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DEVELOPMENT OF SLICED BREAD WITH BETTER NUTRITIONAL QUALITY: OPTIMIZATION OF WHEAT FLOUR REPLACEMENT WITH GERMINATED PSEUDOCEREALS FOR DOUGHS WITH BETTER RHEOLOGICAL PROPERTIES

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Introduction

It is generally common to use wheat flour to make bread, however, it is possible to partially substitute this input with flours from other raw materials, to provide the bread with nutritional and healthy components (bioactive compounds and antioxidant capacity); as is the case of the partial substitution by germinated grain flour (quinoa, kiwicha and cañihua). It is necessary that for partial substitution of wheat flour, an evaluation of the rheological properties of the dough (development time, stability time, resistance to extension, gelatinization temperature and maximum gelatinization) is carried out, in such a way that guarantees the sensory quality of the bread to be made. In this way, it will be possible to obtain sliced bread with higher nutritional quality and acceptable techno-functional properties.

Objectives

- To improve the nutritional properties of sliced bread by replacing wheat flour (WF) with germinated quinoa (GQF), kiwicha (GKF) and cañihua (GCF) flours.
- Optimize the composition of flour mixtures using a Simplex Centroid Mix Design (SCMD), the desired function methodology and performing the analysis of rheological parameters in bread doughs (development time, stability time, resistance to extension, temperature gelatinization and maximum gelatinization).

Materials and methods

Bioactive compounds (total phenolic compounds, TPC; γ-aminobutyric acid, GABA) and antioxidant activity (oxygen radical absorbance capacity, ORAC) of germinated grain flours were determined.
A total of 14 flour formulations based on GQF (5-15%), GCF (5 15%) and WF (80-90%) or GKF (5-15%), GCF (5-15%) and WF (80-90%) were included in the SCMD to determine the optimal dough formulation that guarantees a sliced bread with technological and sensory quality.

Results and Discussion

Table 1 shows the results regarding the content of bioactive compounds and antioxidant capacity for both ungerminated and germinated grain flours (quinoa, cañihua and kiwicha).

Table 1. Content of bioactive compounds and antioxidant capacity of germinated and ungerminated grain flours.

Samples	Grain	Soluble phenolic compounds (mg GAE/100 g d.w.)	GABA (mg/100 g d.w.)	Antioxidant activity (mg TE/100 g d.w.)
Flour Without Germinal	Quinua	62.83±4,89[ab]	32.98±4.42[a]	1275.53±78.70[b]
	Cañihua	87.74±1,80[b]	24.34±4.83[a]	1193.84±71.82[b]
	Kiwicha	49.27±1.44[a]	37.38±1.58[a]	274.53±82.33[a]
Germinated Flour	Quinua	72.65±2.42[ab]	202.54±32.05[c]	3395.04±145.81[d]
	Cañihua	134.06±4.85[d]	217.98±1.48[c]	1876.44±51.55[c]
	Kiwicha	112.89±3.92[c]	100.00±22.45[b]	448.84±36.98[a]

The data represent the mean value ± standard deviation of three replicates. Different letters in the same column indicate significant differences (p< 0.05)

Table 2 and **Table 3** show the results of the experimental design for the 14 samples of the mixture GQF (5-15%), GCF (5-15%), WF (80-90%) and of the mixture GKF (5-15%), GCF (5 15%), WF (80-90%), respectively. The response variables evaluated were: water absorption (AA), optimal development time (TO), stability (S), resistance to extension (RE), extensibility (E) and gelatinization temperature (TG)

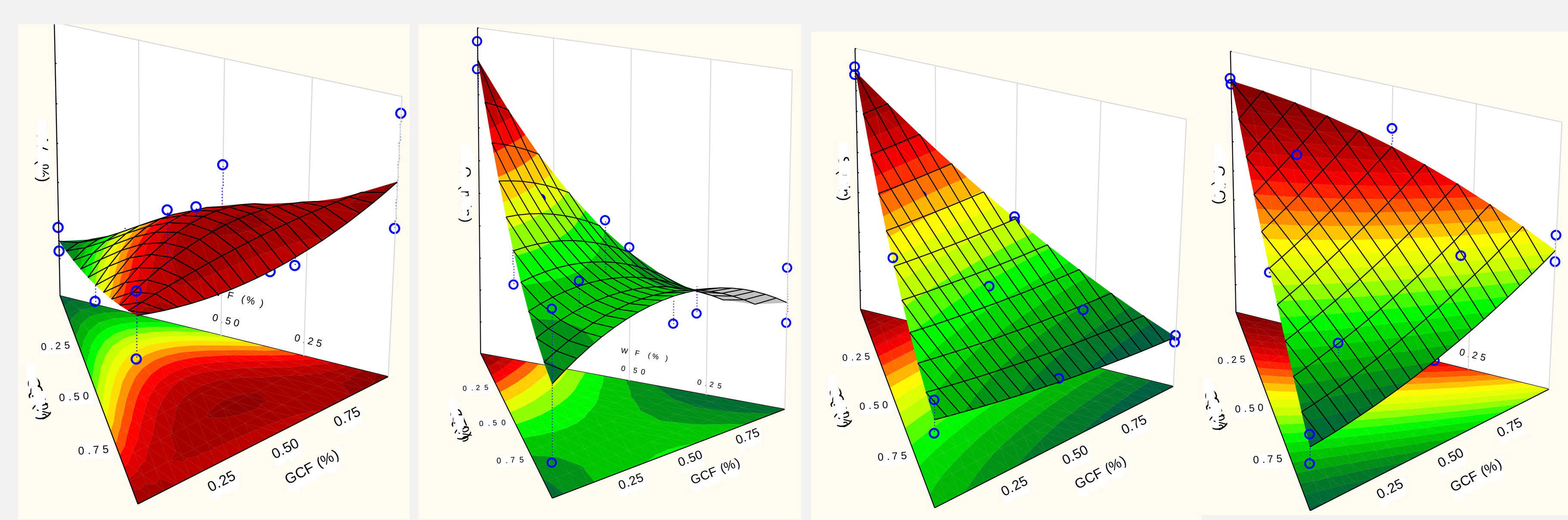
Table 2. Experimental conditions and response values for different flour formulations (GQF, GCF, WF).

Experiments	GQF (%)	GCF (%)	WF (%)	AA (%)	TO (min)	S (min)	RE (BU)	E (mm)	TG (°C)
01	8	8	83	64.3	3.77	4.12	823	71	79.5
02	15	5	80	64.6	2.8	3.73	948	73	76.6
03	10	10	80	64.1	3.35	3.67	1041	71	78
04	5	15	80	63.9	3.12	3.52	1079	69	79.4
05	5	15	80	65.3	3.45	3.45	983	68	80.3
06	5	10	85	63	3.27	4.27	1287	81	81.5
07	7	12	82	63.5	3.2	3.83	886	75	79.8
08	5	5	90	62.6	4.52	5.35	1431	86	83.1
09	15	5	80	63.8	3.67	4.05	868	80	77.6
10	10	5	85	63.2	3.42	4.45	923	70	79.6
11	7	7	87	63.3	3.73	4.57	1215	73	81.9
12	5	10	85	64.2	3.42	4.32	1097	72	82.6
13	12	7	82	64.9	3.62	3.7	986	80	78.8
14	5	5	90	62.9	4.35	5.42	1390	76	82.9

Table 3. Experimental conditions and response values for different flour formulations (GKF, GCF, WF).

Experiments	GQF (%)	GCF (%)	WF (%)	AA (%)	TO (min)	S (min)	RE (BU)	E (mm)	TG (°C)
01	8	8	83	62.6	3.55	4.02	1014	82	81.5
02	15	5	80	62.8	3.27	3.83	837	95	76.1
03	10	10	80	62.7	3.67	3.8	856	72	80.9
04	5	15	80	62.6	2.67	3.55	1040	73	79.8
05	5	15	80	61.8	3.02	3.7	918	69	83.6
06	5	10	85	61.1	3.55	4.17	1086	89	82.6
07	7	12	82	62.7	3.27	3.85	1096	77	80
08	5	5	90	63	4.3	5.2	1388	80	84.5
09	15	5	80	62.6	3.33	3.88	723	72	82.9
10	10	5	85	62.3	3.87	4.63	949	75	85.6
11	7	7	87	63.8	3.65	4.35	1014	82	77.5
12	5	10	85	63.7	3.57	4.38	1110	76	84.5
13	12	7	82	63	3.6	3.58	729	77	77.4
14	5	5	90	63.2	3.98	4.67	1095	80	80.4

Figure 1 and **2** show the response surface for the rheological parameters: water absorption (AA), optimal development time (TO), stability (E), resistance to extension (RE) and temperature of gelatinization (TG) as a function of dough formulations: GQF (5-15%), GCF (5-15%), WF (80-90%) and of the mixture GKF (5-15%), GCF (5 15%), WF (80-90%) respectively. Optimal formulation of bread dough for desirable rheological characteristics were: 84.6% (WF), 5% (GQF) and 10.4% (GCF) for blend 1 and 87.6% (WF), 5% (GKF) and 7.4% (GCF) for blend 2. These values belong to the ranges determined by SCMD and the desired function, guarantee the optimal rheological properties for the aforementioned flour mixtures.



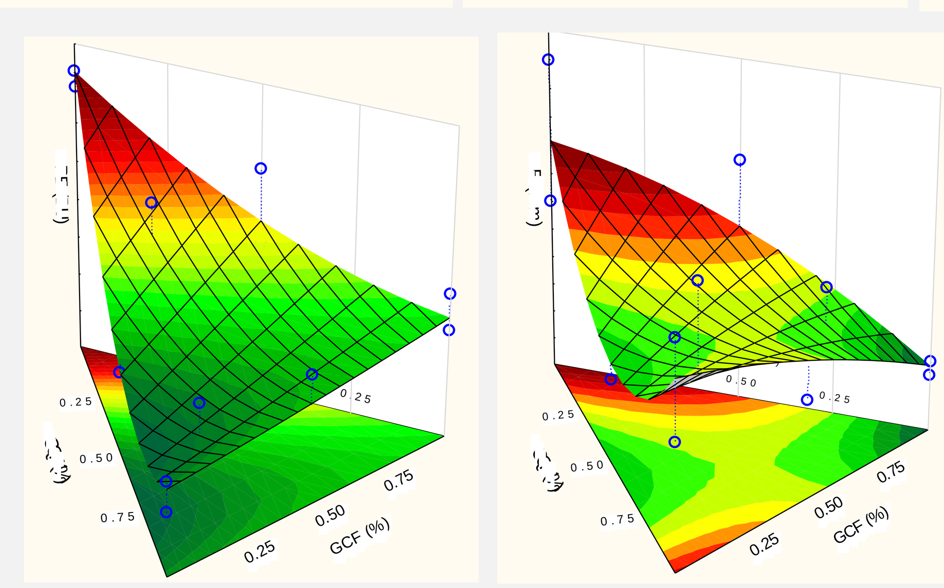
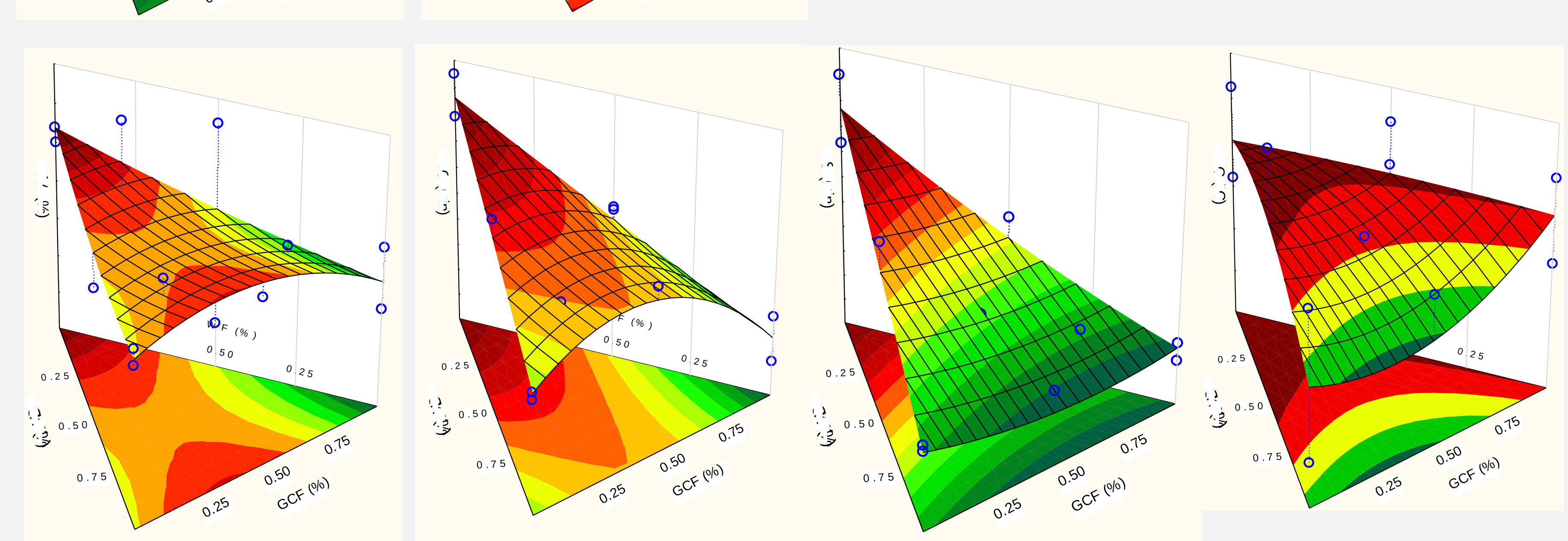


Figure 1. Response surface for the parameters AA, TO, S, E, RE and TG; depending on the percentage of flours GQF, GCF, WF.



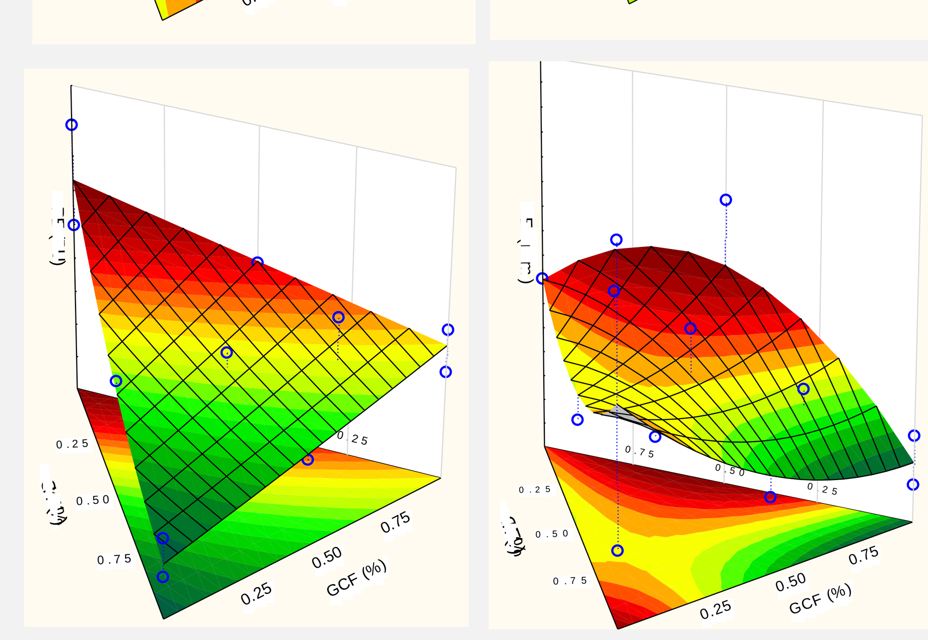


Figure 2. Response surface for the parameters AA, TO, S, E, RE and TG; depending on the percentage of flours GKF, GCF, WF respectively.

Conclusion

The partial replacement of wheat flour by sprouted pseudocereals flours could be used to produce sliced bread with higher nutritional quality and acceptable techno-functional properties.

Acknowledgements

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