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Development and Optimization of Value Added Biscuits Using Response Surface Methodology

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ABSTRACT

Ginger (Zingiber officinale) is an important commercial crop belonging to the family Zingiberaceae grown for its aromatic rhizomes which are used both as spice and medicine. The herbal therapeutic benefits of ginger are mainly due to the presence of volatile oils. Consumption of bakery products in the country is increasing day by day and biscuit is commonly consumed food like bread having several attractive features. In the view of health benefit of ginger, it may be worthwhile to explore possibility of incorporating ginger extract in wheat flour for the development of biscuits to provide a convenient food to supplement the diet's nutrition. Present study was an effort to standardize the level of ginger extract in formulation for the development of value added biscuits. To optimize the quantity of butter, sugar and ginger extract to be added, Response Surface Methodology (RSM) was used, while rest of the ingredient level was kept constant. The lower and upper limits for butter, sugar and ginger extract were taken as 50-70 g, 25-35 g and 8- 16 ml, respectively. Control treatment was prepared without ginger extract addition. All 20 combinations and control were subjected for sensory quality evaluation on a 9 point hedonic scale. From the study, it was found that the biscuit having composition 60 g butter, 20 g sugar, 12 ml ginger extract per 100 g of biscuits was found optimum and the said formulation was acceptable and recommended for value added biscuit. The optimized biscuit was found to be superior in terms of minerals, calcium and iron as compared to control biscuit. Since, the biscuit was a good source of calcium and iron, hence it can be recommended for *consumption for children and old age people. The addition of ginger extract, also gave an excellent antioxidant effect on the biscuits compared with control. Addition of natural antioxidants can increase shelf-life of food products containing fats and oils. It can be recommended as one of the value added product.*

Key words: Biscuits, Gingerol, Oleoresin, Volatile oils, Zingiber officinale,

1. INTRODUCTION

Ginger (Zingiber officinale) is an important commercial crop belonging to the family Zingiberaceae grown for its aromatic rhizomes which are used both as spice and medicine (Badreldin H *et al.,* 2007). It can be used fresh, dried and powdered, or as a juice or oil. Ayurvedic medicine utilizes it for the treatment of arthritis (Thomson M *et al.,* 2002). Other traditional uses of ginger include colic, cold, fever, menstrual cramp and appetite stimulant (Chrubasik S *et al.,* 2005). Ginger supplements are widely available and include liquid extract, syrup, tea and capsules. The herbal therapeutic benefits of ginger are mainly due to the presence of volatile oils and the high oleoresin content. A compound known as gingerol (Bhattarai S *et al.,* 2001), is an acrid chemical constituent of the ginger, and this chemical compound is the agent responsible for the hot taste of ginger and is also one of the reasons that ginger possesses stimulating properties on the body (Wang CC *et al.,* 2003). The aroma of ginger is pleasant and spicy and its flavor is penetrating & slightly biting due to antiseptic or pungent compounds present in it, which make it indispensable in the manufacture of a number of food products like ginger bread, confectionery, ginger ale, curry powder, certain soft drinks like cordials, ginger cocktail, carbonated drinks, bitters, etc. Ginger is also used for the manufacture of ginger oil, oleoresin, essences, tinctures, etc (Francisco BF et al., 2008). Bakery products are an important source of nutrients viz. energy, protein, iron, calcium and several vitamins. Most bakery products can easily be enriched and fortified at a low cost with proteins, various vitamins and minerals to meet the specific needs of the target groups and vulnerable sections of the population, who are undernourished and malnourished. Since fortification and enrichment can be easily carried out, it is very important that more nutritious products should be produced in future (Sharma *et al.,* 1998). Biscuits though not a staple food like bread, have several attractive features mentioned above and these features enhance the value of producing biscuits from composite flours for organoleptic, economic and nutritional reasons. In places where soft wheat flour is not available or too expensive, it becomes economically necessary to produce biscuits from composite flours.

Nutritionally, biscuits can be easily fortified with ginger extract to provide a convenient food to supplement the diet's nutrition. Since consumption of bakery products in the country is increasing day by day and in the view of above health benefit of ginger it may be worthwhile to explore possibility of incorporating ginger extract in wheat flour. Present study was an effort to standardize the level of ginger extract in formulation for the development of value added biscuits.

2 MATERIALS AND METHODS

Ginger used for this investigation were purchased from the local market.

All required ingredients like as sugar, butter, refined white flour, common salt, baking powder, ammonium, cumin seeds were purchased from local market of Allahabad, India. All the chemicals used in analysis were of (analytical reagent) AR grade obtained from Centre of Food Technology, University of Allahabad. This work was carried out from March to June 2016 at Centre of Food Technology, University of Allahabad, Allahabad, U.P., India.

2.1 Preparation of Aqueous Ginger Extract:

The ginger was washed, drained and then grated with the help of grater and then the aqueous extract is prepared & used to incorporate it in the biscuit preparation, (Francisco BF *et al.*, 2008).

2.2 Development and Optimization of Value Added Biscuits

Biscuits were prepared as per the method of Sai Manohar & Haridas Rao, 1999. Sugar and fat were creamed for 3–4 min in a laboratory mixer. The extracts were blended with the fat and the emulsion was mixed with sugar. Dough water containing sodium and ammonium bicarbonate (1.5 and 3 g), and sodium chloride (3 g) was added to the above cream and mixed for 5 min to obtain a homogenous dough. Refined flour sieved twice with baking powder (0.9 g) was added and mixed for 3 min. The dough was sheeted to a thickness of 3.5 mm and cut into circular shapes using 45-mm cutter and placed on an aluminium tray, baked at 160 ^{0}C for 10 min and then allowed to cool. The biscuits were stored in air-tight containers at ambient temperature.

To optimize the quantity of butter, sugar and ginger extract to be added, Response Surface Methodology (RSM) was used while rest of the ingredients like refined white flour, common salt, baking powder, ammonium carbonate, cumin seeds level were kept constant on the basis of hit and trial method on the basis of sensory evaluation using 9-point hedonic scale (Murray, J.M. *et al.*, 2001). Response Surface Methodology (RSM) is a collection of statistical and mathematical technique useful for developing, improving and optimization process (Mugwiza

Telesphore, Q. *et al.,* 2009), for statistical and graphical analysis of the experimental data and also for monitoring the combined effects of variables (Sivakumar, P.S. *et al.,* 2010). The butter (60 g), sugar (30 g), ginger extract (12 ml) was repeated 5 times as central points. The lower and upper limits for butter, sugar and ginger extract were taken as 50-70 g, 25-35 g and 8- 16 ml, respectively. Control treatment was prepared without antioxidant extract addition. All 20 combinations and control was subjected for sensory quality evaluation by 15 trained panelists. The process flow chart is adopted for the preparation of biscuits by using various ingredients like refined white flour, common salt, baking powder, ammonium and cumin seeds by traditional creamery method. The process flow chart for the preparation of biscuit is given in Fig. 1.

Creaming of sugar and butter

↓

Proper mixing of ingredients along with ginger extract in specified proportion of refined wheat flour and dough was made

↓

Biscuit shaped loaves prepared

↓

Kept in oven at 100^{0} C for 15-20 minutes

↓

Crispy ginger biscuits with brown coating were prepared

Fig. 1 Process flow chart in the preparation of value added biscuits.

2.3 Proximate and Mineral Content Analysis

The moisture, crude fat, fibre and protein content of the samples were determined as per AOAC procedures (Philip John Kanu, H.M. *et al.,* 2007); whereas minerals (Ca and Fe) were estimated as per the AOAC procedures (Sai Manohar, R., & Haridas Rao, P. 1999).

2.4 Sensory Analysis

To carry out initial optimization of the ingredients of RSM design, the 30 combinations were judged by a trained panel of 15-members using a 9 point hedonic scale (9-like extremely and 1-dislike extremely) for color, flavor, crispiness and mouthfeel. (Sharma *et al.*, 1998).

2.5 Determination of Antioxidant Activity

The antioxidant activities of native and processed raw materials were also measured by the DPPH radical scavenging method (De Ancos, Sgroppo, Plaza, & Cano, 2002). An aliquot (0.10ml) of sample extract in methanol was mixed with 2 ml of methanolic 0.1 mM DPPH solution and the volume is made upto 5 ml with distilled water. The mixture was thoroughly vortex-mixed and kept in dark for 30 min. The absorbance was measured at 515 nm. The result was expressed as percentage of inhibition of the DPPH radical. The percentage of inhibition of the DPPH radical was calculated according to the following equation:

%inhibition of DPPH = [(Abs control-Abs sample)/ (Abs control)] X 100

where, Abs control is the absorbance of the DPPH solution without the extracts.

2.6 Determination of Total Phenol Content

Total polyphenols were estimated as per procedure described by Singleton *et al.*, (1999) using folin ciocalteu method, where 250 mg sample was taken in 10 ml of acetone and water (70:30 v/v) solution in a graduated test tube and heated on water bath at 70^{o}C for 10 min. The sample was brought to room temperature, centrifuged at 3500 rpm for 10 min. The supernatant (0.2 ml) was made up to 10 ml with distilled water. This solution was diluted 10 fold and sample solution (5 ml) was mixed with saturated sodium carbonate (0.5 ml) and Folin-Ciocalteaue reagent (0.2 ml) and made up to 10 ml with distilled water. The absorbance was read at 765 nm after 60 min by UV visible double beam spectrophotometer (Model Evolution 600, Thermo Electron, US).

2.7 Texture Analysis of Optimized Biscuit

Hardness was measured by Texture analysis of control and optimized developed biscuit with the help of Texture analyzer by operating Force in compression, Pre test speed – 5 mm/sec, Test speed – 10 mm/sec, Post test speed-10 mm/sec, distance -8 mm/sec and Load cell - 5kg.

2.8 Statistical Analysis

The data obtained were analyzed statistically for analysis of variance (ANOVA) using completely randomized design with least significant difference (LSD) at $P < 0.05$ using Co.Stat 6.303, CoHort software (USA).

3 RESULTS AND DISCUSSION

3.1 Optimization of Value Added Biscuit

For the optimization of the variables, the responses, colour, flavour, crispiness and mouthfeel were selected. From the anova result in Table 1, there was significant difference found for each variable of sensory attributes at $p<0.05$. On the basis of that, these responses had direct effect on the quality of biscuits (Puranik, *et al.*, 2013). Butter (Fig. 2) had significant positive ($P < 0.05$) effect on flavour and interaction between sugar and ginger extract showed positive effect on the flavour (Fig. 2). The interaction between butter to ginger extract showed negative effect on flavor, as we increase the concentration of ginger extract (Fig. 2). With increase in the amount of butter, color response decreases, then increases (Fig. 3). Interaction between sugar and ginger extract to colour had significant negative effect on colour ($P < 0.05$) (Fig. 3). With increase in the amount of ginger, crispiness slightly decreases then increases (Fig 4). The interactive effect of butter to sugar showed positive effect on crispiness of biscuits (Fig. 4). On increasing the amount of butter, mouth feel increases and when ginger increases, the mouth feel slightly decreases (Fig.5). On increasing sugar, mouth feel decreases and when butter increases mouth feel decreases & then increases (Fig 5). With increase in the amount of butter and sugar, the mouth feel increases then slightly decreases (Fig.5).
The overall effect of ginger extract was maximum on all sensory responses followed by sugar. To consider all the responses simultaneously for optimization the RSM was used to compromise optimum conditions and it was found that the sensory scores were 8.1, 8.1, 8.1 & 8.12 for colour, flavour, crispiness and mouthfeel corresponding to optimum conditions (Table 2). Biscuit having composition 60 g butter, 20 g sugar, & 12 ml ginger extract per 100 g biscuits was found optimum. Triplicate samples were prepared using the optimum conditions and were evaluated for all the responses. Corresponding values for color, flavor, crispiness and mouthfeel were 8.1, 8.1, 8.1 & 8.12 respectively which were comparatively higher than the predicted value (Table 2). Therefore, biscuit having composition 60 g butter, 20 g sugar, 12 ml ginger extract per 100 g of

biscuits was found optimum and the said formulation was recommended for preparation of value added biscuit.

3.2 Texture Analysis of Optimized Biscuit

From the results of texture analysis, the hardness of control biscuit and optimized biscuit was found to be comparatively near to each other i.e. 915 g and 1015 g respectively (Fig. 6). This result can be correlated with the acceptable sensory scores of control and optimized biscuits (crispiness score of 8 & 8.1 respectively).

3.3 Nutritional Evaluation of Optimized Biscuit

The chemical composition of optimized biscuit regarding moisture, ash, crude fat, crude protein, crude fiber, carbohydrate and mineral contents are presented in (Table 3). The nutritive value of ginger extract incorporated biscuit was significantly higher than that of control. By incorporation of ginger extract, the ash content was increased from 1.56% to 2.64%. The optimized biscuit was found to be superior in terms of minerals, calcium and iron, 60.3 and 0.86 mg/100g respectively as compared to control biscuit (46 & 0.26 mg/100g). The moisture, protein, fat and carbohydrate content was not changed significantly as extract increased in the blends. Since, the biscuit was a good source of calcium and iron (Table 3), hence it can be recommended for consumption for children and old age people.

3.4 Evaluation of Antioxidant Activity

Antioxidant activity in terms of total phenol content and DPPH % radical scavenging activity was found to be 408.92 mgGAE / 100g and 92.81% respectively, for ginger extract incorporated optimized biscuit which was higher than control biscuit (214.09 mgGAE / 100g & 62.11%) (Table 4). The addition of ginger extract, gave an excellent antioxidant effect on the biscuits compared with control. In biscuits, addition of purified extracts of marjoram, mint and basil is reported to have an excellent antioxidant effect compared with the effect of BHA (Bassiouny *et al.*, 1990). The higher efficiency of the ginger extract could be due to the stability of this natural antioxidant during baking. Results of sensory evaluation reveal that the ginger extract at concentrations of 12% may be used in place of synthetic antioxidants in biscuits. Addition of natural antioxidants can increase shelf-life of food products containing fats and oils. In addition, natural antioxidants are safe and impart health benefits to the consumer.

4. CONCLUSION

Consumption of bakery products in the country is increasing day by day and biscuit is commonly consumed food like bread, have several attractive features. Nutritionally, biscuits can be easily fortified with ginger extract to provide a convenient food to supplement the diet's nutrition. The herbal therapeutic benefits of ginger are mainly due to the presence of volatile oils and in the view of health benefit of ginger it may be worthwhile to explore possibility of incorporating ginger extract in wheat flour. Present study was an effort to standardize the level of ginger extract in formulation for the development of value added biscuits. From the study, it was found that the biscuit having composition 60 g butter, 20 g sugar, 12 ml ginger extract per 100 g of biscuits was found optimum and the said formulation was acceptable and recommended for value added biscuit. Ginger extract biscuits provide concentrated form of nutrients along with vitamins and minerals. The nutritive value of ginger extract incorporated biscuit was significantly higher than that of control. The optimized biscuit was found to be superior in terms of minerals, calcium and iron as compared to control biscuit. Since, the biscuit was a good source of calcium and iron, hence it can be recommended for consumption for children and old age people. The addition of ginger extract, also gave an excellent antioxidant effect on the biscuits compared with control. Addition of natural antioxidants can increase shelf-life of food products containing fats and oils. In addition, natural antioxidants are safe and impart health benefits to the consumer. It can be recommended as one of the value added products.

TABLE 1 ANOVA Results for Value Added Biscuits

Source	Color	Flavour	Crispiness	Mouthfeel
Model SS	0.7975	5.0253	14.491	3.2475
Model DF	3	3	3	3
Mean MS	0.27606	0.63023	1.9504	0.1662
Pure Error	0.5630	0.3413	1.824	1.9941
Mean	6.5	7.5	7	7.5
F Tabulated	0.556	0.210	0.050	0.752
F Calculated	0.73	1.81	3.72	0.8941
R square	0.92101	0.93136	0.9121	0.9456

TABLE 2 Effects of Variables on The Sensory Attributes of Developed Ginger Biscuits

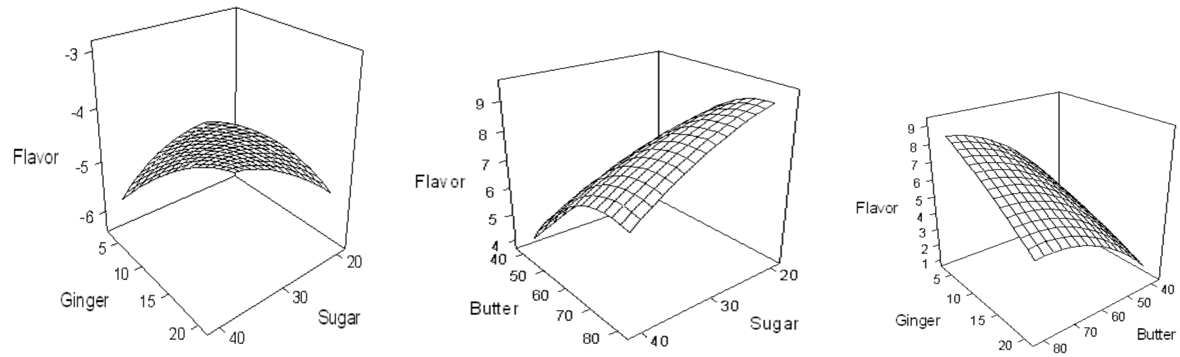
Variables			Sensory Responses			
GINGER	BUTTER	SUGAR	FLAVOR	COLOR	CRISPINESS	MOUTH FEEL
0(12)	-1.68(40)	0(30)	5.1	6.8	5.4	6.2
-1(8)	-1(50)	-1(25)	7.1	6.7	6.6	6.9
0(12)	0(60)	0(30)	7.76	6.76	7.26	7.56
0(12)	0(60)	030)	7.76	6	6.01	7.01
1(16)	-1(50)	-1(25)	6.96	7.06	6.76	6.66
-1(8)	1(70)	1(35)	8.1	8	4.2	8.4
0(12)	0(60)	0(30)	7.76	6.76	7.26	7.56
-1(8)	-1(50)	1(35)	7.4	8.1	7.6	7.7
1(16)	-1(50)	1(35)	7.6	7.7	5.2	7
1(16)	1(70)	1(35)	8	8.4	5.1	8.3
0(12)	0(60)	0(30)	7.76	6.76	7.26	7.56
-1(8)	1(60)	-1(25)	8.2	7.8	8	8.1
-1.68(4)	0(70)	0(30)	7.7	7.3	7.5	7.2
0(12)	1.68(80	)0(30)	7.8	7.4	7.2	7.7
0(12)	0(60)	1.68(40)	6.2	7.14	4.2	7.04
0(12)	0(60)	-1.68(20)	8.1	8.1	8.1	8.12
1.68(20)	0(60)	0(30)	6.8	7.1	7.2	7.1
0(12)	0(60)	0(30)	7.76	6.76	7.26	7.56
0(12)	0(60)	0(30)	7.12	6.26	6.18	6
1(16)	1(70)	-1(25)	7.6	7.5	7.8	7.4
Control			8	7.9	8	8

TABLE 3 Nutritional Composition of Control and Optimised Value Added Biscuits

Biscuit sample	Moisture (%)	Energy (kcal)	Protein (gm)	CHO (gm)	Fat (gm)	Ash (mg)	Ca (mg)	Fe (mg)	Fibre (gm)
Control N	2.34± 0.56	505.96 ± 12.1	2.14± 0.63	68.76± 1.1	25.17±1.03	1.56± 0.23	46± 1.05	0.26± 0.06	0.98± 0.22
Optimised A	3.27±	445.87± 11.02	2.15±0.85	69.31 ± 1.22	23.34± 1.09	2.64± 0.4	60.33± 1.14	0.86± 0.04	0.85± 0.21

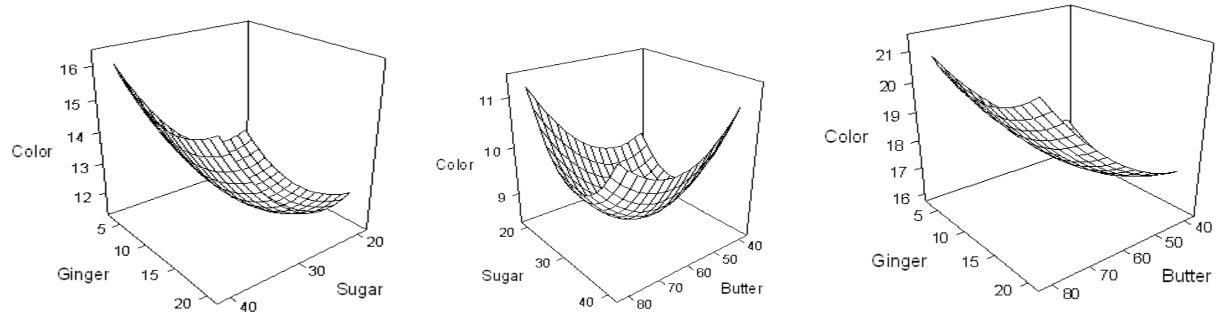
TABLE 4 Antioxidant Activity of Control and Optimized Value Added Biscuits

BISCUIT SAMPLE	TPC (MG GAE/100 GM)	DPPH (%)
CONTROL N	214.09± 10.05	62.11± 1.57
OPTIMISED A	**408.92**± 9.56	**92.81**± 1.83



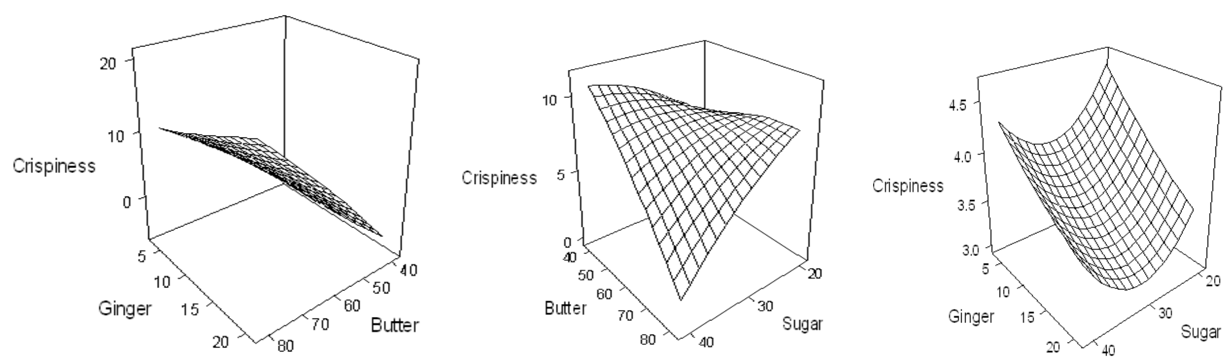
(A) (B) (C)

FIG. 2 Response Surface and Counter Plots Showing Effects of Variable on the Flavor Of Value Added Biscuit, (A) Ginger Vs. Sugar, (B) Butter Vs. Sugar, (C) Ginger Vs. Butter



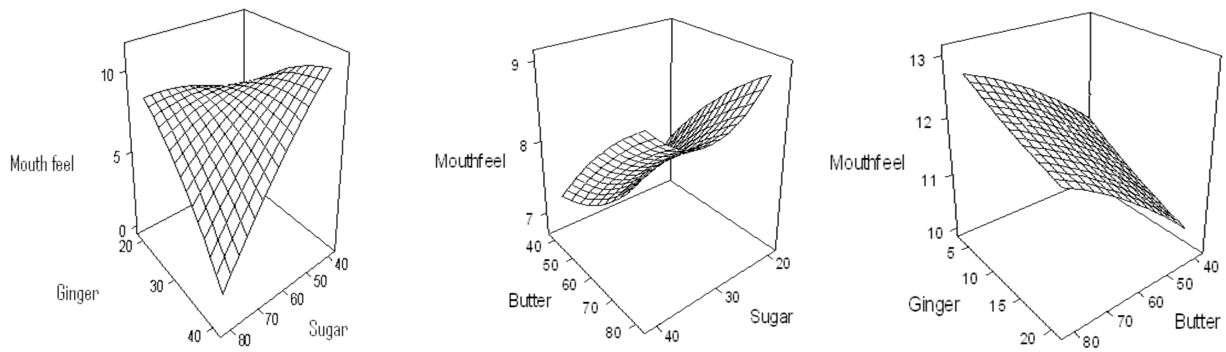
(A) (B) (C)

FIG. 3 Response Surface and Counter Plots Showing Effects of Variable on the Colour Of Value Added Biscuit, (A) Ginger Vs. Sugar, (B) Butter Vs. Sugar, (C) Ginger Vs. Butter



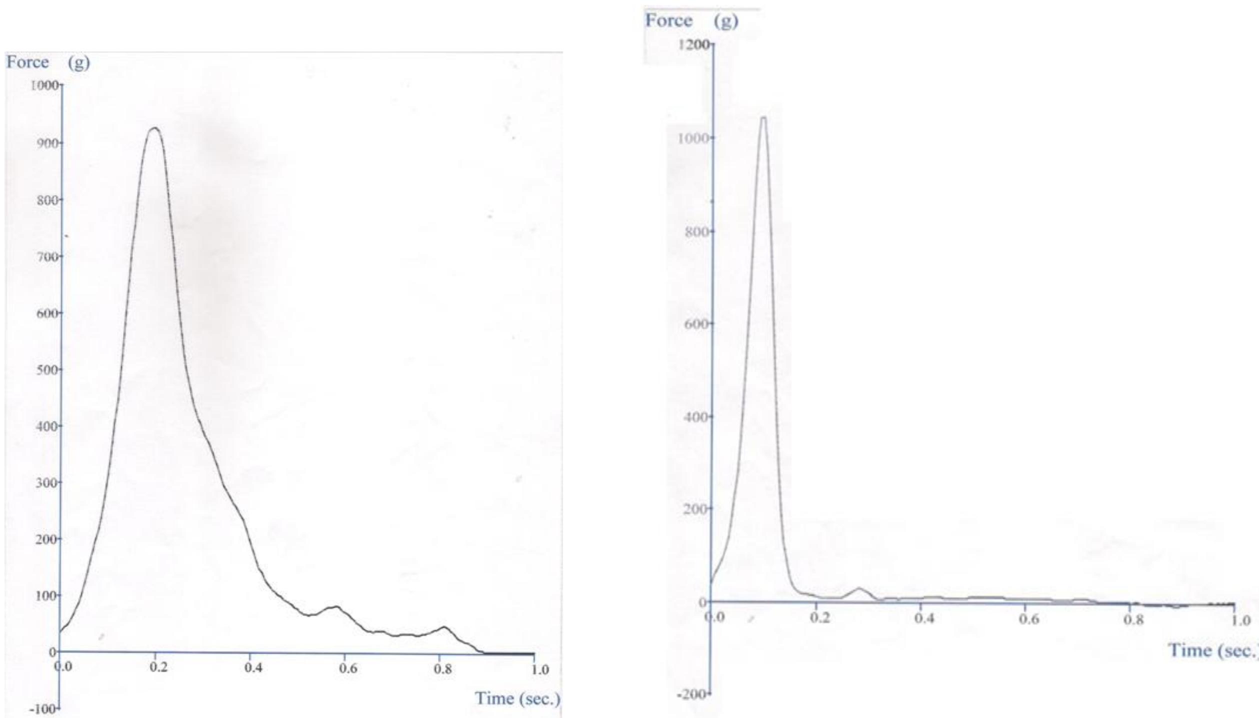
(A) (B) (C)

FIG. 4 Response Surface and Counter Plots Showing Effects of Variable on the Crispiness Of Value Added Biscuit, (A) Ginger Vs. Sugar, (B) Butter Vs. Sugar, (C) Ginger Vs. Butter



(A) (B) (C)

FIG. 5 Response Surface and Counter Plots Showing Effects of Variable on the Mouthfeel of Value Added Biscuit, (A) Ginger Vs. Sugar, (B) Butter Vs. Sugar, (C) Ginger Vs. Butter



(a) (b)

FIG. 6 Effects of Variables on the Texture of Biscuits: (a) Control Biscuit and (b) Optimized Biscuit

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