Chemical components and chain-length distributions affecting quinoa starch digestibility and gel viscoelasticity after germination treatment

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Table S1. The changes of reducing sugars of different quinoa over the germination process (dry weight basis).

Sample	Germination time	Reducing Sugar (%)
WQ	0d	2.00 ± 0.03^{a}
	1d	3.52 ± 0.01^{b}
	2d	3.74 ± 0.09^{c}
	3d	3.98 ± 0.01^{d}
	4d	4.06 ± 0.02^{e}
RQ	0d	2.02 ± 0.02^{a}
	1d	2.29 ± 0.19^{b}
	2d	2.69 ± 0.01^{c}
	3d	2.75 ± 0.01^{c}
	4d	3.00 ± 0.02^{d}
BQ	0d	2.41 ± 0.02^{a}
	1d	2.44 ± 0.01^{a}
	2d	2.73 ± 0.02^{b}
	3d	3.51 ± 0.04^{c}
	4d	3.73 ± 0.02^{d}

Note: The values shown are mean ± SD. Values with different letters in the same column for a single quinoa variety after different days' germination are significantly different at $p<0.05$. The statistical analysis was not performed among different quinoa varieties.

Table S2. The gemination rate and sprout length of white, red, and black quinoa.

		0	1	2	3	4
Germination Rate (%)	WQ	0±0a	38.5±0.7b	46.5±0.7c	57±1.4d	70.5±2.1e
	RQ	0±0a	18.5±0.7b	27.5±0.7c	40±1.4d	55.5±0.7e
	BQ	0±0a	22±0b	37.3±0.4c	48±1.4d	59.5±2.1e
Sprouts bud (cm)	WQ	0±0a	0.5±0.2b	0.8±0.2c	1.1±0.3d	1.7±0.2e
	RQ	0±0a	0.3±0.1b	0.3±0.2b	0.6±0.3c	0.8±0.2d
	BQ	0±0a	0.3±0.1b	0.5±0.1c	0.7±0.1d	0.9±0.3e

Note: The values shown are mean ± SD. Values with different letters in the same row are significantly different ($p<0.05$).

Table S3. DSC parameters for the quinoa samples before and after cooking.

Samples	To (°C)	Tp (°C)	Tc (°C)	ΔH (J/g)
W0	57.18 ± 0.13	64.52 ± 0.16	79.88 ± 0.14	6.75 ± 0.25
R0	58.58 ± 0.74	67.87 ± 0.19	81.28 ± 0.08	3.84 ± 0.15
B0	58.31 ± 0.11	66.85 ± 0.28	80.7 ± 0.06	4.95 ± 0.07
W0-heated	n/d	n/d	n/d	n/d
R0-heated	n/d	n/d	n/d	n/d
B0-heated	n/d	n/d	n/d	n/d

Values are means ± SD. n/d = not detectable. Only the quinoa grains without germination treatment were applied for the measurement of starch gelatinization degree after cooking. Basing on these data, the gelatinization degree for different quinoa samples were all calculated as 100%, which indicates that starch supramolecular structures were all destroyed after cooking.

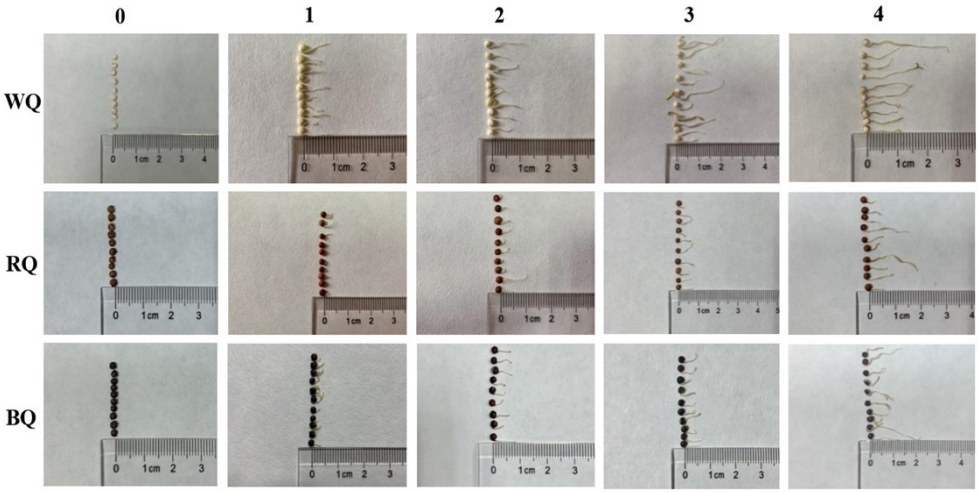

Figure S1. The appearance of three different quinoa grains during germination treatment.

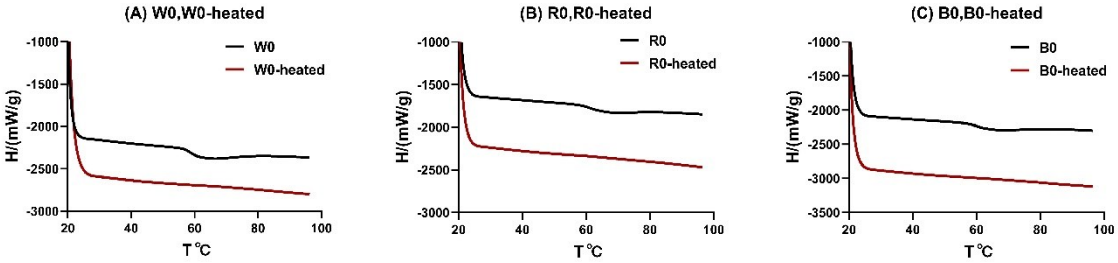

Figure S2. DSC thermograms of quinoa samples before (black curves) and after cooking (red curves). W0, R0 and B0 are the white, red and black quinoa samples without germination treatment.

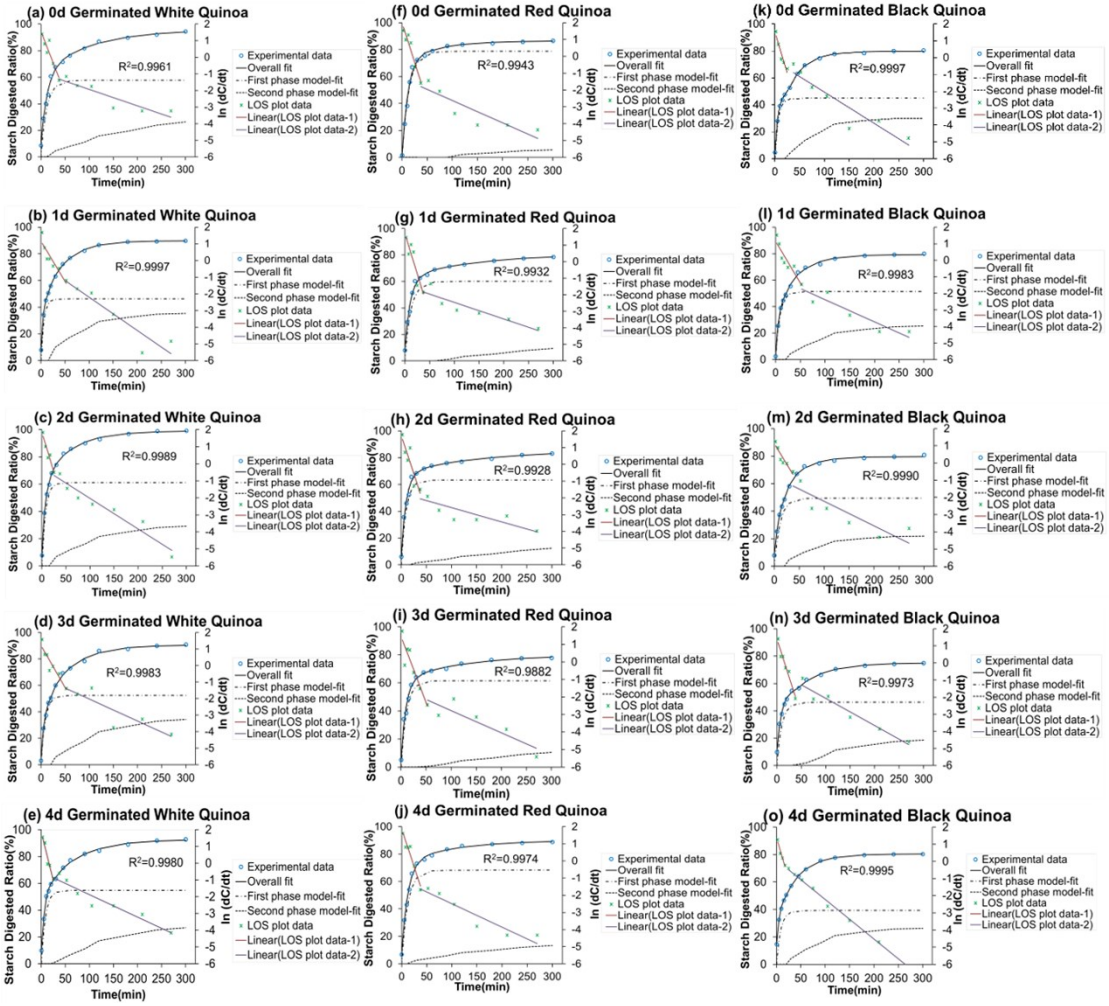

Figure S3. LOS/CPS kinetics model fittings for all starch digestograms of different quinoa flours after the germination treatments.

Method of measuring the gelatinization degree by differential scanning calorimetry (DSC)

The gelatinization degree for the raw quinoa flours after cooking was measured according to our previous method [1]. Briefly, quinoa flours were gelatinized in a boiling water bath for 30 minutes, which were then freeze dried overnight. The cooked quinoa samples after drying were pulverized through a 100-mesh sieve and stored in a desiccator for storage. The gelatinization properties for both the raw and cooked quinoa flour were analyzed by a differential scanning calorimeter (DSC Q2000-TA, America). Quinoa powder (2 mg, dry basis) was weighed into a DSC aluminum pan filled with 6 μL distilled water, which was equilibrated at room temperature for 12 hours before the DSC testing. An empty pan was used as the reference. The tests were from 20 to 100 °C at a heating rate of 10 °C/min. The enthalpy change (ΔH), onset (To), peak (Tp) and conclusion (Tc) temperatures were obtained through the inbuilt software. The degree of gelatinization (DG) was calculated according to the following formula:

$$DG = \left(1 - \frac{\Delta H_{heated}}{\Delta H_{native}}\right) \times 100\%$$

where ΔH_{heated} is the enthalpy change of quinoa powder after cooking and ΔH_{native} is the enthalpy change of raw quinoa powder.

1. M. M. Martinez, C. Li, M. Okoniewska, I. Mukherjee, D. Vellucci and B. Hamaker, Slowly digestible starch in fully gelatinized material is structurally driven by molecular size and A and B1 chain lengths, *Carbohydrate Polymers*, 2018, **197**, 531-539.