ P<0.00001 \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.5983 \\ P=0.018466 \end{gathered}$ |
| 18. | $\mathbf{E}_{\text {DHA/AsA }}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 8 5 0 7} \\ & P=5.8 \mathrm{E}-05 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 8 8 5 0} \\ P=1.2 \mathrm{E}-05 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 7 9 4 7} \\ & P=0.0004 \\ & \hline \end{aligned}$ |
| 19. | GR | $\begin{aligned} & \hline \mathrm{R}=-0.2417 \\ & P=0.385447 \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=\mathbf{0 . 8 9 2 2} \\ & P<0.00001 \\ & \hline \end{aligned}$ | $\begin{gathered} \hline \mathbf{R}=\mathbf{0 . 8 9 4 2} \\ P<0.00001 \\ \hline \end{gathered}$ |
| 20. | APX | $\begin{aligned} & \hline \mathrm{R}=-0.4575 \\ & P=0.086401 \\ & \hline \end{aligned}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 8 5 4 7} \\ & P=4.9 \mathrm{E}-05 \\ & \hline \end{aligned}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 9 3 5 6} \\ & P<0.00001 \\ & \hline \end{aligned}$ |
| 21. | DHAR | $\begin{aligned} & \mathrm{R}=-0.4552 \\ & P=0.088198 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 8 8 8 2} \\ P<0.00001 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 8 7 4 2} \\ & P=2 \mathrm{E}-05 \\ & \hline \end{aligned}$ |
| 22. | MDHAR | $\begin{aligned} & \mathrm{R}=-0.4524 \\ & P=0.090421 \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=\mathbf{0 . 8 6 0 6} \\ & P=3.8 \mathrm{E}-05 \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=\mathbf{0 . 8 9 4 6} \\ & P<0.00001 \\ & \hline \end{aligned}$ |


| No. | Table S4b | $\mathrm{H}_{2} \mathrm{O}_{2}$ |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Seeds stored for 3 months | Seeds stored for 1 year | Seeds stored for 2 years |
| 1. | Protein carbonylation | $\begin{gathered} \mathrm{R}=-0.4839 \\ P=0.067599 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.1920 \\ P=0.493014 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6331 \\ P=0.011295 \end{gathered}$ |
| 2. | Electrolyte leakage | $\begin{gathered} \hline \mathrm{R}=-0.2257 \\ P=0.418622 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.2592 \\ P=0.350888 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathrm{R}=0.7096 \\ P=0.00045 \\ \hline \end{gathered}$ |
| 3. | C16:0 | $\begin{aligned} & \mathrm{R}=-0.1187 \\ & P=0.67351 \end{aligned}$ | $\begin{gathered} \mathrm{R}=-0.5308 \\ P=0.041769 \end{gathered}$ | $\begin{aligned} & \mathbf{R}=-\mathbf{0 . 8 8 4 1} \\ & P=1.2 \mathrm{E}-05 \end{aligned}$ |
| 4. | C18:0 | $\begin{gathered} \mathrm{R}=-0.4851 \\ P=0.066822 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.4518 \\ P=0.090902 \end{gathered}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 9 9 8 1} \\ & P<0.00001 \\ & \hline \end{aligned}$ |
| 5. | C18:1 | $\begin{gathered} \hline \mathrm{R}=-0.4133 \\ P=125706 \\ \hline \end{gathered}$ | $\begin{array}{r} \mathrm{R}=-0.6792 \\ P=005357 \end{array}$ | $\begin{aligned} \mathbf{R} & =\mathbf{0 . 9 8 1 5} \\ P & <0.00001 \end{aligned}$ |
| 6. | C18:2 | $\begin{gathered} \mathrm{R}=-0.3295 \\ P=0.230414 \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.5766 \\ P=0.024444 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 9 7 4 6} \\ & P<0.00001 \end{aligned}$ |
| 7. | C18:3 | $\begin{aligned} & \mathrm{R}=-0.2473 \\ & P=0.37421 \end{aligned}$ | $\begin{gathered} \hline \mathrm{R}=-0.4029 \\ P=0.136482 \end{gathered}$ | $\begin{gathered} \mathbf{R}=-\mathbf{0 . 9 4 7 1} \\ P<0.00001 \end{gathered}$ |
| 8. | PI | $\begin{gathered} \mathrm{R}=0.3031 \\ P=0.272138 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.1986 \\ P=0.477297 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \mathbf{R}=-\mathbf{0 . 7 5 8 2} \\ P=0.001054 \\ \hline \end{gathered}$ |
| 9. | PC | $\begin{gathered} \hline \mathrm{R}=0.5757 \\ P=0.02472 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.3470 \\ P=0.205099 \\ \hline \end{gathered}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 9 2 8 9} \\ & P<0.00001 \\ & \hline \end{aligned}$ |
| 10. | PG | $\begin{gathered} \mathrm{R}=0.4381 \\ P=0.102393 \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.5982 \\ & P=0.01848 \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 8 6 6 8} \\ & P=2.9 \mathrm{E}-05 \end{aligned}$ |
| 11. | PE | $\begin{gathered} \mathrm{R}=0.1068 \\ P=0.704809 \\ \hline \end{gathered}$ | $\begin{aligned} & \hline \mathrm{R}=-0.6045 \\ & P=0.016984 \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \mathbf{R}=-\mathbf{0 . 7 7 4 3} \\ & P=0.000702 \\ & \hline \end{aligned}$ |
| 12. | PA | $\begin{gathered} \mathrm{R}=0.0091 \\ P=0.974323 \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.1134 \\ & P=0.687392 \end{aligned}$ | $\begin{aligned} & \mathrm{R}=-0.4390 \\ & P=0.101609 \\ & \hline \end{aligned}$ |
| 13. | GSH | $\begin{gathered} \mathrm{R}=-0.1537 \\ P=0.584446 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.2779 \\ P=0.315926 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6329 \\ P=0.011329 \end{gathered}$ |
| 14. | GSSG | $\begin{aligned} & \mathrm{R}=-0.2148 \\ & P=0.442021 \end{aligned}$ | $\begin{aligned} & \mathrm{R}=-0.0511 \\ & P=0.85648 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathrm{R}=0.6046 \\ P=0.016961 \\ \hline \end{gathered}$ |
| 15. | $\mathbf{E}_{\text {GSSG/2GSH }}$ | $\begin{gathered} \mathrm{R}=0.1272 \\ P=0.651451 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.4623 \\ & P=0.082735 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathrm{R}=0.4313 \\ P=0.108458 \\ \hline \end{gathered}$ |
| 16. | AsA | $\begin{gathered} \mathrm{R}=0.5988 \\ P=0.018343 \end{gathered}$ | $\begin{aligned} & \mathrm{R}=-0.5677 \\ & P=0.027281 \\ & \hline \end{aligned}$ | $\begin{aligned} \mathrm{R} & =-0.0850 \\ P & =0.76327 \end{aligned}$ |
| 17. | DHA | $\begin{gathered} \mathrm{R}=0.5389 \\ P=0.038486 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.3612 \\ P=0.185918 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=-0.5420 \\ P=0.036878 \end{gathered}$ |
| 18. | $\mathbf{E}_{\text {DHA/AsA }}$ | $\begin{gathered} \mathrm{R}=0.4430 \\ P=0.098173 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.2353 \\ P=0.398557 \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.4208 \\ P=0.118306 \end{gathered}$ |
| 19. | GR | $\begin{gathered} \mathrm{R}=0.7163 \\ P=0.002664 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 6 0 6} \\ P=0.000994 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6398 \\ P=0.010208 \\ \hline \end{gathered}$ |
| 20. | APX | $\begin{aligned} & \hline \mathrm{R}=-0.3083 \\ & P=0.263583 \end{aligned}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 5 7 9} \\ P=0.001062 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6312 \\ P=0.011619 \\ \hline \end{gathered}$ |
| 21. | DHAR | $\begin{gathered} \mathrm{R}=0.2861 \\ P=0.301255 \\ \hline \end{gathered}$ | $\begin{aligned} & \mathbf{R}=\mathbf{0 . 8 7 2 3} \\ & P=2.2 \mathrm{E}-05 \\ & \hline \end{aligned}$ | $\begin{gathered} \mathrm{R}=0.6169 \\ P=0.014297 \\ \hline \end{gathered}$ |
| 22. | MDHAR | $\begin{gathered} \mathrm{R}=0.2879 \\ P=0.298089 \\ \hline \end{gathered}$ | $\begin{gathered} \mathbf{R}=\mathbf{0 . 7 9 9 1} \\ P=0.000352 \\ \hline \end{gathered}$ | $\begin{gathered} \mathrm{R}=0.6207 \\ P=0.013543 \end{gathered}$ |

