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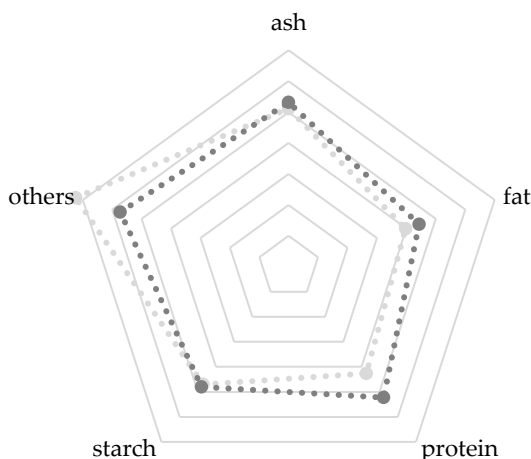


Figure S1. Chemical composition of thirteen quinoa varieties ((a): Atlas, (b): Bastille, (c): Dutchess, (d): Faro, (e): Jessie, (f): Oro de Valle, (g): Pasto, (h): Puno, (i): Rouge Marie, (j): Summer Red, (k): Titicaca, (l): Vikinga, (m): Zwarte) grown under North-West European field conditions in 2017 (●), 2018 (●) and 2019 (●). Values are presented as the mean relative to the three-year mean.

Table S1. Water absorption index at 55, 65, 75, 85 and 95 °C (WAI, g/g) of thirteen quinoa wholemeal flours obtained from seeds grown under North-West European field conditions in 2017, 2018 and 2019 ($n = 3$).

Year	Variety	WAI 55 °C (g/g) ^{1,2}	WAI 65 °C (g/g) ^{1,2}	WAI 75 °C (g/g) ^{1,2}	WAI 85 °C (g/g) ^{1,2}	WAI 95 °C (g/g) ^{1,2}
2017	Atlas	2.42 ± 0.03 abA	3.54 ± 0.03 bcdB	4.14 ± 0.02 deB	4.52 ± 0.05 cA	6.94 ± 0.13 dA
	Bastille	—	—	—	—	—
	Dutchess	2.29 ± 0.03 aA	3.42 ± 0.01 bA	3.75 ± 0.03 bA	4.30 ± 0.07 bA	6.68 ± 0.08 bcA
	Faro	2.35 ± 0.02 abA	3.67 ± 0.05 defB	4.48 ± 0.04 fgA	5.62 ± 0.03 eA	7.25 ± 0.07 eA
	Jessie	2.77 ± 0.04 efB	3.47 ± 0.04 bcA	4.23 ± 0.08 eA	5.12 ± 0.04 dA	6.16 ± 0.10 aB
	Oro de Valle	2.59 ± 0.02 cdB	3.84 ± 0.04 fgA	4.39 ± 0.03 fA	5.92 ± 0.09 fA	7.76 ± 0.01 fA
	Pasto	2.47 ± 0.07 bcA	3.59 ± 0.10 cdeB	3.89 ± 0.03 cA	4.33 ± 0.08 bA	7.25 ± 0.08 eA
	Puno	2.29 ± 0.09 aA	3.95 ± 0.08 gA	4.57 ± 0.06 gA	6.04 ± 0.04 fA	7.32 ± 0.04 eA
	Rouge Marie	—	—	—	—	—
	Summer Red	2.30 ± 0.06 aA	3.13 ± 0.02 aA	3.54 ± 0.02 aA	4.04 ± 0.07 aA	6.00 ± 0.06 aA
	Titicaca	2.87 ± 0.03 fB	3.74 ± 0.05 efA	4.11 ± 0.03 deA	5.62 ± 0.03 eA	6.65 ± 0.02 bA
	Vikinga	2.71 ± 0.08 deB	3.53 ± 0.06 bcdA	4.03 ± 0.04 dA	5.19 ± 0.04 dA	6.00 ± 0.04 aA
	Zwarte	2.60 ± 0.05 cdA	3.51 ± 0.01 bcdA	3.81 ± 0.02 bcA	4.32 ± 0.02 bA	6.85 ± 0.05 cdA
2018	Atlas	2.35 ± 0.02 bA	3.27 ± 0.07 aA	4.03 ± 0.04 bA	4.85 ± 0.05 aB	7.47 ± 0.09 cB
	Bastille	2.04 ± 0.03 aA	3.33 ± 0.02 aA	4.44 ± 0.03 dA	6.28 ± 0.09 eA	8.85 ± 0.04 fB
	Dutchess	2.42 ± 0.05 bcB	3.35 ± 0.02 abA	4.29 ± 0.04 cB	5.35 ± 0.01 cB	7.84 ± 0.04 dB
	Faro	2.67 ± 0.02 efB	3.29 ± 0.09 aA	4.65 ± 0.02 eB	7.35 ± 0.09 gC	9.48 ± 0.06 gC
	Jessie	2.57 ± 0.07 deA	3.39 ± 0.01 abA	4.77 ± 0.07 eB	6.25 ± 0.01 eC	6.48 ± 0.05 aC
	Oro de Valle	2.72 ± 0.02 fgC	3.98 ± 0.05 dB	4.97 ± 0.01 fB	7.59 ± 0.02 hB	8.73 ± 0.04 fC
	Pasto	2.73 ± 0.04 fgB	3.24 ± 0.04 aA	4.00 ± 0.08 abB	5.04 ± 0.01 bB	7.98 ± 0.02 dB
	Puno	2.85 ± 0.03 gB	4.16 ± 0.02 eB	5.90 ± 0.04 hB	6.93 ± 0.08 fB	8.47 ± 0.05 eC
	Rouge Marie	—	—	—	—	—
	Summer Red	2.44 ± 0.02 bcdB	3.69 ± 0.09 cB	3.87 ± 0.03 aB	4.81 ± 0.10 aB	7.14 ± 0.05 bC
	Titicaca	2.68 ± 0.04 efA	4.58 ± 0.06 fB	5.56 ± 0.05 gB	7.36 ± 0.01 gC	8.35 ± 0.02 eC
	Vikinga	2.53 ± 0.01 cdA	3.51 ± 0.01 bA	4.27 ± 0.06 cB	6.05 ± 0.05 dB	7.14 ± 0.04 bB
	Zwarte	—	—	—	—	—
2019	Atlas	2.99 ± 0.04 defB	4.76 ± 0.18 eC	5.40 ± 0.01 gC	6.45 ± 0.02 dC	7.51 ± 0.10 eB
	Bastille	2.76 ± 0.06 bcB	3.47 ± 0.08 aB	4.53 ± 0.01 bB	6.46 ± 0.07 dB	8.38 ± 0.05 ghA

Dutchess	2.90 ± 0.07 ^{deC}	3.85 ± 0.04 ^{bB}	5.26 ± 0.01 ^{fC}	5.89 ± 0.07 ^{bC}	7.76 ± 0.01 ^{fB}
Faro	3.01 ± 0.06 ^{efC}	3.77 ± 0.02 ^{bB}	5.19 ± 0.03 ^{efC}	6.59 ± 0.08 ^{deB}	8.32 ± 0.11 ^{gB}
Jessie	3.30 ± 0.05 ^{gC}	4.79 ± 0.03 ^{eB}	4.86 ± 0.04 ^{cB}	5.72 ± 0.08 ^{aB}	5.80 ± 0.07 ^{aA}
Oro de Valle	2.45 ± 0.05 ^{aA}	4.42 ± 0.08 ^{dC}	5.84 ± 0.09 ^{hC}	7.82 ± 0.05 ^{hC}	8.55 ± 0.06 ^{hB}
Pasto	—	—	—	—	—
Puno	3.67 ± 0.07 ^{hC}	4.41 ± 0.06 ^{dC}	6.11 ± 0.06 ^{iC}	7.01 ± 0.04 ^{gB}	7.66 ± 0.11 ^{efD}
Rouge Marie	2.71 ± 0.03 ^{bA}	4.36 ± 0.03 ^{dA}	4.39 ± 0.07 ^{aA}	6.06 ± 0.02 ^{cA}	6.30 ± 0.05 ^{bcA}
Summer Red	2.87 ± 0.03 ^{cdC}	4.10 ± 0.02 ^{cC}	4.33 ± 0.10 ^{aC}	5.95 ± 0.03 ^{bcC}	6.38 ± 0.13 ^{cB}
Titicaca	3.71 ± 0.02 ^{hiC}	5.14 ± 0.01 ^{fC}	6.28 ± 0.02 ^{jC}	6.72 ± 0.06 ^{efB}	7.31 ± 0.06 ^{dB}
Vikinga	3.82 ± 0.02 ^{iC}	4.34 ± 0.03 ^{dB}	5.12 ± 0.04 ^{deC}	5.96 ± 0.07 ^{bcB}	6.11 ± 0.08 ^{bA}
Zwarte	3.08 ± 0.10 ^{fB}	4.92 ± 0.10 ^{eB}	5.01 ± 0.04 ^{dB}	6.86 ± 0.08 ^{fgB}	7.55 ± 0.07 ^{eB}

¹ Within years, average values followed by the same lowercase letter are not significantly different ($p > 0.05$). Capital letters compare the three years for the same variety, average values followed by the same letter are not significantly different ($p > 0.05$). ² WAI: water absorption index.

Table S2. Pasting parameters of thirteen quinoa wholemeal flours obtained from seeds grown under North-West European field conditions in 2017, 2018 and 2019 ($n = 3$).

Year	Variety	Pasting Temperature (°C) ¹	First Peak Viscosity (mPa.s) ¹	Peak Temperature (°C)	Breakdown (mPa.s) ¹	Second Peak Viscosity (mPa.s) ¹	Final Viscosity (mPa.s) ¹	Total Setback (mPa.s) ¹
2017	Atlas	62.29 ± 0.59 ^{abcB}	2234 ± 32 ^{deB}	95.10 ± 0.01 ^{cdA}	318 ± 15 ^{eC}	2350 ± 30 ^{deC}	1852 ± 25 ^{dB}	-64 ± 4 ^{cA}
	Bastille	—	—	—	—	—	—	—
	Dutchess	64.14 ± 0.91 ^{cdB}	2465 ± 53 ^{fC}	95.06 ± 0.02 ^{eA}	176 ± 22 ^{cB}	2687 ± 31 ^{fB}	1977 ± 65 ^{eB}	-311 ± 31 ^{aA}
	Faro	64.10 ± 0.58 ^{cdA}	2081 ± 32 ^{cC}	95.20 ± 0.03 ^{abC}	577 ± 31 ^{gB}	2379 ± 23 ^{eB}	1992 ± 42 ^{eA}	488 ± 50 ^{eA}
	Jessie	63.60 ± 0.47 ^{bcdB}	1878 ± 33 ^{bC}	95.11 ± 0.00 ^{cdB}	124 ± 11 ^{bC}	2185 ± 37 ^{cC}	1404 ± 30 ^{bB}	-350 ± 13 ^{aA}
	Oro de Valle	61.36 ± 0.41 ^{abA}	2134 ± 13 ^{cB}	95.22 ± 0.03 ^{abB}	643 ± 12 ^{hC}	2287 ± 13 ^{dB}	2036 ± 16 ^{eA}	545 ± 18 ^{eA}
	Pasto	64.27 ± 0.58 ^{cdA}	2560 ± 11 ^{gB}	95.10 ± 0.01 ^{cdA}	348 ± 8 ^{eA}	3193 ± 31 ^{gB}	2364 ± 26 ^{gB}	152 ± 20 ^{dA}
	Puno	62.53 ± 0.65 ^{abcA}	2161 ± 14 ^{cdC}	94.58 ± 0.17 ^{aB}	635 ± 39 ^{hC}	2617 ± 30 ^{fA}	2180 ± 46 ^{fA}	654 ± 79 ^{fA}
	Rouge Marie	—	—	—	—	—	—	—
	Summer Red	65.10 ± 0.75 ^{dB}	1696 ± 38 ^{aC}	95.09 ± 0.01 ^{dA}	-78 ± 17 ^{aA}	2156 ± 44 ^{cC}	1492 ± 44 ^{bcC}	-282 ± 25 ^{aA}
	Titicaca	60.42 ± 0.76 ^{aA}	2272 ± 45 ^{eC}	95.21 ± 0.03 ^{abA}	519 ± 21 ^{fC}	2338 ± 32 ^{deB}	1860 ± 22 ^{dA}	108 ± 11 ^{dA}
	Vikinga	60.86 ± 0.41 ^{aB}	1732 ± 46 ^{aC}	95.14 ± 0.01 ^{bcA}	262 ± 17 ^{dC}	1787 ± 32 ^{aB}	1297 ± 32 ^{aA}	-173 ± 25 ^{bA}
	Zwarte	63.40 ± 0.92 ^{bcdA}	1728 ± 17 ^{aB}	95.11 ± 0.01 ^{cdA}	143 ± 5 ^{bcB}	1979 ± 20 ^{bB}	1542 ± 21 ^{cB}	-43 ± 10 ^{cA}
2018	Atlas	66.14 ± 0.26 ^{cdeC}	1824 ± 50 ^{dA}	95.16 ± 0.00 ^{bA}	276 ± 14 ^{fB}	1879 ± 43 ^{cA}	1566 ± 42 ^{bcA}	19 ± 7 ^{aB}
	Bastille	66.92 ± 0.87 ^{deB}	2492 ± 42 ^{gA}	95.18 ± 0.01 ^{bA}	384 ± 20 ^{gA}	3118 ± 54 ^{hB}	2817 ± 76 ^{gB}	708 ± 55 ^{eB}
	Dutchess	64.71 ± 1.06 ^{bcdB}	1729 ± 54 ^{cB}	95.13 ± 0.06 ^{bA}	66 ± 6 ^{dA}	2032 ± 39 ^{dA}	1956 ± 45 ^{dB}	293 ± 16 ^{cdB}
	Faro	67.11 ± 0.60 ^{eB}	2020 ± 27 ^{fB}	93.69 ± 0.19 ^{aA}	410 ± 9 ^{gA}	2685 ± 41 ^{gC}	2646 ± 40 ^{fB}	1037 ± 24 ^{fC}
	Jessie	64.06 ± 0.11 ^{bcB}	1030 ± 22 ^{aB}	95.13 ± 0.00 ^{bB}	-251 ± 13 ^{aA}	1627 ± 34 ^{bB}	1500 ± 34 ^{bc}	220 ± 15 ^{cB}
	Oro de Valle	62.98 ± 1.73 ^{abA}	2085 ± 29 ^{fB}	95.06 ± 0.26 ^{bB}	317 ± 15 ^{fB}	2565 ± 22 ^{fC}	2522 ± 23 ^{eB}	753 ± 26 ^{eB}
	Pasto	65.60 ± 1.40 ^{cdeA}	1915 ± 20 ^{eA}	95.14 ± 0.00 ^{bA}	378 ± 2 ^{gA}	2288 ± 26 ^{eA}	1914 ± 18 ^{dA}	378 ± 18 ^{dB}
	Puno	62.75 ± 0.34 ^{abAB}	1900 ± 57 ^{deB}	95.16 ± 0.04 ^{bc}	155 ± 29 ^{eB}	2734 ± 28 ^{gB}	2721 ± 32 ^{fB}	976 ± 48 ^{fB}
	Rouge Marie	—	—	—	—	—	—	—
	Summer Red	66.44 ± 0.14 ^{deB}	1092 ± 27 ^{aB}	95.09 ± 0.01 ^{bA}	-81 ± 14 ^{cA}	1432 ± 13 ^{aB}	1238 ± 12 ^{aB}	64 ± 14 ^{abB}
	Titicaca	60.65 ± 0.18 ^{aA}	1924 ± 22 ^{eB}	95.08 ± 0.01 ^{bA}	65 ± 15 ^{dB}	2579 ± 30 ^{fC}	2542 ± 23 ^{eC}	683 ± 48 ^{eC}
	Vikinga	62.86 ± 0.36 ^{abC}	1303 ± 14 ^{bB}	95.14 ± 0.00 ^{bA}	-187 ± 8 ^{bB}	1877 ± 26 ^{cC}	1624 ± 20 ^{cB}	133 ± 15 ^{bB}
	Zwarte	—	—	—	—	—	—	—
2019	Atlas	59.87 ± 1.39 ^{abcA}	1871 ± 27 ^{gA}	95.05 ± 0.02 ^{cdA}	45 ± 19 ^{fgA}	2273 ± 37 ^{fB}	2069 ± 45 ^{ghC}	242 ± 32 ^{bcC}
	Bastille	64.34 ± 0.23 ^{eA}	2453 ± 21 ^{iA}	95.16 ± 0.00 ^{dA}	513 ± 12 ^{iB}	2601 ± 16 ^{gA}	2119 ± 15 ^{hA}	178 ± 40 ^{bA}
	Dutchess	61.80 ± 1.14 ^{cdA}	1656 ± 31 ^{fA}	95.12 ± 0.03 ^{cdA}	94 ± 20 ^{gA}	1996 ± 30 ^{dA}	1843 ± 17 ^{eA}	281 ± 12 ^{cB}
	Faro	63.77 ± 0.90 ^{deA}	1959 ± 21 ^{hA}	94.19 ± 0.24 ^{abB}	555 ± 17 ^{iB}	2135 ± 17 ^{eA}	1965 ± 15 ^{fA}	560 ± 4 ^{dB}
	Jessie	59.31 ± 1.24 ^{abA}	823 ± 15 ^{aA}	94.62 ± 0.09 ^{bcA}	-53 ± 21 ^{dB}	1200 ± 7 ^{aA}	1142 ± 6 ^{bcA}	267 ± 15 ^{cB}

Oro de Valle	61.51 ± 1.28 ^{bcdA}	1677 ± 19 ^{fA}	94.24 ± 0.86 ^{abA}	239 ± 7 ^{hA}	2026 ± 7 ^{dA}	2020 ± 7 ^{fgA}	582 ± 17 ^{dA}
Pasto	—	—	—	—	—	—	—
Puno	64.31 ± 0.24 ^{eB}	1654 ± 25 ^{fA}	93.99 ± 0.25 ^{aA}	−364 ± 49 ^{aA}	3078 ± 26 ^{hC}	3047 ± 28 ^{iC}	1030 ± 58 ^{eB}
Rouge Marie	62.10 ± 0.68 ^{cdeA}	908 ± 13 ^{abA}	94.93 ± 0.24 ^{cdA}	−17 ± 12 ^{deA}	1206 ± 47 ^{aA}	1098 ± 18 ^{abA}	173 ± 9 ^{bA}
Summer Red	62.59 ± 1.15 ^{deA}	940 ± 15 ^{bA}	95.22 ± 0.02 ^{dA}	−41 ± 8 ^{deB}	1183 ± 2 ^{aA}	1027 ± 15 ^{aA}	46 ± 11 ^{aB}
Titicaca	61.44 ± 0.32 ^{bcdA}	1293 ± 23 ^{eA}	95.12 ± 0.00 ^{dA}	−202 ± 10 ^{bA}	2170 ± 4 ^{eA}	2096 ± 3 ^{ghB}	601 ± 20 ^{dB}
Vikinga	57.70 ± 0.75 ^{aA}	1151 ± 24 ^{dA}	95.13 ± 0.00 ^{dA}	−147 ± 7 ^{cA}	1720 ± 14 ^{cA}	1600 ± 15 ^{dB}	303 ± 41 ^{cC}
Zwarte	63.02 ± 1.22 ^{deA}	1054 ± 17 ^{cA}	95.11 ± 0.01 ^{cdA}	1 ± 2 ^{efA}	1361 ± 19 ^{bA}	1225 ± 16 ^{cA}	172 ± 20 ^{bB}

¹ Within years, average values followed by the same lowercase letter are not significantly different ($p > 0.05$). Capital letters compare the three years for the same variety, average values followed by the same letter are not significantly different ($p > 0.05$).

Table S3. Pearson correlation analysis between physicochemical properties ¹.

	WAI 55 °C	WAI 65 °C	WAI 75 °C	WAI 85 °C	WAI 95 °C	PV1	HS	BD	PV2	FV	TSB
WAC	0.758 **	0.616 **	0.560 **	0.373 *	n.s. ²	-0.419 *	n.s. ²	-0.432 *	n.s. ²	n.s. ²	n.s. ²
WAI 55 °C		0.675 **	0.627 **	0.364 *	n.s. ²	-0.454 **	n.s. ²	-0.463 **	n.s. ²	n.s. ²	n.s. ²
WAI 65 °C			0.744 **	0.553 **	n.s. ²	-0.457 **	-0.361 *	-0.371 *	n.s. ²	n.s. ²	n.s. ²
WAI 75 °C				0.809 **	0.395 **	n.s. ²	n.s. ²	n.s. ²	n.s. ²	0.445 **	0.693 **
WAI 85 °C					0.607 **	n.s. ²	n.s. ²	n.s. ²	n.s. ²	0.447 **	0.771 **
WAI 95 °C						0.457 **	0.340 *	0.398 **	0.551 **	0.747 **	0.734 **
PV1							0.848 **	0.736 **	0.856 **	0.647 **	n.s. ²
HS								n.s. ²	0.895 **	0.706 **	n.s. ²
BD									0.415 *	n.s. ²	n.s. ²
PV2										0.902 **	0.433 *
FV											0.748 **

* Correlation significant at $p < 0.05$ level. ** Correlation significant at $p < 0.01$. ¹ WAC: water absorption capacity, WAI: water absorption index, PV1: first peak viscosity, HS: holding strength, BD: breakdown, PV2: second peak viscosity, FV: final viscosity, TSB: total setback ² n.s.: not significant

Table S4. Results of ANOVA (factors, p value).

Variable ¹	Variety	Year	Variety × Year
WAC	$p < 0.001$	$p < 0.001$	$p < 0.001$
WAI 55 °C	$p < 0.001$	$p < 0.001$	$p < 0.001$
WAI 65 °C	$p < 0.001$	$p < 0.001$	$p < 0.001$
WAI 75 °C	$p < 0.001$	$p < 0.001$	$p < 0.001$
WAI 85 °C	$p < 0.001$	$p < 0.001$	$p < 0.001$
WAI 95 °C	$p < 0.001$	$p < 0.001$	$p < 0.001$
pasting temperature	$p < 0.001$	$p < 0.001$	$p < 0.001$
first peak viscosity	$p < 0.001$	$p < 0.001$	$p < 0.001$
peak temperature	$p < 0.001$	$p < 0.001$	$p < 0.001$
breakdown	$p < 0.001$	$p < 0.001$	$p < 0.001$
second peak viscosity	$p < 0.001$	$p < 0.001$	$p < 0.001$
final viscosity	$p < 0.001$	$p < 0.001$	$p < 0.001$
total setback	$p < 0.001$	$p < 0.001$	$p < 0.001$

¹ WAI: water absorption capacity; WAI: water absorption index