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Process Optimization For Development of Gluten Free Muffins Using Response Surface Methodology

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Abstract

In recent era prevalence of celiac disease has been increased in drastic manner leading to increasing demand for development of gluten free products. The present study aimed to develop finger millet-based gluten free muffins. Millets are known to play an important nutritional role especially in developing countries. Finger millet seeds were subjected to three different variables viz; soaking time (4-24 hrs), germination time (24-72hrs) and germination temperature (25-35°C)varied at five different levels. Set of experiments were carried out using response surface methodology (RSM) to check effect of process parameters (soaking time, germination time and germination temperature) on product responses (proximate, physicochemical and phytochemical properties). Sensory analysis depicts the higher scores of overall acceptability for optimized product as compared to market samples.

Keywords: Gluten free muffins, physiochemical properties, phytochemical properties, optimization, consumer acceptability

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1.Introduction

Celiac disease is an autoimmune disorder in which gluten is not metabolized in body and immediate and adverse response is produced when exposed to it (Masih et al., 2019). Gluten free cereals are preferably used for making value added food products for toddlers and are advisable for patients suffering from celiac disease. Cereals are the major source of carbohydrates and minerals (Hejazi et al., 2016) and it is not advisable to completely avoid a food group. According to Farzana et al. (2015), the use of protein- calorie source of food products as a supplementation has been planned as a possible solution of this problem. This is one of the most effective way by which celiac diseases can be managed and prevented by addition of low-cost value-added product (Vyas et al., 2016). Following the increased number of celiac patient and more people avoid gluten sources, the food market has been seen a surge in the production and sale of gluten free products (Masih et al., 2019; Wunsche et al., 2018).

Millets are known to play an important nutritional role especially in developing countries like India which are referred as coarse cereals as they are not only cheap but are also rich in calcium, dietary fiber, polyphenols, and protein (Devi et al., 2014). Millets are least allergenic and easily digestible grains. Millets stay for longer period of time and grow well in dry region that are best suited as compared to paddy rice or wheat (Kumar et al., 2018; Michaelraj et al., 2013).

Small millets as a group includes several grain crops such as finger millet, kodo millet and little millet. Finger millets are rich in calcium content (344 mg/ 100 g) and is grown in various region of India and Africa. It ranks sixth in production after other cereals and grains (rice, bajra, maize, sorghum) in India. Consumption of whole grain cereals and their products protect from risk of

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various diseases such as cardiovascular disease, type 2 diabetes, gastrointestinal cancer etc. (Devi et al., 2014). Finger millets contain 5-8% protein, 65-75% carbohydrates, 2.5-3.5% minerals, 3.60% crude fiber, 1.43% fat (Chetan and Malleshi, 2016; Kumar et al., 2018). As compared to other cereals, potassium content is also high in finger millet (408 mg/100 g) and contain some important amino acids such as isoleucine, leucine, methionine (Shaikh et al., 2017). It used in preparation of different traditional foods, such as roti, ambali (thin porridge) etc. (Devi et al., 2014). Therefore, in this study, gluten free muffins are planned to be prepared by elimination trial method.

2. Material and Methods

2.1 Collection of raw material

Finger millet grains were procured from Phagwara, Punjab, India and other ingredients such as baking soda, baking powder, curd, jaggery and oil were bought from the local market of Phagwara, Punjab, India.

2.2 Process optimization using response surface methodology (RSM)

Finger millet seeds were cleaned and washed to eradicate the dust and were subjected to three different variables. Independent variables included soaking time (4-24 hrs), germination time (24-72 hrs) and temperature (25-35°C). Coded and un-coded levels for independent variables are shown in**Table 1**. The variables were optimized using response surface methodology. The seeds were dried at 60 °C for 5 hrs in a tray dryer. The dried seeds were ground into fine powder using milling machine. The product was developed at various runs as per RSM and from that best product was selected.

2.3 Preparation of muffins

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Gluten free muffins were prepared by replacement of refined wheat flour with finger millet. Muffin batter was prepared by mixing curd, jaggery with the help of spoon to avoid lumps. After 5 minutes add baking and baking powder was added and mixed well and kept for 5 minutes to become batter fluffy. After that sieved finger millet was added to curd mixture in batches and was mixed in fold and cut method, so that each ingredient mixed properly. The batter was poured in muffin cups which were greased with oil and was baked in a preheated oven at 160°C for 30 minutes.

2.5 Proximate and phytochemical analysis

2.5.1 Proximate properties

Moisture content and ash content was determined by AOAC official method (AOAC, 2016). Protein digestibility was determined by kjeldhal method (AOAC, 2016). Fat content was determined by Soxhlet extraction method. The fat was determined by using 2g dried sample and extracted with 80 ml petroleum ether (AOAC, 2016). Dietary fiber was measured using dietary kit assay (AOAC, 2016).

2.5.2 Phytochemical properties

Ascorbic acid determined by using a method described in Ranganna, (2016). Total phenol determined by using folin-ciocalteu reagent (Ranganna, 2016). DPPH was determined by using 3.9 ml (3.955 µl) DPPH (Owheruo et al., 2018). Flavonoid content was determined by using aluminum chloride method (Ranganna, 2016).

2.5.3 Antinutrients properties

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Tannin content was determined by using vanillin hydrochloride method with slight modification (Ranganna, 2016). Phytic acid was determined by using trichloroacetic acid (Sadasivam and Manickam, 2008).

2.6 Statistical analysis

The results were reported as means and standard deviations of three replicates. Statistical analysis was done by using SPSS 25.0 (IBM, NY, USA). The results were checked for variance (ANOVA) followed by Duncan’s Multiple Range test. RSM was performed using Box Behnken Design from the Software Minitab 18.0.

2.7 Sensory analysis

Nine points hedonic scale was used for conducting sensory evaluation of germinated finger millet muffins. The panel of judges was selected to evaluate the product for various sensory parameters i.e., flavor and sweetness, body and texture, color, mouth feel, overall acceptability.

3. Results and Discussions

3.1 Effect of process parameters on proximate properties

Proximate analysis contains moisture, ash, fiber, carbohydrates and fat. Figure 1 shows that soaking time (5,14.5,24 hrs) increased ash content (11.55%) at square level which was highly significant ($P<0.05$) whereas germination time (25, 48.5, 72 hrs) increased (6.14%) moisture at square level. With the increased in germination time (25, 48.5, 72 hrs), significant increase was observed in protein (2.91%) and fat (2.30%) content at linear level (figure 1). Similar results were shown by Mbithi-Mwikya et al. (2000) and Abioye et al. (2018) that increase in time of germination increases protein and fat content. Finger millet has positive influence on protein content and was capable of biological synthesis off new amino acids during germination. The

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interaction between soaking and germination time significantly increased fiber content (3.77%) at2- way interaction level whereas square of germination time increased carbohydrate content (8.90%) at square level.

3.2 Effect of process parameters on phytochemical properties

Phytochemical properties contain vitamin C, carotenoids, DPPH, flavonoids, polyphenols. Figure 1 shows that soaking time increased vitamin C content (0.90 mg/100 g) at square level whereas temperature increased (2.76 µg/100 g) carotenoids content at square level. The square of soaking time increased DPPH at square level. DPPH content (10.60-10.45%) highly significant ($P<0.05$) with soaking time (5 hrs, 14.5, 24 hrs) at square leveland linear level. The interaction between germination time and temperature increased flavonoid content (1.47 mgQE/100 g) at interaction level.The increased in polyphenol content (7.23 mg GAE/100g)due to temperature (25, 30, 35°C) at square level (figure 1) which was highly significant ($P<0.05$). Sharma et al. (2015) study showed that flavonoid compound of millet (foxtail) increased by germination time.

3.3 Effect of process parameters on antinutrient content

Antinutrients content contain phytic acid and tannin. Figure 1 shows that germination time (25 hrs-72 hrs) decreased tannin content (0.01 mgTAE/100 g) at square level whereas soaking time and temperature reduced phytic acid (0.06 mg/100 g) at linear level and square level. Similar study followed by Ocheme et al. (2008) and Abioye et al. (2018) showed that germinating significantly reduced 50% phytic acid and tannin content in finger millet with increase in time of germination. Antinutrients affect digestive tract and hence germination process reduced the antinutrients of finger millet. Reducing antinutrients during time of soaking and sprouting could

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be attributed to leaching in soaking water and increase enzymatic treatment during germination (Bonifacce et al., 2011).

3.2 Numerical optimization using response surface methodology (RSM)

As per the desired goals, optimization was carried out for maintaining higher quality. The software generating predicted values for different variables (19.20 hrs soaking time, 65.35 hrs germination time, 25° C temperature) i.e., ash (%) 3.80, 24.87 % moisture, 4.59 % fat, 2.86 % protein, 3.87 % fiber content, 63.89% carbohydrates and 7.70 % vitamin C; antioxidant activity: 69.37 % DPPH, 23.52 mg/ 100 g flavonoid and 30.31 mg/ GAE/ 100 g polyphenol; antinutrients: 0.44 mg/100 g tannin, 0.07 mg/100 g phytic acid. As shown in table 2, the nearest value of predicted from RSM i.e., 5 hrs soaking, 48.5 hrs germination and 25°C temperature, obtained best product. A difference was drawn between predicted and experiment values of parameters to check the efficiency of experiment. In figure 1, sensory analysis was shown for different variables i.e., soaking time, germination time and temperature and the optimized product (14.5 hrs soaking, 72 hrs germination, 25°C temperature) obtained was same as the value which was predicted from RSM.

3.3 Sensory analysis of optimized product

The result of sensory profiling was done in different variables which are given in figure 1. Reduction in color, flavor, texture and mouthfeel of muffin was observed as the content of temperature of germinated finger millet increase. An improved in color, flavor, texture and mouthfeel of muffins was observed as the content of temperature decrease while germinating finger millet. The best product which are predicted (S14.5G72T25) after sensory evaluation.

Conclusion

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The gluten free muffins were optimized using response surface methodology (RSM). The product was rich in nutrients like vitamin C (7 mg/100 g) and DPPH (74.96%). The processing techniques resluted in a reduction in anti-nutrient content. The overall acceptability of selected product was (7.85). The developed product most effective way for celiac diseases and prevented by addition of low-cost value-added product and which make it suitable for health-conscious people.

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Run	Soaking time (hrs)	Germination time (hrs)	Temperature (°C)
1	5	48.5	25
2	14.5	25	35
3	24	48.5	35
4	5	72	30
5	5	48.5	35
6	24	25	30
7	24	72	30

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8	5	25	30
9	24	48.5	25
10	14.5	25	25
11	14.5	48.5	30
12	14.5	48.5	30
13	14.5	72	35
14	14.5	72	25
15	14.5	48.5	30

Table 1. Coded levels for independent variables used in developing experimental data

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Table 2: Software generated optimum conditions along with its predicted and experimental values

Process variables				Responses						
	Soaking time (hrs)	Germination time (hrs)	Germination temperature (°C)	Vitamin C	Carotenoids (g/l)	Tannin	Phytic acid	DPPH	Flavonoid	Polyphenol
Predicted Values	19.20	65.35	25	7.70	0.04	0.44	0.07	69.37	23.52	30.31
Experimental	14.5	72	25	7.00	0.04	0.16	0.01	74.96	20.64	30.09

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Process variables				Responses					
	Soaking time (hrs)	Germination time (hrs)	Germination temperature (°C)	Ash (%)	Moisture (%)	Fat (%)	Protein (%)	Fiber (%)	CHO (%)
Predicted Values	19.20	65.35	25	3.80	24.87	4.59	2.86	3.87	63.89
Experimental	14.5	72	25	0.50	22.33	5.00	2.47	3.47	69.70

Table 3: Software generated optimum conditions along with its predicted and experimental values

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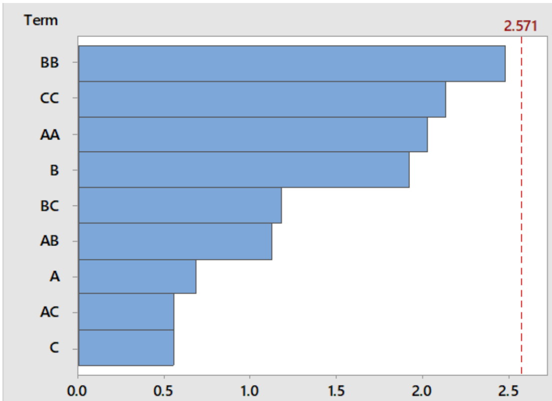
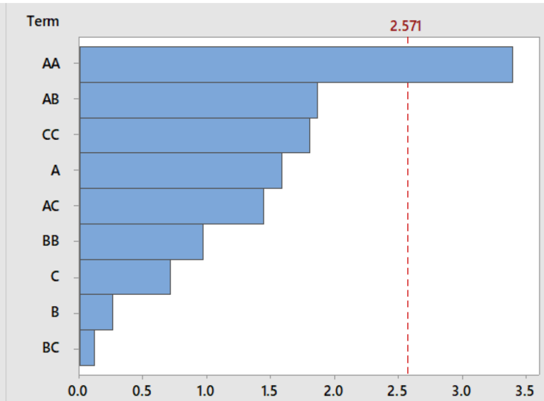
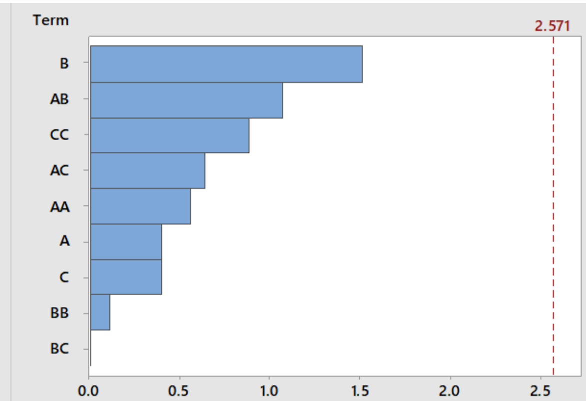
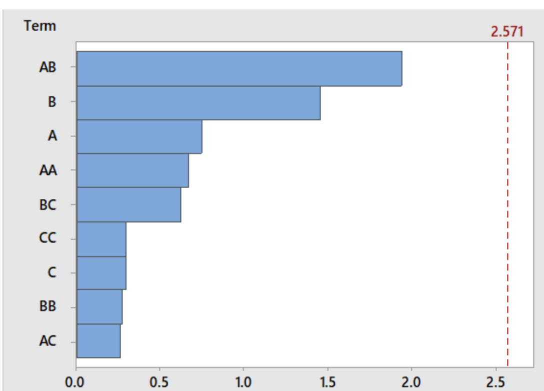
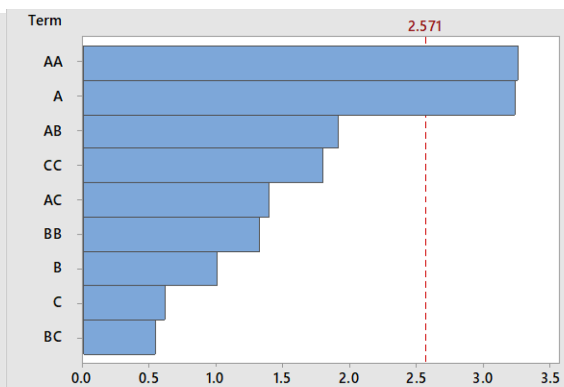


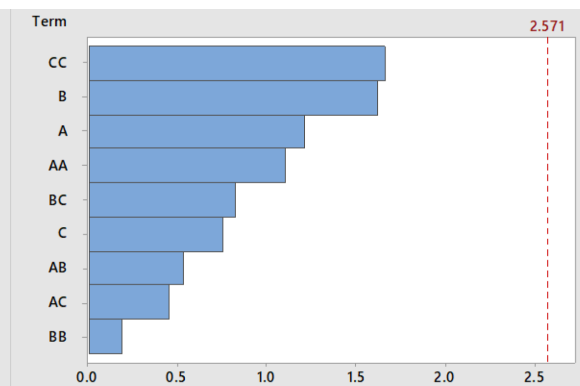




Moisture (%) **Ash (%)** **Fat (%)**







Fiber (%) DPPH (%) **Carotenoids (µg/100 g)**

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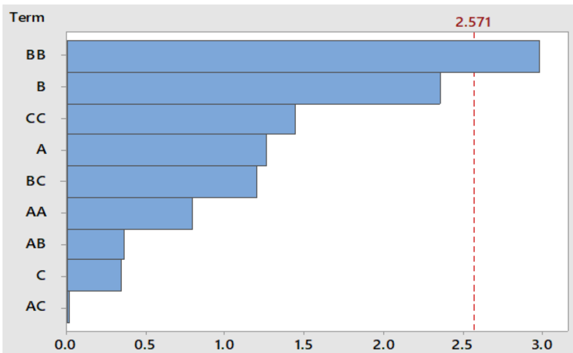
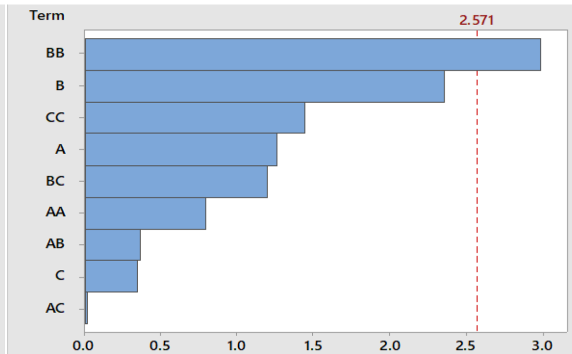
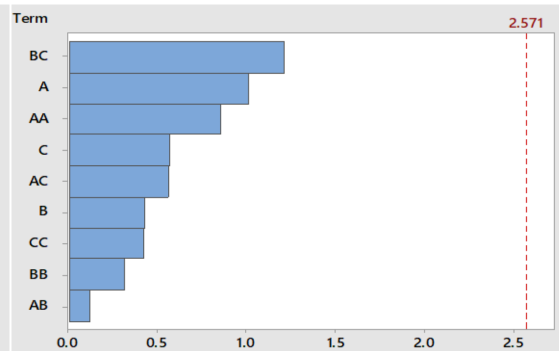


Carbohydrates (%)



Protein (%)



Flavonoid (mgQE/100 g)

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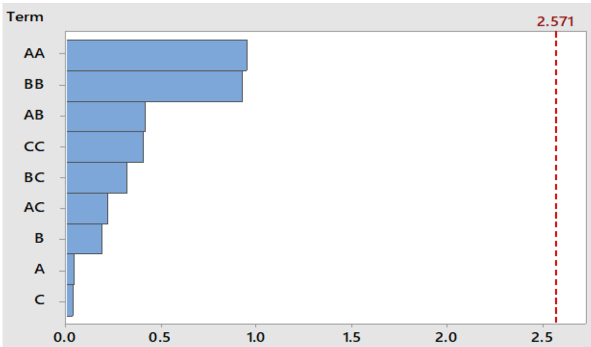
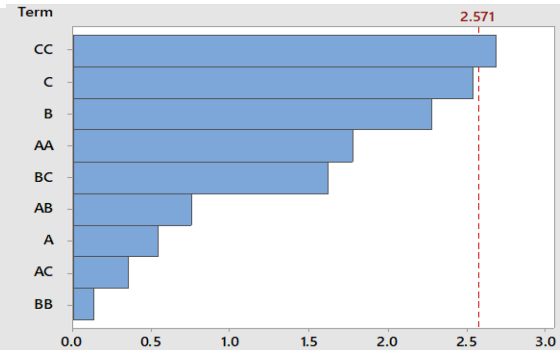
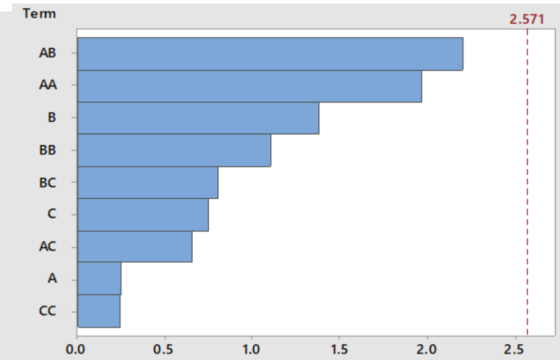


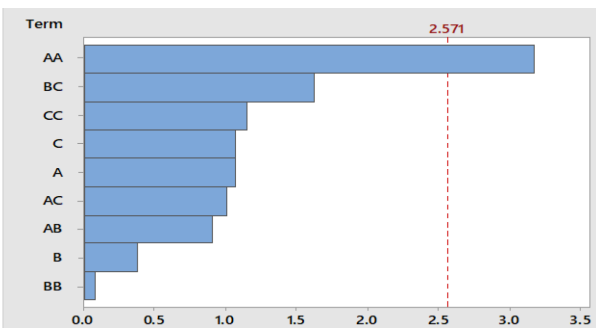
Vitamin C (mg/100 g)



Polyphenol (mgGAE/100 g)



Phytic acid (mg/100 g)



Tannin (mgTAE/100 g)

Figure 1: Influence of process parameters on the response variables when other processing variables are kept constant