

Table S1. Relative antioxidant properties of kisra bread during natural fermentation.

Processing stages	Antioxidant parameters ¹		
	DPPH (%)	TPC (%)	Tannin (%)
First fermentation			
0 h	100.00	100.00	100.00
24 h	87.70	103.00	76.80
48 h	78.80	99.24	76.80
Second fermentation			
0 h	80.20	102.30	76.80
6 h	83.20	105.30	88.40
12 h	76.90	95.50	123.20
Baking			
kisra bread	118.07	118.32	146.50

¹ Relative antioxidant properties are represented as the percentage with respect to the corresponding 0 hour of fermentation.

Table S2. Changes in physicochemical and microbial properties during kiswa fermentation with or without different lactic acid bacterial species.

Groups ¹	Physicochemical and microbial properties	Processing stages						
		First fermentation			Second fermentation			Baking
		0 h	24 h	48 h	0 h	6 h	12 h	Kiswa bread
Control group (Natural fermentation group)	LAB count (log CFU/g)	8.9±0.13 ^{2,a}	9.12±0.28 ^a	9.12±0.07 ^a	8.63±0.24 ^a	8.60±0.85 ^a	8.95±0.19 ^a	ND ^{3,b}
	pH	6.74±0.02 ^a	3.68±0.25 ^c	3.23±0.11 ^d	4.49±0.04 ^b	3.72±0.30 ^c	3.53±0.27 ^{cd}	3.31±0.01 ^{cd}
	a _w	0.992±0.0004 ^a	0.988±0.001 ^{ab}	0.986±0.001 ^{bc}	0.989±0.001 ^{ab}	0.958±0.04 ^{abc}	0.985±0.003 ^{bc}	0.982±0.01 ^c
	TTA (%) ⁴	0.146±0.002 ^c	0.863±0.10 ^b	1.415±0.40 ^a	0.468±0.05 ^{bc}	0.62±0.16 ^b	0.746±0.16 ^b	1.635±0.01 ^a
LP group	LAB count (log CFU/g)	8.28±0.95 ^c	9.50±0.03 ^a	9.31±0.08 ^a	8.42±0.05 ^{ba}	9.14±0.09 ^{ab}	9.23±0.07 ^{ab}	ND ^d
	pH	6.74±0.004 ^a	3.32±0.02 ^c	3.14±0.02 ^f	5.36±0.01 ^b	3.72±0.01 ^c	3.42±0.004 ^d	3.34±0.04 ^c
	a _w	0.992±0.0004 ^a	0.99±0.001 ^a	0.992±0.001 ^a	0.988±0.002 ^{ab}	0.988±0.001 ^{ab}	0.986±0.001 ^{ab}	0.982±0.01 ^b
	TTA (%)	0.108±0.02 ^g	0.882±0.02 ^c	1.134±0.01 ^b	0.317±0.002 ^f	0.498±0.004 ^c	0.678±0.02 ^d	1.325±0.05 ^a
LF group	LAB count (log CFU/g)	7.64±0.70 ^c	9.45±0.03 ^a	9.31±0.01 ^a	8.48±0.10 ^b	9.09±0.004 ^{ab}	9.52±0.27 ^a	ND ^d
	pH	6.76±0.04 ^a	3.31±0.03 ^c	3.19±0.01 ^f	5.61±0.01 ^b	3.84±0.06 ^c	3.46±0.03 ^d	3.34±0.014 ^c
	a _w	0.992±0.002 ^a	0.990±0.001 ^{ab}	0.992±0.001 ^a	0.988±0.001 ^{ab}	0.989±0.001 ^{ab}	0.985±0.001 ^{bc}	0.982±0.01 ^c
	TTA (%)	0.095±0.01 ^c	0.806±0.01 ^{bc}	0.959±0.04 ^{bc}	0.236±0.03 ^{dc}	0.486±0.01 ^{cd}	0.644±0.002 ^{bc}	1.47±0.39 ^a
LB group	LAB count (log CFU/g)	8.30±1.20 ^b	9.50±0.10 ^a	9.32±0.01 ^{ab}	8.37±0.24 ^b	9.05±0.08 ^{ab}	9.23±0.06 ^{ab}	ND ^c
	pH	6.75±0.01 ^a	3.30±0.02 ^c	3.15±0.02 ^f	5.63±0.06 ^b	3.88±0.004 ^c	3.46±0.01 ^d	3.34±0.02 ^c
	a _w	0.993±0.0004 ^a	0.991±0.001 ^b	0.991±0.001 ^b	0.990±0.001 ^b	0.990±0.001 ^b	0.984±0.0004 ^c	0.983±0.0004 ^c
	TTA (%)	0.089±0.002 ^g	0.893±0.05 ^c	1.016±0.002 ^b	0.27±0.004 ^f	0.429±0.01 ^c	0.681±0.03 ^d	1.439±0.05 ^a
WC group	LAB count (log CFU/g)	7.48±0.33 ^b	9.10±0.10 ^a	7.44±0.06 ^{bc}	7.10±0.08 ^c	9.15±0.11 ^a	9.23±0.06 ^a	ND ^d
	pH	6.77±0.01 ^a	3.77±0.01 ^d	3.75±0.03 ^d	5.99±0.06 ^b	4.25±0.12 ^c	3.85±0.10 ^d	3.50±0.12 ^c
	a _w	0.993±0.002 ^a	0.993±0.001 ^b	0.993±0.002 ^b	0.991±0.0004 ^b	0.996±0.001 ^b	0.986±0.0004 ^c	0.985±0.0004 ^c
	TTA (%)	0.09±0.004 ^b	0.545±0.011 ^b	0.569±0.02 ^b	0.303±0.05 ^b	0.434±0.08 ^b	0.557±0.05 ^b	1.143±0.50 ^b

¹ Control group (kiswa naturally fermented without an inoculum; this group also served as the natural fermentation group in Figure 2), LP group (kiswa fermented with *L. plantarum*), LF group (kiswa fermented with *L. fermentum*), LB group (kiswa fermented with *L. brevis*), WC group (kiswa fermented with *W. cibaria*).

² Data represented as mean±standard deviation from triplicate measurements. Values in the same row of the same group followed by different letters (a-g) are significantly different ($p < 0.05$).

³ ND: not detected.

⁴ Total titratable acidity expressed as lactic acid percentage.

Table S3. Changes in biogenic amine content during kiswa fermentation with or without different lactic acid bacterial species.

Groups ¹	Processing stages		Biogenic amine content (mg/kg) ²								
			TRP	PHE	PUT	CAD	HIS	TYR	SPD	SPM	
Control group (Natural fermentation group)	First Fermentation	0 h	ND ³	ND	3.97±0.06 ^{4,c}	ND ^c	ND ^c	ND ^f	5.86±0.20 ^c	4.14±0.08 ^b	
		24 h	ND	ND	7.05±0.03 ^c	51.58±1.19 ^b	6.64±0.13 ^c	3.67±0.04 ^d	6.42±0.24 ^b	3.83±0.02 ^d	
		48 h	ND	ND	26.53±0.27 ^a	69.04±0.91 ^a	3.5±0.08 ^d	15.52±0.07 ^a	6.42±0.01 ^b	3.97±0.07 ^c	
	Second Fermentation	0 h	ND	ND	4.19±0.06 ^c	5.60±0.05 ^d	ND ^c	ND ^f	4.56±0.05 ^c	3.10±0.01 ^c	
		6 h	ND	ND	5.63±0.08 ^d	4.95±0.08 ^d	ND ^c	2.94±0.08 ^c	5.68±0.08 ^c	3.85±0.02 ^d	
		12 h	ND	ND	15.08±0.16 ^b	7.38±0.22 ^c	10.92±0.55 ^b	10.26±0.51 ^c	5.18±0.20 ^d	3.90±0.04 ^{cd}	
	Baking	kiswa	ND	ND	26.83±0.72 ^a	6.11±0.07 ^{cd}	14.76±0.61 ^a	13.73±0.04 ^b	7.72±0.05 ^a	5.04±0.04 ^a	
	LP group	First Fermentation	0 h	ND	ND	6.55±0.04 ^{bc}	ND	ND	ND	4.71±0.15 ^a	6.95±0.22 ^{cd}
			24 h	ND	ND	6.80±0.06 ^{ab}	ND	ND	ND	3.58±0.08 ^c	6.59±0.10 ^d
			48 h	ND	ND	6.40±0.02 ^c	ND	ND	ND	3.18±0.08 ^d	7.95±0.35 ^b
Second Fermentation		0 h	ND	ND	6.99±0.33 ^a	ND	ND	ND	4.80±0.09 ^a	8.27±0.24 ^b	
		6 h	ND	ND	4.54±0.01 ^c	ND	ND	ND	2.61±0.04 ^c	7.23±0.01 ^c	
		12 h	ND	ND	5.72±0.01 ^d	ND	ND	ND	3.78±0.03 ^b	7.24±0.02 ^c	
Baking		kiswa	ND	ND	5.99±0.19 ^d	ND	ND	ND	4.79±0.001 ^a	10.54±0.08 ^a	
LF group		First Fermentation	0 h	ND	ND	6.58±0.30 ^a	ND	ND	ND	4.41±0.08 ^b	6.97±0.10 ^d
			24 h	ND	ND	5.11±0.08 ^c	ND	ND	ND	3.83±0.04 ^c	6.93±0.03 ^d
			48 h	ND	ND	6.48±0.08 ^a	ND	ND	ND	3.42±0.004 ^d	8.30±0.04 ^{bc}
	Second Fermentation	0 h	ND	ND	6.10±0.09 ^b	ND	ND	ND	3.97±0.01 ^c	8.10±0.02 ^c	
		6 h	ND	ND	5.87±0.03 ^b	ND	ND	ND	3.26±0.02 ^c	6.48±0.02 ^c	
		12 h	ND	ND	3.98±0.05 ^c	ND	ND	ND	2.91±0.06 ^f	8.39±0.09 ^b	
	Baking	kiswa	ND	ND	4.63±0.07 ^d	ND	ND	ND	5.98±0.11 ^a	12.68±0.25 ^a	
	LB group	First Fermentation	0 h	ND	ND	6.95±0.31 ^a	ND	ND	ND	4.48±0.04 ^b	7.50±0.08 ^c
			24 h	ND	ND	6.40±0.05 ^b	ND	ND	ND	3.49±0.07 ^d	7.29±0.03 ^f
			48 h	ND	ND	6.17±0.01 ^b	ND	ND	ND	3.49±0.01 ^d	8.20±0.07 ^d
Second Fermentation		0 h	ND	ND	6.15±0.07 ^b	ND	ND	ND	4.78±0.03 ^a	8.24±0.02 ^d	
		6 h	ND	ND	5.11±0.11 ^c	ND	ND	ND	3.00±0.02 ^c	8.70±0.06 ^c	
		12 h	ND	ND	5.03±0.003 ^c	ND	ND	ND	3.05±0.06 ^c	9.13±0.02 ^a	
Baking		kiswa	ND	ND	4.87±0.19 ^c	ND	ND	ND	3.75±0.11 ^c	8.90±0.01 ^b	
WC group		First Fermentation	0 h	ND	ND	7.04±0.32 ^a	ND	ND	ND	3.96±0.002 ^g	8.26±0.15 ^b
			24 h	ND	ND	7.10±0.05 ^a	ND	ND	ND	4.60±0.05 ^f	6.66±0.03 ^d
			48 h	ND	ND	6.94±0.11 ^a	ND	ND	ND	4.86±0.04 ^c	6.71±0.12 ^d
	Second Fermentation	0 h	ND	ND	6.49±0.16 ^b	ND	ND	ND	5.39±0.10 ^c	8.00±0.05 ^b	
		6 h	ND	ND	6.08±0.07 ^c	ND	ND	ND	4.99±0.03 ^d	7.39±0.13 ^c	
		12 h	ND	ND	5.67±0.02 ^d	ND	ND	ND	6.21±0.04 ^b	8.51±0.03 ^b	
	Baking	kiswa	ND	ND	5.00±0.001 ^c	ND	ND	ND	6.72±0.01 ^a	10.38±0.52 ^a	

¹ Control group (kiswa naturally fermented without an inoculum; this group also served as the natural fermentation group in Figure 3), LP group (kiswa fermented with *L. plantarum*), LF group (kiswa fermented with *L. fermentum*), LB group (kiswa fermented with *L. brevis*), WC group (kiswa fermented with *W. cibaria*).

² TRP: tryptamine; PHE: β-phenylethylamine; PUT: putrescine; CAD: cadaverine; HIS: histamine; TYR: tyramine; SPD: spermidine; SPM: spermine.

³ ND: not detected.

⁴ Data represented as mean±standard deviation from triplicate measurements. Values in the same column of the same group followed by different letters (a-g) are significantly different ($p < 0.05$).