



Study the Dough Raising Capacity of Composite Pseudo Cereal Flours for Formulation of Bread

S. Nivedha¹, M. Deepa¹, S. Snehith¹

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ABSTRACT

Background: Millet is a vast growing segment in baking industry and it has paved a way for new innovative products using different varieties of flours. When the consumer demand towards the low gluten products increases, the demand for refined wheat flour alternative also increases. Development of bread with varying proportions of two pseudo cereal flours. Buckwheat flour and quinoa flour was added to refined wheat bread, especially in greater amounts, it proved more efficient at protein content.

Methods: A meticulous investigation was conducted to assess the impact of different quantities of RWF (30-50 g), QF (20-40 g) and BF (10-30 g) on the quality attributes of the millet bread, using a D-Optimal design for optimization.

Result: The findings revealed that an increased proportion of refined wheat flour (RWF) enhanced the overall acceptability of the bread. Furthermore, the hardness and dough raising of the bread was influenced by higher RWF quantities and reduced levels of quinoa flour (QF) and buckwheat flour (BF). In general, mineral contents increased as the amounts of buckwheat and quinoa flour increased. The optimized proportions for RWF, BF and QF were determined to be 50 g, 39.04 g and 10.955 g, respectively. This optimization yielded the following outcomes: the dough raising capacity of yeast was 57.3185 % and the loaf volume 606.14 and its crust colour is 70.240 a bread texture (hardness) of 443.650 N/cm². These results are in concurrence with the predictions made by the significantly ($p < 0.05$) fitted quadratic models.

Key words: Buckwheat flour, D-optimal design, Quinoa flour, Raising capacity Dough property.

Abbreviation: AOAC: Association of Official Analytical Chemists, BF: Buckwheat Flour, DPPH: 2,2-diphenylpicrylhydrazyl, QF: Quinoa Flour, RSM: Response Surface Methodology, RWF: Refined Wheat Flour.

INTRODUCTION

Bread is globe's most popular foods. The main ingredients in bread making are wheat flour, water and yeast. Due to the high cost, geographical scarcity and tremendous demand for wheat flour, powerful initiatives are being taken to provide substitutes of flour (Menon *et al.*, 2015). Combining wheat flour and water results in a multidimensional dough. However, flour from wheat factors vary. Technical requirements and practical criteria typically require data within a certain range, which can be adjusted with appropriate additives. In addition to wheat or millet flours, food products may contain other additives that affect technological criteria and functional value (Gavurníková *et al.*, 2011). Wheat genotype like durum have some potential to survive under saline condition based on growth parameters (Soni *et al.*, 2020). Then millets are also gluten-free, making them a staple in many multigrain diets in Western countries. Some of the most popular millets are foxtail millet, pearl millet, finger millet, proso millet, teff and pseudo cereals (Mahalakshmi *et al.*, 2022).

There are numerous gluten-free grains available, including buckwheat, quinoa and amaranth pseudocereals. Additionally, these seeds have a superior nutritious profile (Alvarez-Jubete *et al.*, 2010). Gluten sensitivity accounts for the vast majority of dietary intolerances, making gluten-free bread vital. There are numerous typical gluten-free bread recipes; however, contemporary gluten-free bakery product

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technology is based on starches from various cereals, such as rice and corn. Unfortunately, gluten-free products are frequently of inferior quality, poor texture with smaller loaf volume and bad mouth feel due to a lack of low nutritional content and gluten elasticity. The nutritional content and techno-functional qualities of pseudo-cereals such as quinoa, buckwheat and amaranth can increase shelf life and quality of gluten-free breads (Turkut *et al.*, 2016).

Several investigations were undertaken to demonstrate that pseudocereal flours can be used in bread recipes. As a result, the aim of this study was to use an RSM to determine the maximum limits and appropriate quantities of Pseudocereal flour (buckwheat (BF) and quinoa (QF) in conjunction with refined wheat flour (RF) to produce bread with better technological, sensory and nutritional

attributes. A wider range of food products, including baked goods, are being made with cereals and pseudocereal flour. However, this raw material's lack of gluten (or low baking value), low water swellability, decreased activity of amylolytic enzymes and the starch response to their action and a sizable number of disulfide bonds in protein substances (Berezina *et al.*, 2020).

The annual crop buckwheat is classified as a pseudocereal, but due to its comparable chemical composition and intended use, its grains are classified as cereals. Nine species of buckwheat are valuable for agriculture and nutrition. Tartary buckwheat (*F. tartaricum*) and common buckwheat (*F. esculentum*) are the two buckwheat species that are frequently cultivated. Buckwheat grain is an extremely nutrient-dense food item that has been demonstrated to have many positive benefits. Reduced plasma anticancer, cholesterol, neuroprotection, antidiabetic, anti-inflammatory and improved conditions related to hypertension are among the health benefits linked to buckwheat (Gimenez-Bastida and Zielinski, 2015). The amount of buckwheat flour in the recipe increased the inositol phosphates antioxidant. A notable rise in protein content was noted in bread containing 20% buckwheat flour. Lysine was the limiting amino acid in the protein of the examined flours and breads. The amino acid score ranged from 45.67 to 75.38% for buckwheat flour bread and 44.71% for wheat bread (Kowalski *et al.*, 2022). In buckwheat genotypes PRB-9001, VL-27 and S-B-201 proved to be more effective cultivars based on the overall grading of nutrient-wise desirable characteristics (Dogra, 2019). the roasting and sprouted flours can be used commercially to produce better, more affordable and high in nutrients food products for individuals with health issues related to cereal consumption (Tanwar *et al.*, 2019).

Quinoa is regarded as a versatile agricultural and commercial crop. The high nutrient content found in the crop makes it suitable for use as animal raw materials, in flour products and for human use. It is necessary to identify and maximise on the unique beneficial qualities of quinoa for industrial applications, it can be eaten in a variety of forms, including prepared, in fact as flour and extruded. In Europe, quinoa bread have been introduced (James, 2009). Additionally, quinoa seeds can be fermented to produce beer or "chicha," a customary ceremonial alcohol drink from South America. Quinoa seedlings are quinoa sprouts that have germinated and are added to salads. Quinoa leaves are consumed similarly to spinach (Vilcacundo and Hernández-Ledesma, 2017). It provides a more complete protein than many vegetables because it is high in the vital amino acid known as lysine. Those with celiac disease and those allergic to wheat can both consume it because it doesn't contain gluten. Compared to rice (0.798 g/100 g edible matter) and wheat (1.7 g/100 g edible matter) quinoa seed has a lipid composition of approximately 5.5-7.4 g/100 g edible matter, which makes it acceptable as a substitute for oilseed seed. Quinoa also

has an elevated amount and good natural quality of their proteins (Vilcacundo and Hernández-Ledesma, 2017). Pseudocereals are high in micronutrients and fibre. By adding these quinoa, bread's nutritional value can be improved. Due to the exceptional nutritional value of its seeds, as well as their high protein content and quality, good amino acid composition and high polyunsaturated fatty acid content, quinoa has recently attracted more scientific and commercial attention (Joshi *et al.*, 2023). Quinoa's oil percentage is (4.6-12.4%) shows it has the potential to produce edible oil. Quinoa seed oil primarily contains linolenic, oleic, linoleic, as well as palmitic acids. (Tekguler *et al.*, 2015). To study the genotype of quinoa in germination test by radical emergence test should be used at 25°C for 60 hours and the seeds should be soaked in a 1.0% per cent tetrazolium solution for 20 hours at 30°C (Bhuker *et al.*, 2020).

Due to its more nutritional value, therapeutic qualities and gluten resist composition, quinoa is said to benefit high-risk consumers, including children, the elderly, high-performance athletes, people with lactose intolerance, women who are at risk of osteoporosis, people with diabetes, dyslipidemia, obesity and celiac disease. It is well known that certain grain processing methods, such as soaking, germination and malting, increase the amount of nutrients and reduce the amount of antinutrients in quinoa grains (Srujana *et al.*, 2019). This study will raise the public's knowledge of the positive health benefits and nutritional value of quinoa, encouraging the use of quinoa-rich products on a large scale. The following protein origin appears without gluten and low in sugar, so it can help improve its nutrient content for elderly people and people with dietary restrictions. Additionally, it can be used to assist those with dietary intolerances (Olawuni *et al.*, 2023).

MATERIALS AND METHODS

The research took place in September 2023 at the Department of Food Technology, Kongu Engineering College in Erode.

Raw materials

Refined wheat flour (RWF), quinoa flour (QF), buckwheat flour (BF), yeast, sugar, salt, butter was procured from local stores.

Preparation of bread

The pseudo-millet-based bread dough preparation process involves several distinct steps. Initially To activate the yeast, 3 g of sugar are dissolved in lukewarm water at a temperature of 43°C, followed by the addition of 3 g of yeast. This yeast-sugar mixture is left to incubate for 15 minutes at room temperature. Subsequently, ingredients like refined wheat flour (RWF), quinoa flour (QF), buckwheat flour (BF) were blended as given in Table 1. Additionally, salt is added at a ratio of 2% per 100 g of flour. The activated yeast is then introduced into this mixture, along with 5 g of butter for every 100 g of flour, ensuring thorough mixing for uniform distribution. The resulting dough is kneaded for

10 minutes to evenly distribute all components. The prepared dough undergoes a proofing process at room temperature for 2 hours, with a knocking-back step after 1.5 hours. Finally, the bread dough is baked at 160°C for 15 minutes.

Experimental design

This study utilizes the statistical software Design-Expert (Stat-Ease, Version 13) to employ RSM for optimizing the formulation. The selection of D-optimal design for experimental trials was made due to its effectiveness in foreseeing interactions among various factors affecting dependent responses and preventing extreme conditions. The independent variables like refined wheat flour (30-50 g), quinoa flour (20-40 g) and buckwheat flour (10-30 g), were denoted as RWF, QF and BF, respectively. The dependent variables encompassed dough raising capacity (%), colour L*, Texture (measured in hardness, N/cm^2) and loaf volume cm^3 .

Proximate analysis

The proximate composition was determined in accordance with standard AOAC (2005) method.

Dough raising capacity

The standard method described by weighing 4 gram of baker's yeast (compressed) or 1.00 gram of baker's yeast (dried) with 100 grams of Maida with addition of sucrose and a suitable quantity of water is required and the dough was kneaded well. Press the resulting dough into a glass beaker and note the initial level of the dough by means of a scale from the bottom of the beaker. And covered the beaker for one hour at 27°C. The rise in the level of dough is noted at 15 minutes interval for one hour. A graph between time and the rise in dough volume is plotted to estimate the dough raising capacity of yeast.

$$\text{Dough raising capacity} = \frac{(B-A)}{B} \times 100 \quad (3.1)$$

Where,

B = Final volume of dough.

A = Initial volume of dough.

Texture

The textural attributes of the bread were assessed using a TA XT Plus texture analyzer (Texture Technologies Corp., Scarsdale, NY) Using a serrated bread knife, 2.5 cm cubes were carefully cut out of the middle of each bread to reveal the crumb for texture analysis. Using a cylindrical probe, texture profile analysis (TPA) was used to measure the texture of the crumbs. The pre-test speed was 5 mm/s, the test speed was 1 mm/s, the post-test speed was 2 mm/s and the distance was 10 mm (Bhaduri *et al.*, 2013).

Colour analysis

The Hunter L*, a* and b* were used to determine the colour of flour using a Minolta Chromameter (Model CR-400, Minolta Co., Osaka, Japan). a* values measure redness when positive and greenness when negative; b* values measure yellowness when positive and blueness when negative and L* values measured from black to white (0-100).

The following equation was used to calculate colour change (ΔE) from the 'L', 'a' and 'b' values:

$$\Delta E = (\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2 \sqrt{0.5}$$

Sensory analysis

A sensory analysis was conducted with a group of 30 semi-trained volunteer assessors aged 20 to 50. These assessors evaluated the colour, taste, aroma, texture, flavour and overall acceptability of samples presented to them in random order. Samples were served at room temperature (24±1°C) and evaluated under standard lighting conditions. To ensure accurate assessments, the panellists rinsed their palates with water between samples. Their ratings were based on a 9-point hedonic scale, with 1 representing the lowest score (Dislike Extremely) and 9 representing the highest score (Like Extremely).

RESULTS AND DISCUSSION

Effect of independent variables on dough raising capacity

Illustrates the impact of flour composition on the dough raising property. The dough raising property response demonstrated a highly suitable quadratic model, as confirmed by a significant analysis of variance ($P < 0.0001$). The regression analysis revealed that the combination of flour composition had a coefficient of regression (R_2) value of 0.9508 and a non-significant lack of fit. Table 2 presented the linear regression equation for the dough raising property response. The dough raising property analysis indicated that the bread acceptability was highest when the quantity of refined wheat flour (A) 50 g and quinoa (B) 39.095 g, buckwheat (C) 10.955 g.

$$\text{Overall acceptability} = +1.68679 A - 1.77916 B - 3.15830 C + 0.0123^* AB + 0.012615^* AC + 0.107540^* BC$$

In the depicted Fig 1 it's evident that RWF is the primary influencing factor on dough raising capacity, with QF and BF flours following in importance. The data illustrates that as the quantity of refined wheat flour increases and pseudo millet flours decrease, the overall acceptability of the bread increases, reaching a maximum limit.

Effect of independent variables on hardness

The hardness response demonstrated a highly suitable quadratic model, as confirmed by a significant analysis of variance ($P < 0.0001$). The regression analysis revealed that the combination of flour composition had a coefficient of regression (R_2) value of 0.9424 and a non-significant lack of fit. Table 2 presented the linear regression equation for the hardness response. The hardness analysis indicated that the bread acceptability was highest when the quantity of refined wheat flour (A) 50 g and quinoa (B) 39.095 g, buckwheat (C) 10.955 g by Fig 2.

$$\text{Hardness} = -11.54712 A - 20.14750 B + 45047432 C + 0.674527^* AB - 0.070175^* AC + 0.072649^* BC$$

Since buckwheat flour were added, the developed bread weight and hardness changed (Gogoi *et al.*, 2023).

When mixing dough, gluten plays a crucial role in creating a structure that traps carbon dioxide produced during fermentation. When gluten-free flours replace wheat flour, the reduced gluten content results in a weaker dough network, leading to denser and harder bread compared to bread made with gluten-containing flour, as shown in a study by (Mannuramath *et al.*, 2015). Furthermore, the fiber content in millet flour can interact with starch through its water-binding and embedding capacity. This interaction may delay the aging process of starch and assist in preserving the textural characteristics of flour-based products. The composition involving a 40% replacement exhibited favorable texture, aligning with the conclusions of (Mastrascusa *et al.*, 2021).

Effect of independent variables on colour

The colour response demonstrated a highly suitable quadratic model, as confirmed by a significant analysis of variance ($P < 0.0001$). The regression analysis revealed that the combination of flour composition had a coefficient of regression (R_2) value of 0.9358 and a non-significant lack of fit. Table 2 presented the linear regression equation for the colour response. The colour analysis indicated that the bread acceptability was highest when the quantity of refined wheat flour (A) 50 g and quinoa (B) 39.095 g, buckwheat (C) 10.955g by Fig 3.

$$\text{Colour} = +1.07886 * A + 1.47973 * B - 1.39554 * C - 0.018471 * AB + 0.021495 * AC - 0.004449 * BC$$

Table 1: Experimental data.

Trial	Independent variables			Dependent variables			
	Refined wheat flour	Quinoa flour	Buck wheat flour	Dough raising capacity	Hardness	Colour	Loaf volume
	g	g	g	%	N/cm ²	L*	cm ³
1	40	30	30	45.9	1056.82	45.24	552
2	50	26.66	23.33	58.5	832.17	57.84	612
3	30	40	30	39.4	1060.45	42.56	538
4	40	40	20	49.3	755.56	57.14	584
5	43.33	33.33	23.33	56	878.37	55.09	604
6	40	40	20	49.3	720.45	64.45	583
7	36.66	36.66	26.66	44	832.35	43.45	546
8	40	30	30	47.44	1117.03	46.63	564
9	50	33.33	16.66	65.7	564.17	65.5	620
10	50	20	30	50	989.34	52.75	590
11	46.66	26.66	26.66	57.4	876.23	51.89	608
12	40	30	30	44.12	1163.76	46.84	548
13	50	30	20	62.12	767.23	62.54	618
14	50	40	10	55	410.37	70.24	603
15	40	40	20	48.6	743.45	56.32	579
16	30	40	30	41.5	1054.76	41.46	532

Note: Dependent variable values represent the mean of three repeated measurements.

Table 2: Analysis of variance for second-order polynomial model of dependent variables.

Source	F value and fit statistics			
	Overall acceptability	Antioxidant (%)	Texture (Hardness, g)	Protein (%)
Model	38.67*	32.72*	29.17	29.84
Linear mixture	80.26*	80.77*	71.97	67.92
AB	0.5753	1.95	0.6997	0.5676
AC	0.6031	0.0213	0.9539	4.43
BC	31.88	0.0166	0.0297	8.69
Lack of fit	4.19	4.72	0.8189	3.92
Coefficient of determination (R^2)	0.9508	0.9424	0.9358	0.9372
Adjusted R^2	0.9262	0.9136	0.9038	0.9058
Predicted R^2	0.8284	0.8916	0.7648	0.8585
Standard deviation	2.04	60.53	2.77	9.16
Coefficient of variance (%)	4.02	7.01	5.15	1.58

Notes: *Significant with 5% level of significance; A- Refined wheat flour; B- Quinoa flour; C- Buckwheat flour; AB- interaction between RWF and QF; AC- interaction of RWF and BF; BC- interaction between QF and BF.

BF emerges as the primary factor influencing the colour of the bread, with QF and RWF following in significance.

Effect of independent variables on loaf volume

The loaf volume response demonstrated a highly suitable quadratic model, as confirmed by a significant analysis of

variance ($P < 0.0001$). The regression analysis revealed that the combination of flour composition had a coefficient of regression (R^2) value of 0.9372 and a non-significant lack of fit. Table 2 presented the linear regression equation for the loaf volume response. The loaf volume analysis indicated that the bread acceptability was highest when

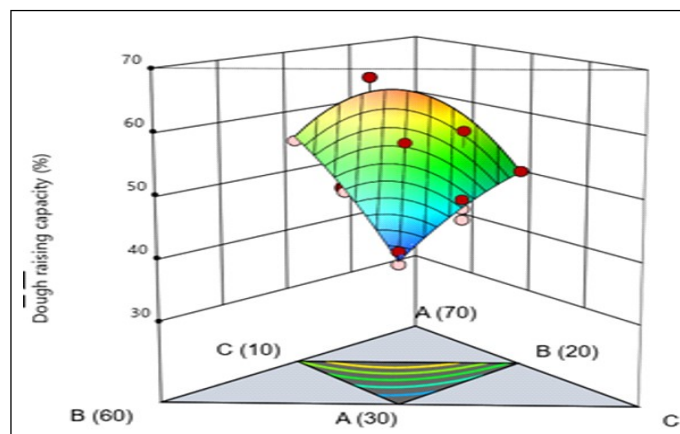


Fig 1: Effect of different composition of flour on dough raising capacity.

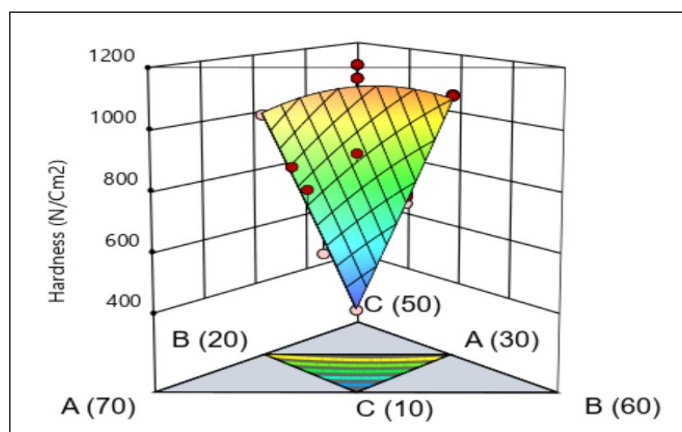


Fig 2: Effect of different composition of flour on hardness.

Table 3: Physio-chemical analysis of optimized composition.

Parameters	Control	Optimized sample
Moisture (%)	32	36
Ash (%)	1.4	1.8
Carbohydrate (%)	79.51	69.9
Protein (%)	10.65	16.2
Crude Fiber (%)	0.3	1.26
Fat (%)	5.03	10.56
Energy value	378.3 kcal	367.2124 kcal
Texture	Hardness(N)	443.650
Colour	Crust colour	L*=52.32
		a*=-13.97
		b*=31.80
Loaf volume (cm ²)	560	606.146
Water activity	0.432	0.525
Loaf weight	175	181

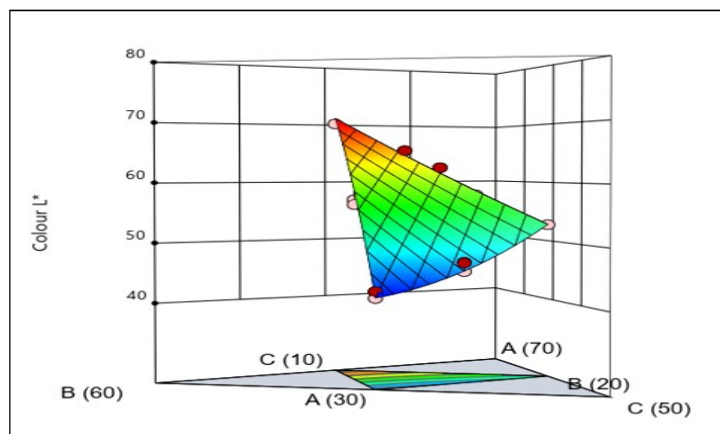


Fig 3: Effect of different composition of flour on colour.

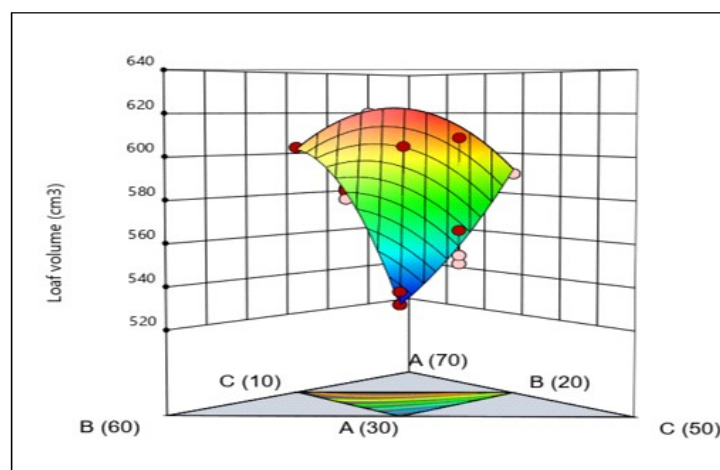


Fig 4: Effect of different composition of flour on protein.

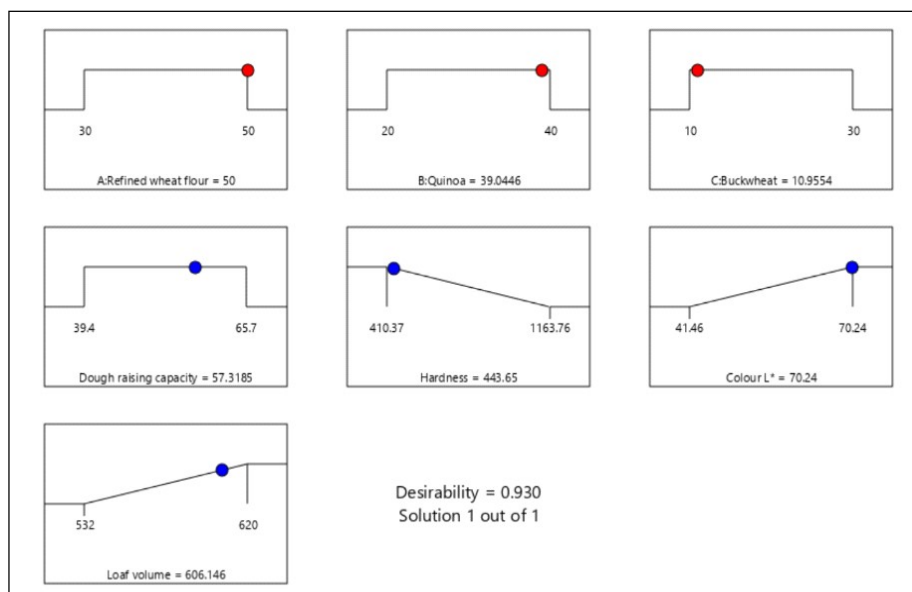


Fig 5: Optimized composition.

the quantity of refined wheat flour (A) 50 g and quinoa (B) 39.095 g, buckwheat (C) 10.955 g by Fig 4.

$$\text{Protein} = 9.39875 * A + 3.98347 * B - 9.44120 * C + -0.055036 * AB + 0.153182 * AC + 0.251647 * BC$$

The analysis of the F value indicates that loaf volume is predominantly influenced by RWF, followed by QF and BF.

Optimized composition

Using the design expert software, the desirability of 0.911 was obtained (Fig 5). The preferred ration were the desirability was maximum was RWF: 50 g, QF: 39.045 g, BF: 10.955 g. The optimized composition was subjected to further physio-chemical analysis as given in Table 3.

CONCLUSION

Product optimization was done using response surface methodology tool and buckwheat flour, quinoa flour and refined wheat flour were chosen as independent variable were varied in accordance with the trials generated to obtain optimized products. The optimized bread consists of 39% moisture content and has good overall acceptability and hardness were close to 443.650 N/cm^2 . The proportion of buckwheat, quinoa and refined wheat flours of 10.955 g, 39.045 g and 50 g respectively. Also, the dough raising capacity of yeast was 57.3185% and the loaf volume 606.14 and its crust colour is 70.240. Water activity of the optimized sample ranges from 0.525 has less chance of yeast and mold growth in the breads. And it was found to be feasible then the pseudo cereal flours can be substituted for wheat flour or refined wheat flour in making nutritionally rich and cost-effective bakery product.

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Conflict of interest

All authors declare that they have no conflicts of interest.

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