

RESEARCH PAPER

# Effect of Incorporation of Pomegranate Peel Powder: Rice Bran and Baking Temperature on the Quality Characteristic of Slice Bread

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## ABSTRACT

In this paper the effect of incorporation of pomegranate peel powder and rice bran (0.5:9.5, 1:9, 1.5 :8.5, 2:8, and 2.5:7.5 %) and baking temperature i.e., 175°C, 200°C and 225°C on the various physico-chemical quality characteristics i.e. moisture content, protein, fat, fiber, ash carbohydrate the textural properties (hardness, springiness, chewiness, gumminess, adhesiveness, cohesiveness, along with the sensory attributes i.e. color, flavor, texture, taste of the developed slice bread was evaluated of slice bread has been studied. The sensory score was also evaluated. The bread were prepared by replacing the refined wheat flour with the pomegranate peel powder and rice bran Response surface analysis was performed with the quality attributes indicated that the slice bread prepared with pomegranate peel powder: rice bran. (0.5:9.5, 1:9, 1.5:8.5, 2:8, and 2.5:7.5 %) and baked at 175 °C, 200°C, 225°C resulted the best quality of slice bread having best nutritional, textural and sensory qualities. The optimum product quality characteristics of moisture content 33.073 %, Protein 13.380%, Fat 1.523 %, Fiber 0.883 %, Ash 0.647 %, Carbohydrate 50.493 %,Textural properties i.e. Hardness 33.667, springiness 0.637 g , Chewiness 18 g, gumminess 30 g, adhesiveness 3.967 J, cohesiveness 1.290. The sensory analysis of the optimum product quality were colour 7.413, flavor 7.103, texture and taste 8.180 respectively.

**Keywords:** Pomegranate peel powder slice bread, physiochemical quality, Sensory analysis

Bread may be described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking (Dewettinck *et al.* 2008). Bread is one of the most popular staple foods in the world. In view of its nutritive value, low price, and its simplicity of usage, it has become the diets of all civilizations. Bread consumption provides energy (mainly from starch) and delivers dietary fibre and a wide range of vitamins and minerals (Dewettinck *et al.* 2008). Moreover, optional ingredients can be added to improve processing or produce specialty and novelty bread with enhanced

nutritional and nutraceutical quality (Sivam *et al.* 2010).

Bread has become one of the most widely consumed non-indigenous food item in India. Fresh bread is characterized by a soft and elastic crumb, a brownish crust, a pleasant aroma and a moist mouth feel (Giannou *et al.* 2003). Baking is an important step of bread preparation. During this process, the raw

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dough piece gets transformed into a light, porous, flavorful and readily digestible product under the influence of heat (Therdthai *et al.* 2002). Bread is a bakery product prized for its taste, aroma and texture. It is a staple food prepared by baking dough of flour and water (Osuji, 2006). Salt, fat and yeast are common ingredients, in addition to a wide range of other ingredients, namely, milk, egg, sugar, spice, fruits, vegetables, nuts and seeds. In recent years, the consumption of wheat bread has risen in many developing nations as a result of increasing population, urbanization and changing food habits (Oloye, 2006).

Rice is a staple food for more than half of humanity. According to the Association of Japanese Agricultural Scientific Societies (1975), every continent on the planet produces rice except, Antarctica. The major rice growing countries are China, India, Indonesia, Bangladesh, Thailand, Burma, Vietnam, Japan and the Philippines. Frequently, rice is eaten in cooked form by humans to obtain various nutrients as well as to supplement their caloric intake (Kim *et al.* 2011). The milling of paddy rice has nearly a 70% yield of rice (endosperm) as its major product, although there are some unconsumed portions of the rice produced such as rice husk 20 % rice bran 8 % and rice germ 2% (Van *et al.* 2006).

India is the second largest producer of rice in the world next to China. In India paddy occupies the first place both in area and production. Apart from rice milling, processing of rice bran for oil extraction is also an important agro processing activity for value addition, income and employment generation (Qureshi *et al.* 2000).

Rice bran constitutes 8 per cent of the weight of the whole grain and contains most of the nutrients (65 per cent), such as vitamins, minerals, oils, trace elements, antioxidants, phytosterols and phytochemicals. It contains 12-22 per cent oil, 11-17 percent protein, 6-14 per cent Fiber, 10-15 per cent moisture and 8-17 per cent ash. It is rich in vitamins including vitamin E, thiamin, niacin and minerals like aluminum, calcium, chlorine, iron, magnesium, manganese, phosphorus, potassium, sodium and zinc (Qureshi *et al.* 2000)

Rice bran is used for the enrichment of foods, due to its high dietary fiber content. Increased intake of dietary fiber can have beneficial effects against diseases, such as cardiovascular diseases, gastrointestinal disease, decreasing blood cholesterol, diverticulosis, and diabetes and colon cancer. In view of the therapeutic potential of dietary fiber, more fiber incorporated food products are being developed. Addition of dietary fiber to a wide range of products will contribute to the development of value-added foods or functional foods that currently are in high demand (Hu *et al.* 2009)

Pomegranate fruits (*Punica granatum L.*) belong to *Punicaceae* family. Pomegranate grows well in semiarid, mild temperate to subtropical climates and is naturally adopted to regions with cool winters and summers. The fruit is nearly round ranging from 2.5 to 5 inch in diameter with a tough leathery skin or rind of yellow to red color. The interior of the fruit is separated by whitish spongy membranous walls into compartments packed with juicy corn arils which are pink red in appearance with sweet-tart taste. Each aril contains a soft to hard white or red angular seed. Seeds represents about 52% of weight of the whole fruit (Morton, 1987). Pomegranate are cultivated and consumed globally. India is largest producers of Pomegranate, followed by Iran and China, United State is among the top ten producers of pomegranate (World Pomegranate Market, 2015).

The seed and surrounding pulp (arils) are the edible portion of the Pomegranate and are commonly used for the preparation of juice, syrup, jelly, food seasoning and colouring agents. Pomegranate fruits peel is a byproduct from juice processing industries was reported to contain a series of bioactive compounds, minerals and fiber for wide range of dietary requirement (Mirdeghan and Rahemi, 2007). Pomegranate fruits peel is an inedible part obtained during processing of pomegranate juice. Inedible part contain antioxidant phenolic compounds and flavonoids high quantities (Li *et al.* 2006). Pomegranate peel is a rich source of tannins, flavonoids and other phenolic compounds, and antioxidant and antibacterial properties. Pomegranate peel has

received less attention as natural preservatives in meat (Li *et al.* 2006). The peel (outer thick skin or rind) provides a rich source of punicalins (PC), Punicalagins (PG) and elagic acids (EA), Punicalagins are reported their beneficial effects against dysentery, hemorrhage, Helminthiasis, diarrhea and acidosis. (Miguel, Neves and Anthnes, 2010).

Various researchers have used the dried pomegranate peel powder into the value added products like slice bread, cookies, bread, noodles. (Ismail *et al.* 2014; Shrivastava *et al.* 2014; Mehder 2013; Bandal *et al.* 2014). Utilization of pomegranate peel powder and peel extracts has been successfully experienced in various food preparations including meat and meat products, edible oils, bakery products and jellies (Altunkaya *et al.* 2013; Devatkal *et al.* 2012; Iqbal *et al.* 2008; Kanatt *et al.* 2010; Naveena *et al.* 2008; Ventura *et al.* 2013).

An alternative for recycling the fruit industrial residue is to submit it to drying processes. Dehydrated pomegranate peel powder could be used in the formulation. The purpose of the present study was to develop slice bread formulations using pomegranate peel powder and rice bran along with the appropriate baking temperature of bread with the good acceptability. The effect of these formulation was also studied

## MATERIALS AND METHODS

### Raw material

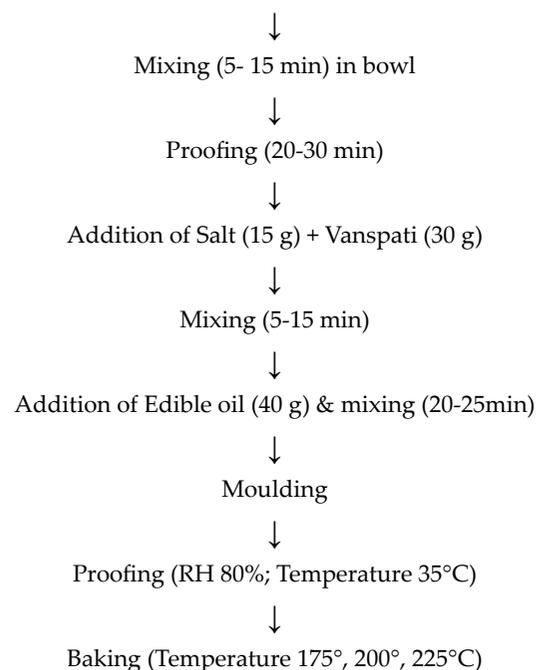
Fresh, healthy disease free pomegranate fruit were obtained from the farmer field from Akluj District Solapur, Maharashtra, India, Pomegranate fruit were washed to remove dirt; dust using tap water, and diseased infected portion was removed. The Pomegranate fruits were peeled manually and cut into slices. The peels were cut into small pieces having thickness 5mm. The peel slices was dried in the convective hot air dried at 40°C for 20 hrs and grounded to the partial size  $\mu$  The raw rice bran was procured from the Gulaba Rice Mill, Roha. Refined wheat flour and other ingredient were procured from local market, Roha Dist-Raigad. The

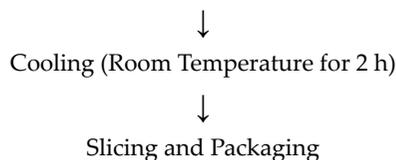
dried pomegranate peel powder and rice bran of varied concentration i.e. 0.5:9.5 %, 1.0:9.0%, 1.5:8.5 %, 2.0:8.0%, 2.5 : 7.5 %, respectively used in slice bread formation.

### Process for Preparation of Bread

Fig. 1 shows the process flow chart for preparation of slice bread. The bread was prepared by taking wheat flour (1 kg), sugar 100g, milk powder 20g, bread improver 3g, water 550 mL, yeast 15gm along varied concentration of pomegranate peel : rice bran i.e. (0.5:9.5, 1.0:9.0, 1.5:8.5, 2.0:8.0, and 2.5:7.5 %) into a bowl. Table 1 shows the experimental level of pomegranate peel and rice bran levels in the slice bread. The ingredients were allowed to mix up to 5 – 15 minutes for well mixing. The dough is allowed to keep as such for natural proofing in the same mixer at normal temperature  $35 \pm 2^\circ\text{C}$  and relative humidity 80-95% for 25 minutes. The dough was added with salt 15 g and Vanaspati 30 g and allowed to mix up to 5 minutes for proper mixing of salt and Vanaspati. The mixed dough was added with edible oil 40 g and allowed to mix for 20 -30 minutes.

Wheat flour (1 kg) + Sugar (100 g) + yeast (5g) + Milk powder (20 g) + Bread Improver (3g) + Water (550 mL) + Glycerol mono stearate (0.2g) + Calcium propionate (0.15g)





**Fig. 1:** Process Flow chart for preparation of bread

The dough was now ready for shaping. 300 g of above prepared dough was taken into the mould. The moulds were kept for proofing and allowed to raise at 80% RH and 40°C for 1 hr. The moulds were kept in the oven for temperature (175°, 200°, and 225°C). The breads in the moulds were observed continuously for each 2 minutes upto 15 minutes interval from initial. The breads should have yellowish colour developed on its crust. When the crust get yellowish colour the time for baking was recorded. The breads after achieving the yellowish colour was taken from the oven and allowed to cool at room temperature 35± 2°C for 2 hrs. Table 1 shows slice bread prepared from various combination for T<sub>1</sub> to T<sub>15</sub>.

**Table 1:** Experimental level of pomegranate peel and rice bran in slice bread

Sample code	Pomegranate Peel powder	Rice bran	Refined wheat flour	Baking temp. °C
T <sub>1</sub>	0.5 %	9.5 %	90	175°C
T <sub>2</sub>	1 %	9 %	90	175°C
T <sub>3</sub>	1.5 %	8.5 %	90	175°C
T <sub>4</sub>	2 %	8 %	90	175°C
T <sub>5</sub>	2.5 %	7.5 %	90	175°C
T <sub>6</sub>	0.5 %	9.5 %	90	200°C
T <sub>7</sub>	1 %	9 %	90	200°C
T <sub>8</sub>	1.5 %	8.5 %	90	200°C
T <sub>9</sub>	2 %	8 %	90	200°C
T <sub>10</sub>	2.5 %	7.5 %	90	200°C
T <sub>11</sub>	0.5%	9.5 %	90	225°C
T <sub>12</sub>	1 %	9 %	90	225°C
T <sub>13</sub>	1.5 %	8.5 %	90	225°C
T <sub>14</sub>	2 %	8 %	90	225°C
T <sub>15</sub>	2.5 %	7.5 %	90	225°C
Control	00	00	100	225°C

## Evaluation of Quality Parameter for the Pomegranate peel and rice bran powder slice bread

### 1. Moisture content

The initial moisture content of slice bread prepared from pomegranate peel powder and rice bran was determined by AOAC (2010). 10-15 g of the slice bread samples was taken in to each three different moisture boxes. The initial weight of moisture box was recorded. The samples were exposed to 105°C ± 1°C for 24 hr.in a hot air oven (Make M/s: Aditi Associate, Mumbai. Model: ALO-136). The final weight was recorded. The moisture content of the sample were determined by equation (1) the experiment was repeated for three times for replication the average reading reported.

$$\text{Moisture content (\% db)} = \frac{W_2 - W_1}{W_3 - W_1} \times 100 \quad \dots(1)$$

Where,

W<sub>1</sub> = Weight of moisture box, g

W<sub>2</sub> = Weight of moisture box + sample g

W<sub>3</sub> = Weight of moisture box + oven dried sample, g

### 2. Protein

Protein of slice bread prepared from pomegranate peel powder and rice bran was determined by a micro-Kjeldahl distillation method (AOAC 1990). The slice bread were digested by heating with concentrated sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) in the presence of digestion mixture, potassium sulphate (K<sub>2</sub>SO<sub>4</sub>) and copper sulphate (CuSO<sub>4</sub>). The mixture was then made alkaline with 40% NaOH. Ammonium sulphate thus formed. Released ammonia which was collected in 4% boric acid solution and titrated again standard HCL. The percent nitrogen content of the sample was calculated the formula given below. Total protein was calculated by multiplying the amount of percent nitrogen with appropriate factor (6.25).

$$\% \text{ N} = \frac{(\text{Sample titre} - \text{Blank titre}) \times \text{N HCL} \times 1.4 \times 100}{\text{Weight of sample}} \times 100 \quad \dots(2)$$

% Protein = % N × Factor (6.25).

### 3. Ash Content

The ash content of slice bread prepared from pomegranate peel powder and rice bran was determined using the method of AOAC (1990) porcelain crucible were dried and cooled in desiccators before weighing. Five grams of the slice bread were weighed into the crucible and the weight was taken. The crucible containing the samples were placed into the muffle furnace and muffle furnace at 500°C. This temperature was maintained for three hours. The muffle furnace was then allowed to cool; the crucibles were then brought out, cooled and weighed. The ash content was calculated as follows:

$$\% \text{ Ash} = \frac{W_2 - W_1}{\text{weight of sample}} \times 100 \quad \dots(3)$$

Where,

$W_1$  = weight of empty crucible;  $W_2$  = weight of crucible + ash.

### 4. Fat Content

The fat content of slice bread prepared from pomegranate peel powder and rice bran was determined using solvent extraction in a soxhlet apparatus as described by James, (1995) Two grams of each of the slice bread were wrapped in a filter paper and placed in a soxhlet reflux flask which is connected to a condenser on the upper side and to a weighed oil extraction flask full with two hundred ml petroleum ether. The ether was brought to its boiling point, the vapor condensed into the reflux flask immersing the samples completely for extraction to take place on filling up the reflux flask siphons over carrying the oil extract back to the boiling solvent in the flask. The process of boiling, condensation, and reflux was allowed to go on for four hours before the defatted samples were removed. The oil extract in the flux was dried in the oven at 60°C for thirty minutes and then weighed.

$$\% \text{ Fat} = \frac{W_4}{W_2} - \frac{W_3}{W_1} \times 100 \quad \dots(4)$$

Where:

$W_1$  = weight of oven dried thimble;  $W_2$  = weight of sample used;  $W_3$  = weight of round bottom flask;  $W_4$  = weight of round bottom flask with fat residue.

### 5. Crude Fiber

About 2 g fat free residue of slice bread prepared from pomegranate peel powder and rice bran was taken and then transferred to the digestion flask. 200 ml boiling sulphuric acid was added and immediately the flask was connected to condenser. The flask was heated, boiled by frequently rotating for 30 min and the volume was maintained with hot water. Then filtered through filter cloth in a fluted funnel. The residue was washed on cloth with hot water or potassium sulphate solution. The residue was returned to digestion flask by washing with hot water. 200 ml boiling sodium hydroxide was added and boiled for 30 min. The volume was adjusted with boiling water, filtered it thorough the muslin cloth and the residue free of alkali was washed. The residue was transferred into crucible and washed with 15 ml alcohol and the crucible was dried at 110°C for 2 hrs. The crucible was cooled in desiccators and weighed the crucible was ignited in the furnace at 550°C for 30 min then cooled and weighed. The loss in weight represented the crude fiber.

$$\text{Crude fiber (\%)} = \frac{(W_1 - W_2)}{\text{Weight of sample (g)}} \times 100 \quad \dots(5)$$

Where,

$W_1$  = Weight of material before ashing (g)

$W_2$  = Weight of material after ashing (g)

### 6. Carbohydrate Content

Carbohydrate content of slice bread prepared from pomegranate peel powder and rice bran was determined by subtracting the total sum of protein, fiber, ash and fat from the total dry matter (James, 1995). The carbohydrate was calculated by using following equation (6):

$$\% \text{ Carbohydrate} = 100 - (\% \text{ protein} + \% \text{ fat} + \% \text{ fiber} + \% \text{ ash} + \% \text{ moisture content}) \quad \dots(6)$$

## 7. Textural properties

The texture of slice bread was measured with TexVol Texture analyzer. (Make: M/s Perten Instrument; Model: TexVol TVT- 300 XP) in Dept. of FPTM, College of Fisheries, Shiragaon Dist. Ratanagiri. as shown in Fig. 2.



Fig. 2: Texture analyzer (TEXVOL (TVT))

A cylindrical probe with 5mm/sec of pre-test and post-test speeds and 4mm compression was taken for TPA analysis. TPA is two-bite test, which includes the first and second compression cycles. The first and second compression cycles indicate the force vs. time data during the first and second compression of the product by the instrumental probe. The parameters recorded were hardness, springiness, chewiness, gumminess, adhesiveness and cohesiveness. The test was configured so that the six TPA parameters, hardness, springiness, chewiness, gumminess, adhesiveness and cohesiveness were calculated at the time of the test by determining the load and displacement at predetermined points on the TPA

curve. Fig 3. Shows a typical curve of a textural profile analysis.

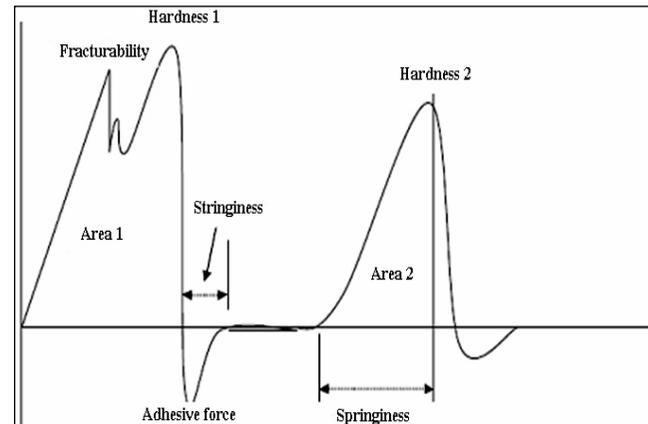


Fig. 3: A typical TPA description curve (Peleg 1976)

Hardness ( $h$ ) was the maximum load, expressed in kg, applied to the samples during the first compression. Cohesiveness ( $A_2/A_1$ ) was the ratio of the area under the curve for the second compression ( $A_2$ ) to that under the curve for the first compression ( $A_1$ ). Springiness, expressed as ( $D_2/D_1$ ), was the ratio of the duration of contact with the sample during the second compression ( $D_2$ ) to that during the first compression ( $D_1$ ). Chewiness was the mathematical product of hardness, cohesiveness, and springiness. Hardness is the force necessary to obtain a given deformity. Fracture is the force of a significant break in the first bite. Cohesiveness is the strength of the internal bonds making up the body of the sample. Adhesiveness is the necessary force to overcome the attractive forces between the surface of the food and the surface of the materials which the food comes in contact with. Gumminess is the energy needed to disintegrate a semisolid food until swallowing. Chewiness is the energy needed to chew a solid food until ready to swallow. Springiness is the distance recovered by the sample during the time between the end of the first bite and the start of a second bite. The TPA parameters, hardness, springiness, chewiness, gumminess, adhesiveness and cohesiveness was measured for three slice bread for each combination (Baking temperature 175, 200 and 225°C and pomegranate peel and rice bran powder (0.5:9.5%,

1.0:9%, 1.5:8.5%, 2.0:8 %, 2.5:7.5%). The typical textural profile curve obtained with one complete run is presented in Fig. 3.

### 8. Colour

The slice bread prepared from pomegranate peel powder and rice bran were used to measure the colour value using a colorimeter (M/S Konica Minolta, Japan Model- Meter CR-400). The colour of slice bread prepared from pomegranate peel powder and rice bran were measured in dark room. The equipment was calibrated by placing on the white tile. After the calibration is over, the slice bread prepared from pomegranate peel powder and rice bran was placed in the pettry dish and keeping the color reader on the top of the product and colour was measured. The colour was measured as per  $10^{\circ}/D_{65}$  (ASTM) standard. It represents  $L$ ,  $a$  and  $b$  value. Degree of lightness or darkness of the sample was represented by ' $L$ ' value, redness or greenness by ' $a$ ' and yellowness to blueness by ' $b$ ' value on hunter scale. The experiment was repeated five times and average values were reported. The whiteness index samples were measured in 4 no. replication for each sample to estimate the degree of lightness ( $L$ ), redness/greenness ( $a$ ) and yellowness/blueness ( $b$ ) using a colorimeter. Whiteness index was calculated by the following equation (7) of Park, (1994):

$$\text{Whiteness index} = [(100-L)]^2 + a^2 + b^2]^{(1/2)} \quad \dots(7)$$

Where,

$L^*$  values, which indicate lightness of the product

$a^*$  represents redness (+  $a$ ) to greenness (-  $a$ ) and

$b^*$  represents yellowness (+  $b$ ) to blueness (- $b$ )

### 9. Optimization of Slice bread

The slice bread prepared from pomegranate peel powder and rice bran should have nutritional quality i.e. more moisture, more protein, low ash, low fat, moderate fiber and moderate carbohydrate. In textural properties low hardness, lower gumminess, lower cohesiveness, moderate springiness, moderate chewiness, and moderate adhesiveness. Based on

these desirable attributes, the contour plot of each responses were superimposed for the optimum product quality. Based on the desirable common attribute the optimum zone of desirable properties have been obtained.

### 10. Sensory Evaluation

The sensory attribute of slice bread prepared from pomegranate peel powder and rice bran was evaluated with semi-trained panelists. The panelists were trained for the product testing and were familiar with product sensory evaluation. Slice bread samples were placed in plates. The slice bread prepared from all the treatments were coded from A to P there were around 15 different samples and one treatment was for control various sensory scores i.e. colour, flavor texture, taste was obtained from the sensory panelists. The rating was based on nine-point hedonic scale the attributes were summed up for total score of each panelists the data were analyzed statistically for the significance of each attributes by ANOVA.

### 11. Correlation of the quality parameter i.e. subjective and object tests

The optimum product quality based on the desirable quality attribute i.e. more protein, low fat, low ash, moderate fiber, moderate carbohydrate, low hardness low gumminess, low cohesiveness, moderate springiness, moderate chewiness, moderate adhesiveness and more whiteness index with optimum zone was compared with the best sensory attribute of the best treatment judged by the sensory panelist. The best treatment was decided based on the correction between the optimum product qualities with the subjective quality evaluation.

## RESULTS AND DISCUSSION

### Evaluation of Quality Parameter for the Slice bread prepared from pomegranate peel powder and rice bran

#### 1. Moisture Content ( $M_c$ ) (%)

Fig. 4 (a) shows the surface plot showing the effect

of incorporation of Pomegranate peel powder (%) and Baking temperature (°C) on the Moisture content (%) Slice bread prepared from pomegranate peel powder and rice bran. The Moisture content for all the treatments were in the range of 33.04-37.20%. As the Pomegranate peel (%) incorporation increases from 0.5 to 2.5 %, the moisture content increases. Similarly as the baking temperature increases from 175°C to 225°C, the moisture content decreases. As both the Pomegranate peel powder (%) and Baking temperature (°C) increase the moisture content increases. This can be seen from contour plot Fig. 4 (b). The effect of incorporation of Pomegranate peel (%) and baking temperature (°C) on the Moisture content can be seen by the second order polynomial equation (8). The equation is well fitted with  $r^2 = 0.953$  and  $MSE = 0.119$

$$M_c = 35.862 - 0.0290Y + 6.933Y^2 + 0.331X + 1.466 \times 10^{-4} XY + 0.5565X^2 \quad \dots(8)$$

Where,

$M_c$  = Moisture content, (% db);  $X$  = Pomegranate peel powder (%), and  $Y$  = Baking temperature, (°C)

Table 2 (a) shows the ANOVA for the moisture content of slice bread prepared from pomegranate peel and rice bran. It indicates that the effect of incorporation of pomegranate peel powder was significant at  $p \leq 0.01$ . Effect of baking temperature on moisture content of slice bread is non-significant at  $p \leq 0.01$ . Also the interaction of both the composition pomegranate peel and rice bran powder and baking temperature are non-significant at  $p \leq 0.01$ . The moisture content increased when the substituting of wheat flour by pomegranate peel powder. This might be due to a higher insoluble dietary fiber of the pomegranate peel powder which provides a high capacity to retain water (Tharshini *et al.* 2018).

Tharshini *et al.* (2018) reported that the slice bread prepared from wheat flour, soybean flour and pomegranate peel powder the moisture content of bread increased with increasing pomegranate peel powder from 2 to 6 % which was 30.38 to 30.81% respectively.

Bandal *et al.* 2014 reported that the slice bread prepared from 5 % banana peel flour and 5 % pomegranate peel powder was 33.74%. Also increased from

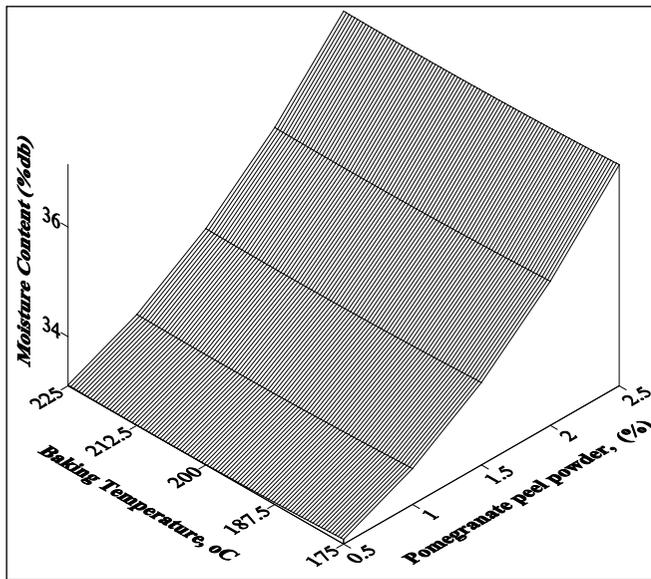


Fig. 4 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Moisture content of the Slice bread prepared from pomegranate peel powder and rice bran

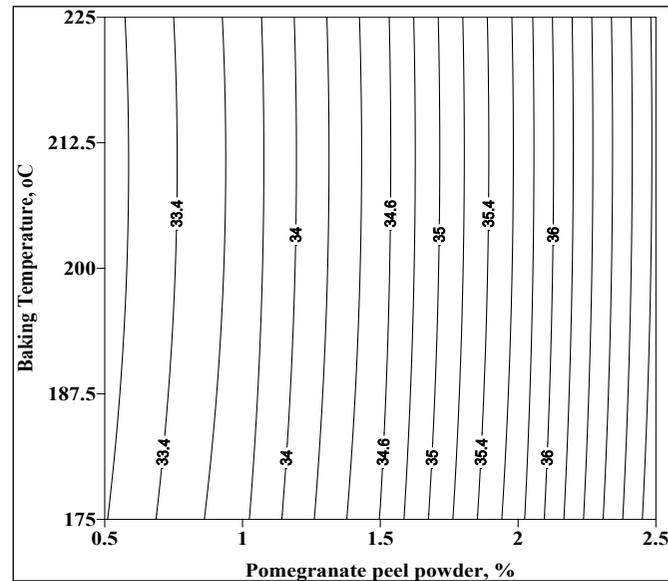


Fig. 4 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Moisture content of the Slice bread prepared from pomegranate peel powder and rice bran

27.99% to 40% with increasing banana peel flour and pomegranate peel powder. Nadife (2011) reported that slice bread prepared from soybean flour moisture content was 28.5 % to 39.5 % with increasing of flour.

## 2. Protein ( $P_r$ )

Fig. 5 (a) shows the surface plot showing the effect of incorporation of Pomegranate peel powder (%) and Baking temperature ( $^{\circ}\text{C}$ ) on the Protein content (%) slice bread prepared from pomegranate peel powder and rice bran. The protein content for all the treatments were in the range of 12.210-13.380%. As the Pomegranate peel powder levels increases from 0.5 to 2.5%, the protein content decreases. Similarly as the baking temperature increases from  $175^{\circ}\text{C}$  to  $225^{\circ}\text{C}$  the protein content shows no much change. As both the Pomegranate peel powder (%) increases and baking temperature ( $^{\circ}\text{C}$ ) increases, the protein content increases. This can be seen from contour plot Fig. 5 (b). The effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the protein content can be seen by the second order polynomial equation (9). The equation is well fitted with  $r^2=0.962$  and  $\text{MSE}=0.006$

$$P_r = 13.59 + 1.393 \times 10^{-3} Y - 2.666Y^2 - 1.07X + 6.799 \times 10^{-4} XY + 0.142X^2 \quad \dots(9)$$

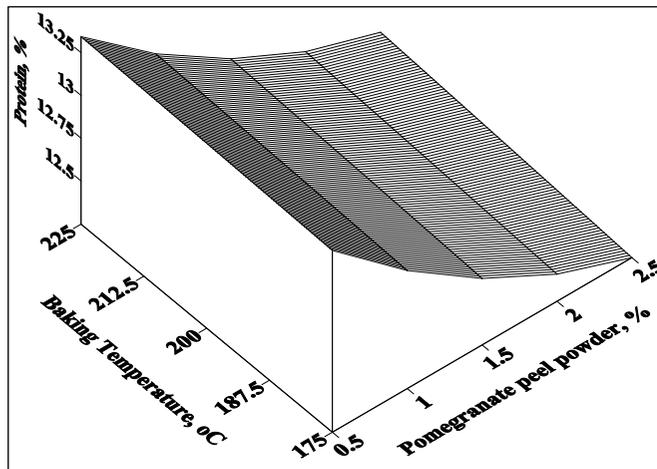


Fig. 5 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Protein of the Slice bread prepared from pomegranate peel powder and rice bran

Where,

$P_r$  = Protein

$X$  = Pomegranate peel powder (%), and

$Y$  = Baking temperature, ( $^{\circ}\text{C}$ )

Table 2 (b) shows the ANOVA for the protein content of slice bread prepared from pomegranate peel powder and rice bran. It indicates that the effect of incorporation of pomegranate peel powder was significant at  $p \leq 0.01$ . Effect of baking temperature on protein of slice bread is non-significant at  $p \leq 0.01$ . Also the interaction of both the composition pomegranate peel (%) and Baking temperature ( $^{\circ}\text{C}$ ) are non-significant at  $p \leq 0.01$ .

Tharshini *et al.* (2018) reported that the slice bread prepared from wheat flour, soybean flour and pomegranate peel powder the protein content of bread decreasing with increasing pomegranate peel powder from 2 to 6 % which was 13.27 % to 12.39 % respectively.

Bandal *et al.* 2014 reported that the slice bread prepared from 5 % banana peel flour and 5 % pomegranate peel powder was 9.40%. Also increased from 9.40% to 11% with increasing banana peel flour and pomegranate peel powder. Nadife (2011)

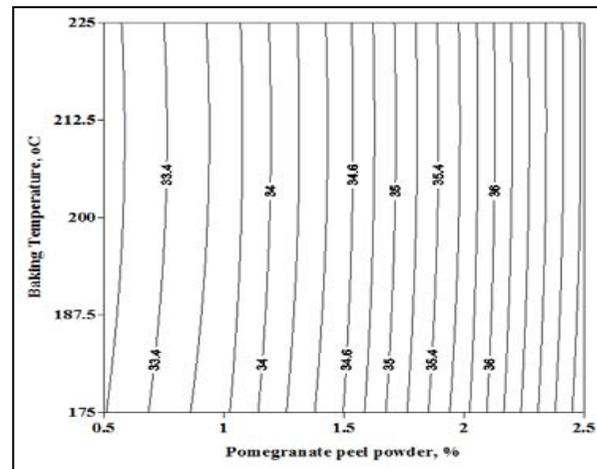


Fig. 5 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Protein of the Slice bread prepared from pomegranate peel powder and rice bran

reported that slice bread prepared from soybean flour protein content was 8.13 % to 12.5 % with increasing of soyflour. The supplementation of wheat flour with rice bran holds the potential to uplift the nutritional profile of their food products with special reference to protein contents (Sekhon *et al.* 1997).

### 3. Fat ( $f_t$ )

Fig. 6 (a) shows the surface plot showing the effect of incorporation of Pomegranate peel powder (%) and Baking temperature ( $^{\circ}\text{C}$ ) on the fat content (%) of Slice bread prepared from pomegranate peel powder and rice bran. The fat content for all the treatments were in the range of 1.360-5.810%. As the Pomegranate peel powder (%) increases from 0.5 to 2.5% the fat content increases. Similarly as the baking temperature increases from  $175^{\circ}\text{C}$  to  $225^{\circ}\text{C}$ , the fat content increases. As both the Pomegranate peel powder (%) and Baking temperature ( $^{\circ}\text{C}$ ) increases, the fat content increases. This can be seen from contour plot Fig. 6 (b). The effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the fat content can be seen by the second order polynomial equation (10). The equation is well fitted with  $r^2 = 0.958$  and  $\text{MSE} = 0.0948$

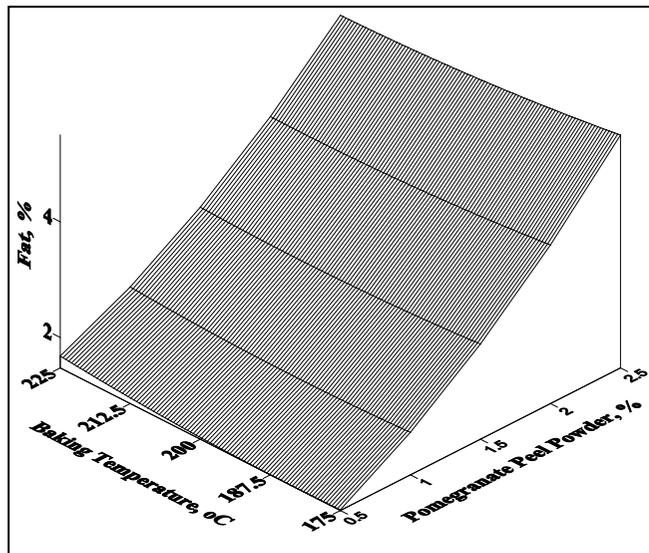


Fig. 6 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Slice bread prepared from pomegranate peel powder and rice bran

$$P_r = 13.59 + 1.393 \times 10^{-3} Y - 2.666Y^2 - 1.07X + 6.799 \times 10^{-4} XY + 0.142X^2 \quad \dots(10)$$

Where,

$F_t$  = Fat

$X$  = Pomegranate peel powder (%), and

$Y$  = Baking temperature, ( $^{\circ}\text{C}$ )

Table 2 (c) shows the ANOVA for the fat content of Slice bread prepared from pomegranate peel powder and rice bran. It indicates that the effect of incorporation of rice bran and Pomegranate peel was significant at  $p \leq 0.01$ . Effect of baking temperature on fat of slice bread is non-significant at  $p \leq 0.05$ . Also the interaction of both the Pomegranate peel powder and Baking temperature are non-significant effect on the fat of slice bread.

Tharshini *et al.* (2018) reported that the slice bread prepared from wheat flour, soybean flour and pomegranate peel powder the fat content of bread increasing with increasing pomegranate peel powder from 2 to 6 % which was 5.74% to 6.17% respectively.

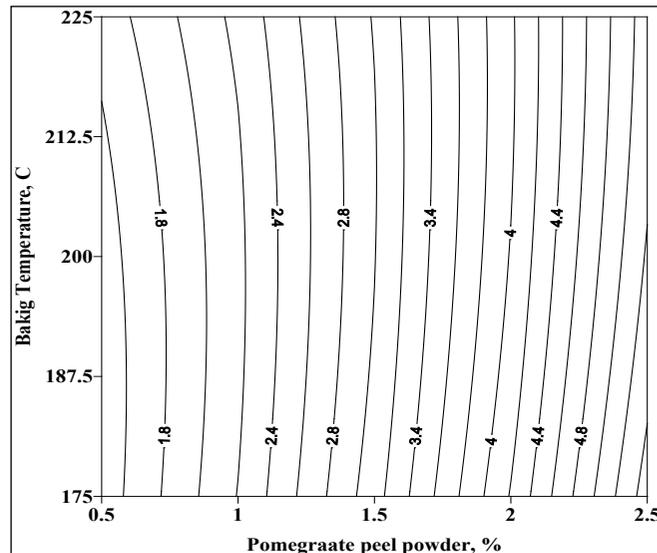


Fig. 6 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Fat of the Slice bread prepared from pomegranate peel powder and rice bran

Bandal *et al.* 2014 reported that the slice bread prepared from 5 % banana peel flour and 5 % pomegranate peel powder was 10.12gm. Also increased from 10.12 g to 13g with increasing 5 % banana peel flour and 10 % pomegranate peel powder. Nadife (2011) reported that slice bread prepared from soybean flour fat content was 4.0 % to 6.4 % with increasing of soy flour.

#### 4. Fiber ( $f_b$ )

Fig. 7 (a) shows the surface plot showing the effect of incorporation of Pomegranate peel powder (%) and Baking temperature ( $^{\circ}$ C) on the Fiber content (%) of Slice bread prepared from pomegranate peel powder and rice bran. The Fiber content for all the treatments were in the range of 0.83-2.89%. As the Pomegranate peel powder levels increases from 0.5 to 2.5%, the fiber content increases. Similarly as the baking temperature increases from 175 $^{\circ}$ C to 225 $^{\circ}$ C, the fiber content increases. As both the Pomegranate peel powder (%) and Baking temperature ( $^{\circ}$ C) increases the fiber content increases. This can be seen from contour plot Fig. 7 (b). The effect of incorporation of Pomegranate peel powder (%) and

baking temperature ( $^{\circ}$ C) on the Fiber content can be seen by the second order polynomial equation (11). The equation is well fitted with  $r^2 = 0.965$  and  $MSE = 0.0211$

$$F_b = -1.026 + 0.0101Y - 2.453Y^2 + 1.816X + 2.799 \times 10^{-4} XY - 0.299X^2 \quad \dots(11)$$

Where

$F_b$  = Fiber

$X$  = Pomegranate peel powder (%), and

$Y$  = Baking temperature, ( $^{\circ}$ C)

Table 2 (e) Shows the ANOVA for the Fiber content of slice bread prepared from pomegranate peel powder and rice bran. It indicates that the effect of incorporation of Pomegranate peel and rice bran was significant at  $p \leq 0.01$  Effect of baking temperature on fiber of slice bread is non-significant at  $p \leq 0.01$ . Also the interaction of both the composition pomegranate peel and Baking temperature was also non-significant at  $p \leq 0.01$ . Fibre in general may cause firmer crumb structure by a thickening effect on the area that surround the air bubbles in fibre added dough.

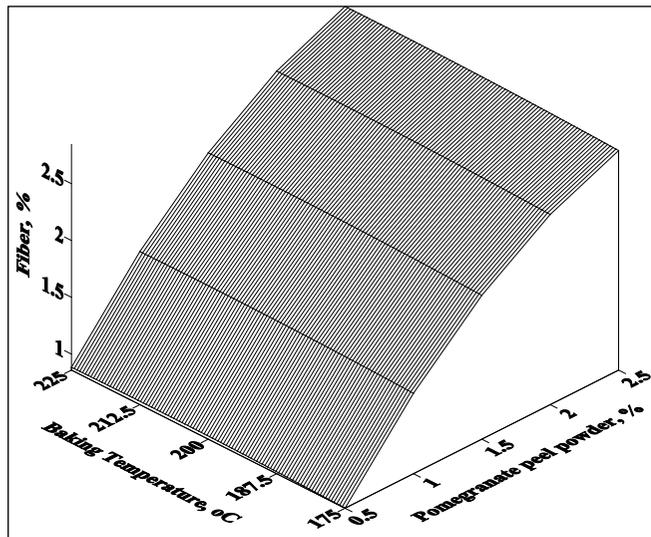


Fig. 7 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}$ C) on the Slice bread prepared from pomegranate peel powder and rice bran

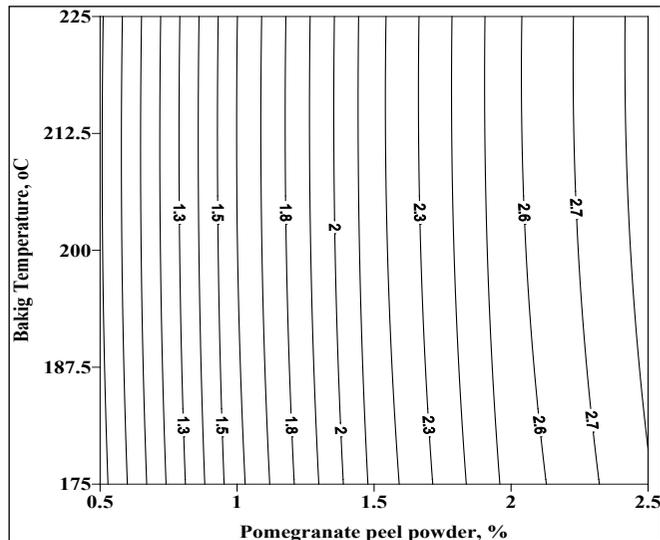


Fig. 7 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}$ C) on the Slice bread prepared from pomegranate peel powder and rice bran

Tharshini *et al.* (2018) reported that the slice bread prepared from wheat flour, soybean flour and pomegranate peel powder the fat content of bread increasing with increasing pomegranate peel powder from 2 to 6 % which was 1.84 % to 3.21 % respectively.

Bandal *et al.* 2014 reported that the slice bread prepared from 5 % banana peel flour and 5 % pomegranate peel powder was 9.80g. Fiber increased from 9.80 g to 18 g with increasing 5 % banana peel flour and 10 % pomegranate peel powder. The increase in fibre content leads to an increase in water requirement for the bread preparation. Also the moisture content of bread increased with increase in the substitution of banana and pomegranate flour Nadife (2011) reported that slice bread prepared from soybean flour fiber content was 3.30 % to 5.60 % with increasing of soyflour.

### 5. Ash ( $a_s$ )

Fig. 8 (a) shows the surface plot showing the effect of incorporation of Pomegranate peel powder (%) and Baking temperature ( $^{\circ}\text{C}$ ) on the ash content (%) of Slice bread prepared from pomegranate peel powder

and rice bran. The ash content for all the treatments were in the range of 0.64-2.38 %. As the Pomegranate peel powder levels increases from 0.5 to 2.5%, the ash content increase. Similarly as the baking temperature ( $^{\circ}\text{C}$ ) increases from 175 $^{\circ}\text{C}$  to 225 $^{\circ}\text{C}$ , the ash content decrease slightly. This can be seen from contour plot Fig. 8 (b). The effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the ash content can be seen by the second order polynomial equation (12). The equation is well fitted with  $r^2 = 0.950$  and  $\text{MSE} = 0.0176$

$$A_{sh} = 1.469 - 9.966 \times 10^{-3} Y + 2.346Y^2 + 0.831X - 8.399 \times 10^{-4} XY + 0.02349X^2 \quad \dots(12)$$

Where

$A_{sh}$  = Ash (%)

X = Pomegranate peel powder (%), and

Y = Baking temperature, ( $^{\circ}\text{C}$ )

Table 2 (d) shows the ANOVA for the ash content of slice bread prepared from pomegranate peel powder and rice bran. It indicates that the effect of

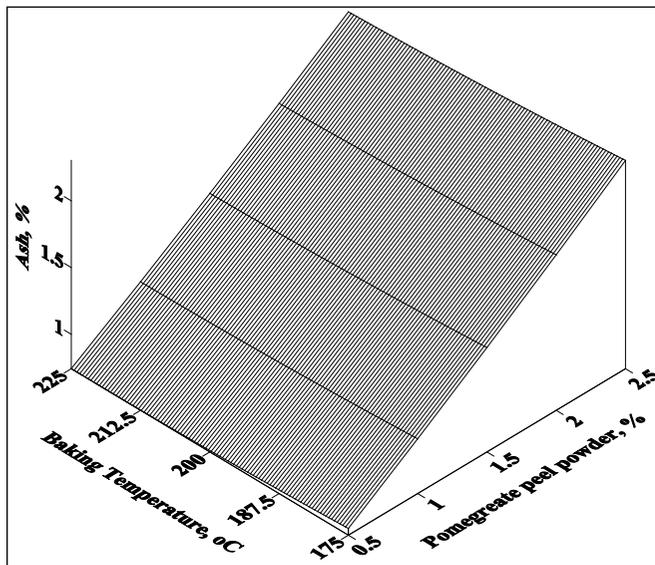


Fig. 8 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on Ash the Slice bread prepared from pomegranate peel powder and rice bran

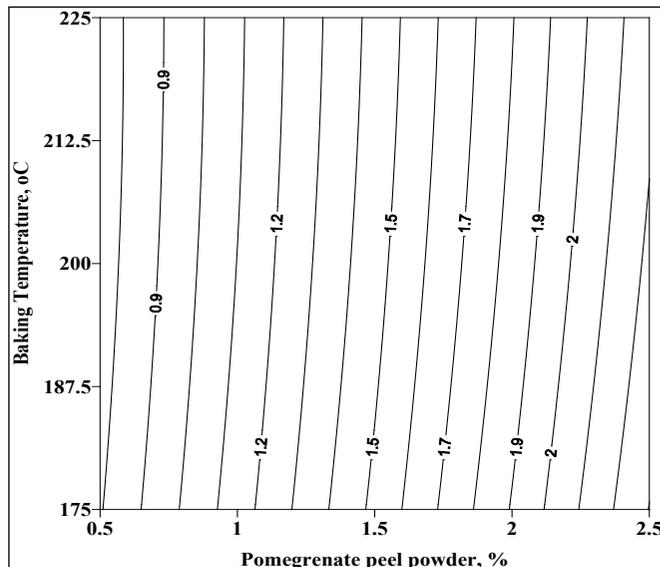


Fig. 9 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Ash of the Slice bread prepared from pomegranate peel powder and rice bran

incorporation of Pomegranate peel was significant at  $p \leq 0.01$ . Effect of baking temperature on ash of slice bread was significant at  $p \leq 0.01$ . Also the interaction of both the composition pomegranate peel powder and baking temperature are non-significant at  $p \leq 0.01$ .

Tharshini *et al.* (2018) reported that the slice bread prepared from wheat flour, soybean flour and pomegranate peel powder the ash content of bread increasing with increasing pomegranate peel powder from 2 to 6 % which was 2.75 % to 3.39 % respectively.

Bandal *et al.* 2014 reported that the slice bread prepared from 5 % banana peel flour and 5 % pomegranate peel powder was 9.80g. Also ash content increased from 1.07 g to 2.3 g with increasing 5 % banana peel flour and 10 % pomegranate peel powder. The addition of pomegranate and banana peel flour to bread leads to increase in ash content of bread.

Nadife (2011) reported that slice bread prepared from soybean flour ash content was 1.82 % to 2.65 % with increasing of solflour.

### 6. Carbohydrate ( $C_{ab}$ )

Fig. 9 (a) shows the surface plot showing the effect of

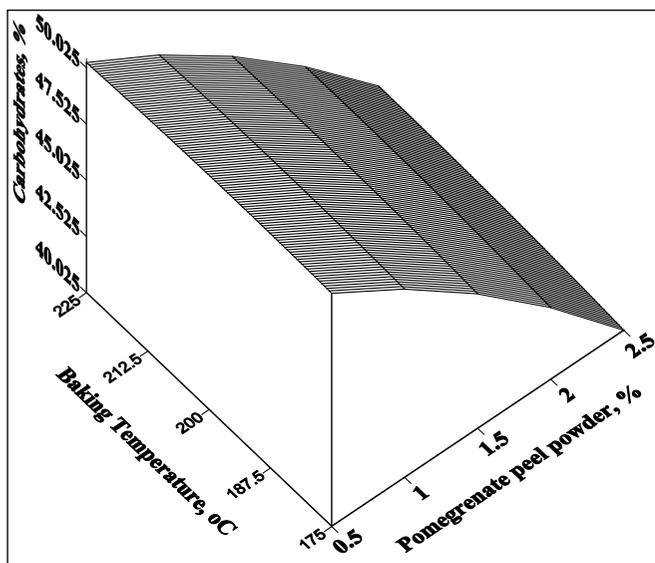


Fig. 9 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Carbohydrate of the Slice bread prepared from pomegranate peel powder and rice bran

incorporation of Pomegranate peel (%) and Baking temperature (°C) on the carbohydrates content (%) Slice bread prepared from pomegranate peel powder and rice bran. The carbohydrates content for all the treatments were in the range of 39.633-50.70%. As the Pomegranate peel (%) increases from 0.5 to 2.5%, the carbohydrates content decreases. Similarly as the baking temperature increases from 175°C to 225°C the carbohydrates content decreases. As both the pomegranate peel powder (%) and as Baking temperature (°C) increases the carbohydrate (%) decreases. This can be seen from contour plot Fig. 9 (b). The effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the carbohydrates content can be seen by the second order polynomial equation (13). The equation is well fitted with  $r^2 = 0.975$  and  $0.401$

$$C_{ar} = 45.480 + 0.0701Y - 0.0001Y^2 - 3.822X + 0.00592XY - 0.7952X^2 \quad \dots(13)$$

Where,

$C_{ar}$  = carbohydrate (%);  $X$  = Pomegranate peel powder (%), and  $Y$  = Baking temperature, (°C)

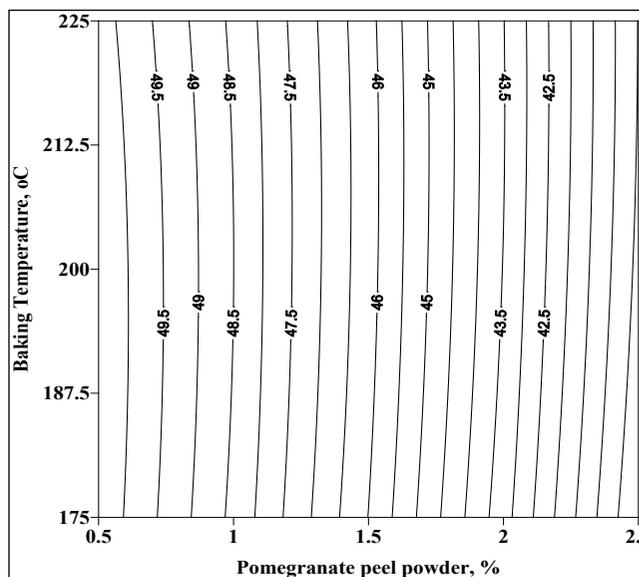


Fig. 9 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Carbohydrate of the Slice bread prepared from pomegranate peel powder and rice bran

Table 2 (f) shows the ANOVA for the carbohydrates content of. Slice bread prepared from pomegranate peel powder and rice bran. It indicated that the effect of incorporation of Pomegranate peel was significant at  $p \leq 0.01$ . Effect of baking temperature on carbohydrate slice bread is non-significant at  $p \leq 0.01$ . Also the interaction of both the composition pomegranate peel and baking temperature are non-significant at  $p \leq 0.01$ .

Sayed-Ahmed 2014 reported that the significant decreases of carbohydrate content were observed by increasing in Pomegranate peel powder levels to reach to the minimum value  $78.72 \pm 0.08$  at 7.5% compared with unfortified bread  $80.42 \pm 0.14$ .

### 7. Hardness (g)

Fig. 10 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Hardness (g) of the slice bread prepared from Pomegranate peel powder and rice bran. The hardness varies in the range of 33.66–62.66 g as the pomegranate peel powder (%) increases in the slice bread from 0.5 to 2.5% the hardness increases. As the baking temperature increases hardness increases up to  $200^{\circ}\text{C}$  then decrease trend. Fig 10(b) shows the contour plot of effect of pomegranate peel

powder (%) and baking temperature in slice bread on hardness. As both the baking temperature and pomegranate peel powder (%) increases hardness increases. The effect of incorporation of pomegranate peel powder (%) and the baking temperature ( $^{\circ}\text{C}$ ) on hardness was determined by the second order polynomial equation (13) the equation is well fitted to the experiment data with  $r^2 = 0.240$  and  $\text{MSE} = 50.895$

$$H_r = -356.151 + 3.936Y - 0.009652Y^2 + 4.342X - 0.04396XY + 3.1723X^2 \quad \dots(13)$$

Where

$H_r$  = Hardness (g)

$X$  = Pomegranate peel powder (%), and

$Y$  = Baking temperature, ( $^{\circ}\text{C}$ )

Table 2(g) shows the ANOVA for effect of pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) of slice bread on hardness. It indicates that the effect of incorporation of pomegranate peel shows the significant effect at  $p$ . Effect of baking temperature on hardness of slice bread is significant effect at  $p$ . Also the interaction of pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on slice bread shows significant effect at  $p$  on hardness in slice bread.

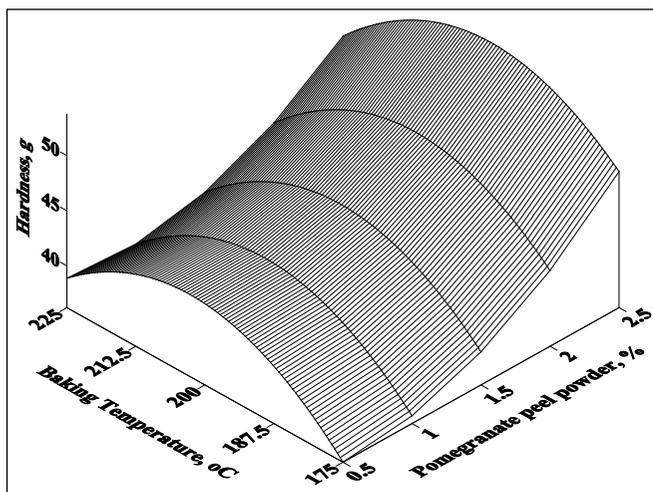


Fig. 10 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Hardness of the Slice bread prepared from pomegranate peel powder and rice bran

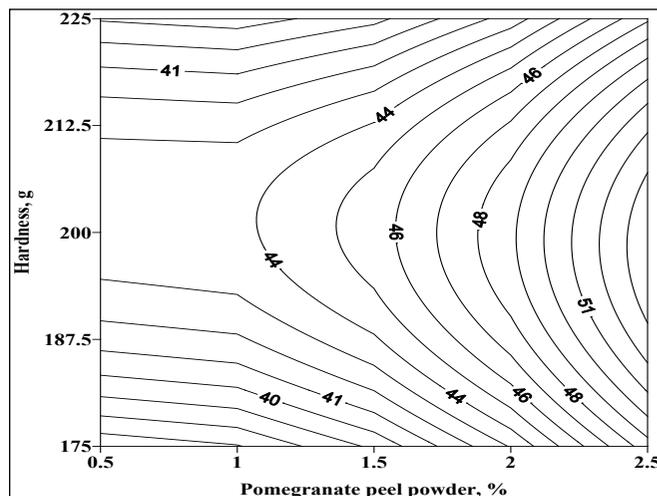


Fig. 10 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Hardness of the Slice bread prepared from pomegranate peel powder and rice bran

Sayed Ahmed 2014 reported that hardness of functional wheat bread was increased with increase in supplementation of pomegranate peel powder. With regard to dough texture, higher hardness with increasing pomegranate peel powder addition this effect to the thickening of the walls surrounding the air bubbles in the crumb. Feili *et al.* (2013) reported that bread hardness was due to interactions between gluten and fibrous materials. As can be seen, addition of jackfruit rind flour (JRF) in formulation of bread samples significantly affected the textural properties of the product. Hardness of bread samples were significantly ( $p \leq 0.05$ ) increased by increasing the jackfruit rind flour in their formula from 2.4 to 5.3 in 15% jackfruit rind flour. Bread samples substituted with 15 per cent jackfruit rind flour were not significantly ( $p \leq 0.05$ ) harder than those with 10 per cent jackfruit rind flour. Eriksson *et al.* (2014) reported that although bread hardness is dependent on moisture content, moisture migration and redistribution of water, gluten starch interactions and retro gradation of starch are very important phenomena responsible for bread hardness.

### 8. Springiness ( $S_p$ )

Fig. 11 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking

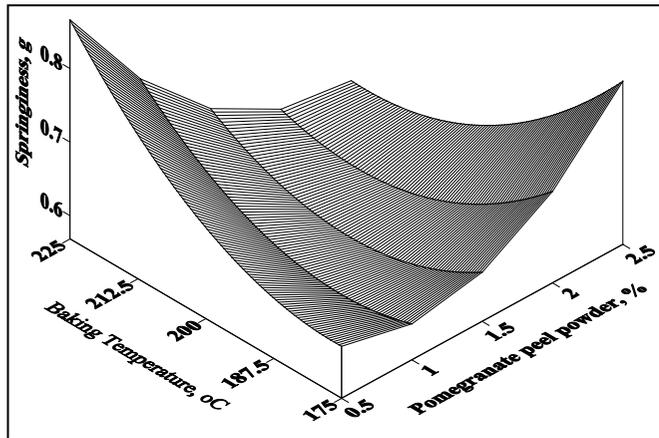


Fig. 11 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Slice bread prepared from pomegranate peel powder and rice bran

temperature (°C) on the springiness (g) of the slice bread prepared from pomegranate peel powder and rice bran. The springiness (g) varies in the range of 3.08 - 3.40 g as the pomegranate peel powder (%) increases in the slice bread from 0.5 to 2.5%. The springiness increases. At the baking temperature increases from 175 to 225 °C springiness increases. Fig. 11 (b) shows the contour plot of effect increasing of incorporation of pomegranate peel powder (%) and baking temperature in slice bread on springiness. As both the incorporation of pomegranate peel powder and baking temperature (%) increases springiness decreases. The effect of incorporation of pomegranate peel powder (%) and the baking temperature (°C) on springiness was determined by the second order polynomial equation (15) the equation is well fitted to the experiment data with  $r^2 = 0.0472$  and  $MSE = 0.015$

$$S_p = 3.327 - 0.0319Y + 9.679Y^2 + 0.613X - 0.00443XY + 0.0794X^2 \quad \dots(15)$$

Where

$S_p$  = Springiness;  $X$  = Pomegranate peel powder (%); and  $Y$  = Baking temperature, (°C)

Table 2 (g) shows the ANOVA for effect of pomegranate peel powder (%) and baking temperature (°C) of slice bread on springiness.

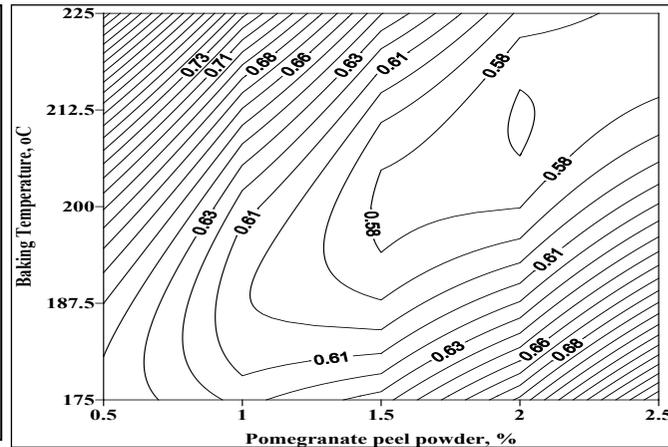


Fig. 11 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Slice bread prepared from pomegranate peel powder and rice bran

It indicated that the effect of incorporation of pomegranate peel shows the non-significant effect at pon springiness. Effect of baking temperature on springiness of slice bread is non-significant effect at p. Also the interaction of pomegranate peel powder (%) and baking temperature (°C) of in slice bread shows non-significant effect on springiness in slice bread.

Springiness of the bread samples significantly were reduced by addition of jackfruit rind flour in their formulation. Sayed-Ahmed (2014) reported that addition of pomegranate peel powder in formulation of bread samples significantly affected the textural properties of the breads. Springiness of bread samples were significantly ( $p \leq 0.05$ ) decreased by increasing of pomegranate peel powder level. The springiness of bread samples containing 10 percent and 15 per cent JRF were not significantly different ( $p \leq 0.05$ ).

### 9. Chewiness (g)

Fig. 12 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the chewiness (g) of the slice bread prepared from pomegranate peel and rice

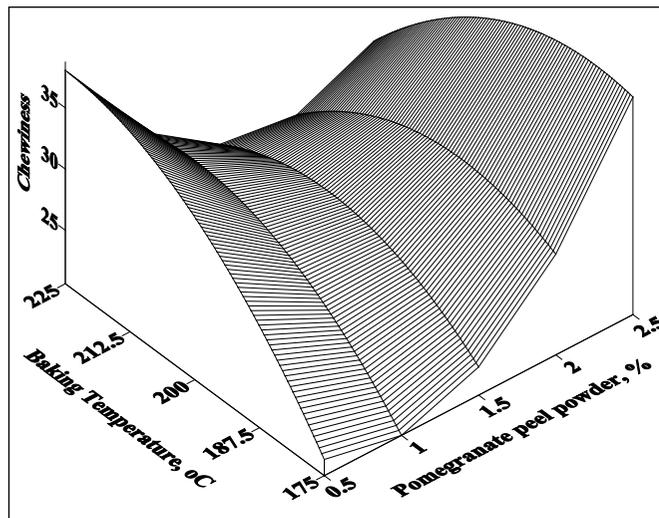


Fig. 12 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Slice bread prepared from pomegranate peel powder and rice bran

bran. The chewiness was in the range of 0.88- 48 .33g. As the pomegranate peel powder increases 0.5-2.5% the chewiness decreased up to 1.5% pomegranate peel powder then increasing in trend. As the baking temperature (°C) increases from 175°C to 225°C the chewiness was found to increase. It can be clear from the contour plot Fig. 12 (b) as both the pomegranate peel and baking temperature increases the chewiness was found to be increased upto 1.55(%) pomegranate peel and 212.5 baking temperature (°C) followed by decreasing trend. The effect of incorporation of pomegranate peel powder (%) and the baking temperature (°C) on chewiness was determined by the second order polynomial equation (16) the equation is well fitted to the experiment data with  $r^2 = 0.0276$  and  $MSE = 90.746$

$$Che = -299.336 + 2.957Y - 0.00624Y^2 + 34.116X - 0.2721XY + 7.248X^2 \quad \dots(16)$$

Where

$C_{he}$  = Chewiness (g)

X= Pomegranate peel powder (%), and

Y= Baking temperature, (°C)

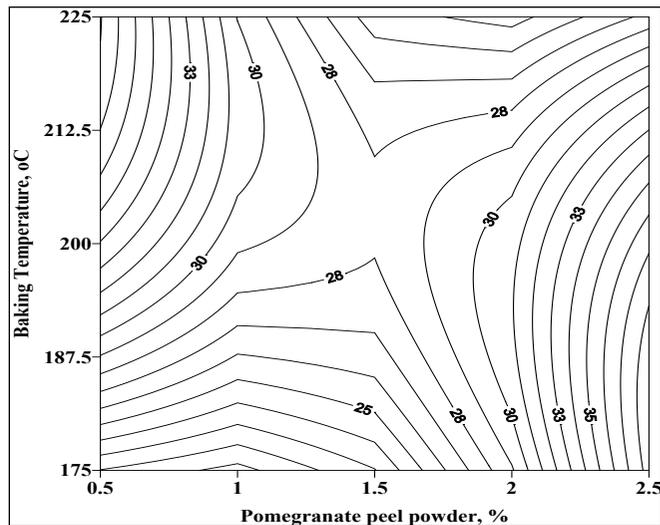


Fig. 12 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Slice bread prepared from pomegranate peel powder and rice bran

Table 2(g) shows the ANOVA for effect of pomegranate peel powder (%) and baking temperature (°C) of slice bread on chewiness. It indicated that the effect of incorporation of pomegranate peel shows the non-significant effect at p. Effect of baking temperature on chewiness of slice bread was non-significant effect at p. Also the interaction of pomegranate peel powder (%) and baking temperature (°C) of in slice bread shows significant effect at p on chewiness in slice bread.

Eriksson *et al.* (2014) reported that the chewiness of bread from 10 percent *afisiifi* and 10 per cent *bankye hemmaa* compared fairly well with that of 100 percent wheat. Sayed ahmed 2014 reported that the chewiness was significantly ( $p < 0.05$ ) increased by increasing of pomegranate peel powder level in their formula from  $5.61 \pm 0.01$  for bread control to  $8.32 \pm 0.02$  in 7.5% pomegranate peel powder bread formula. Level of 2.5% and 5% pomegranate peel powder bread formulas were better than 7.5% pomegranate peel powder bread formula for texture profile properties. Dhillon and Amarjeet (2013) reported that the Cinnamon powder increased the chewiness of bread. At 1 per cent level, chewiness was 1.06 which significantly increased to 1.37 at 4 per cent level.

## 10. Gumminess (g)

Fig. 13 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Gumminess (g) slice bread prepared from Pomegranate peel and rice bran. The gumminess varies in the range of 30-70 g. As the pomegranate peel powder (%) increases in the slice bread from 0.5 to 2.5% the gumminess decreases up to 1.5% then increasing in trend was observed. As the baking temperature (°C) increases gumminess increases. Fig 13(b) shows the contour plot of effect of pomegranate peel powder (%) and baking temperature (°C) in slice bread on gumminess. The effect of incorporation of pomegranate peel powder (%) and the baking temperature (°C) on gumminess was determined by the second order polynomial equation (17) the equation is well fitted to the experiment data with  $r^2 = 0.19$  and  $MSE = 102.48$

$$G_{um} = -451.532 + 4.894Y - 0.01178Y^2 - 11.270X - 0.0373XY + 7.936X^2 \quad \dots(17)$$

Where,

$G_{um}$  = Gumminess (g);  $X$  = Pomegranate peel powder (%), and  $Y$  = Baking temperature, (°C)

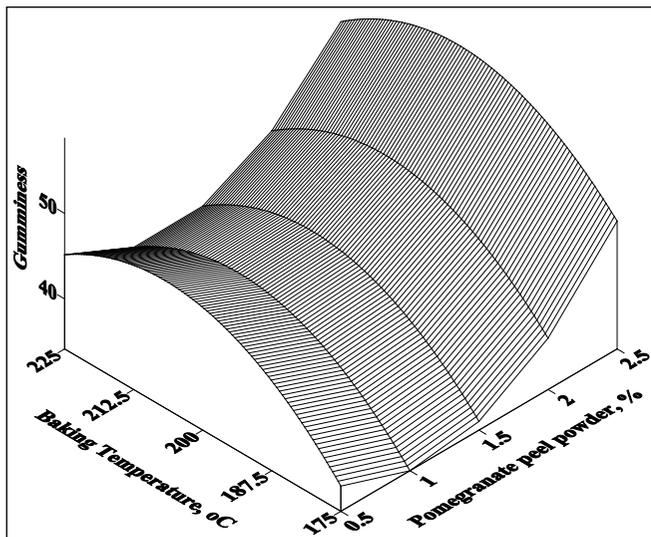


Fig. 13 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Gumminess of the Slice bread prepared from pomegranate peel powder and rice bran

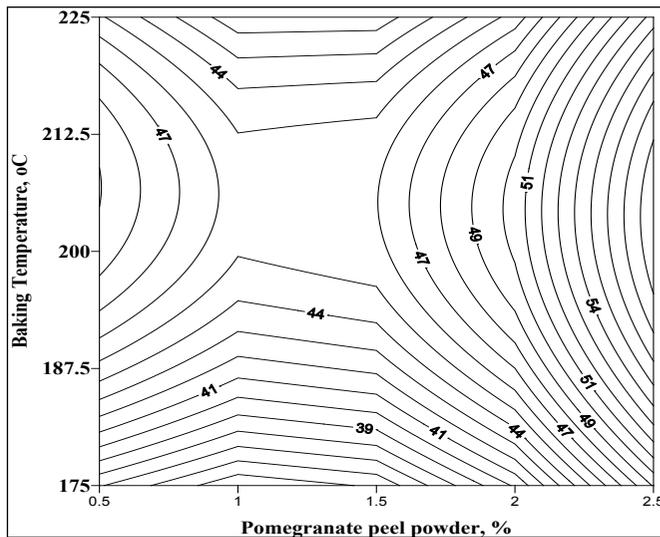


Fig. 13 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Gumminess of the Slice bread prepared from pomegranate peel powder and rice bran

Table 2 (g) shows the ANOVA for effect of slice bread prepared from pomegranate peel powder and rice bran. It indicates that the effect of incorporation of pomegranate peel powder is significant effect at p. Effect of baking temperature on gumminess of slice bread is significant effect at p the interaction of both pomegranate peel powder and baking temperature ( $^{\circ}\text{C}$ ) had effect is significant effect at p.

Sayed Ahmed (2014) reported that the addition of pomegranate peel powder in formulation of bread samples significantly affected the textural properties of the breads, gumminess, of bread samples were significantly ( $p < 0.05$ ) decreased by increasing of pomegranate peel powder level in their formulas from  $0.74 \pm 0.02$  respectively in 7.5% pomegranate peel powder bread formula. Dhillon and Amarjeet (2013) reported a significant increase at 4 per cent level of cinnamon powder in the bread. Since gumminess is dependent on hardness, similar influence trends were observed. Cinnamon powder significantly increased the gumminess of bread at 4 per cent level as compared to control. Gumminess was 1.13 at 1 per cent which increased to 1.37 at 4 per cent level.

## 11. Adhesiveness (J)

Fig. 14 (a) shows the surface plot showing the effect of pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the adhesiveness (g) of Slice bread prepared from pomegranate peel powder and rice bran. The adhesiveness varies in the range of 2.700- 17.300 J. As the pomegranate peel powder (%) increases in the slice bread from 0.5 to 2.5% the adhesiveness increases. As the baking temperature increases adhesiveness increases. Fig. 14 (b) shows the contour plot of effect of incorporation pomegranate peel powder (%) and baking temperature in slice bread on adhesiveness. As the pomegranate peel powder (%) increases adhesiveness increases. The effect of incorporation of pomegranate peel powder (%) and the baking temperature ( $^{\circ}\text{C}$ ) on adhesiveness was determined by the second order polynomial equation (18) the equation is well fitted to the experiment data with  $r^2 = 0.95$  and  $\text{MSE} = 12.702$ .

$$A_{dh} = 126.666 - 1.319Y + 0.0036Y^2 + 7.525X - 0.0700XY + 1.965X^2 \quad \dots(18)$$

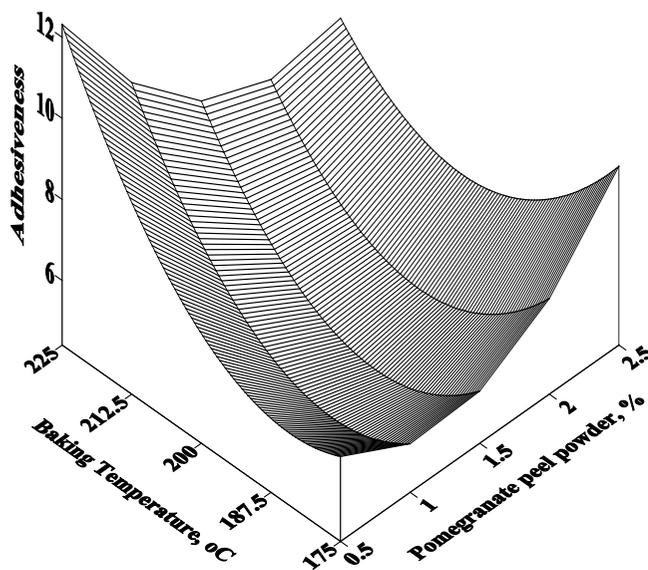


Fig. 14 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Adhesiveness of the Slice bread prepared from pomegranate peel powder and rice bran

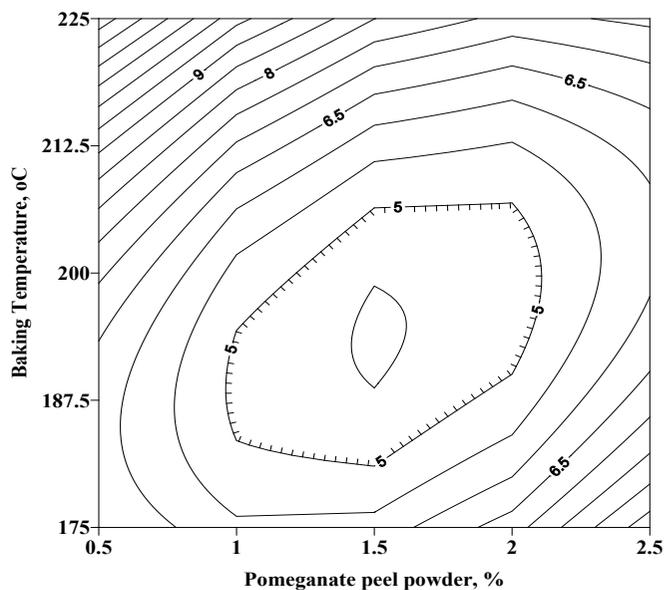


Fig. 14 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Adhesiveness of the Slice bread prepared from pomegranate peel powder and rice bran

Where,

$A_{dh}$  = adhesiveness (J)

X = Pomegranate peel powder (%), and

Y = Baking temperature, (°C)

Table 2 (g) shows the ANOVA for effect of incorporation pomegranate peel powder and rice bran slice bread. It indicated that the effect of incorporation of pomegranate peel powder and baking temperature on adhesiveness of slice bread was non-significant effect at p. Effect of baking temperature on adhesiveness of slice bread is non-significant effect at p. The interaction of both pomegranate peel powder and baking temperature (°C) significant effect was significant effect at p.

**12. Cohesiveness (g)**

Fig. 15 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Cohesiveness of the Slice bread prepared from pomegranate peel powder and rice bran. The cohesiveness varies in the range of 1.010-1.330 g. As the pomegranate peel powder (%) increases in the slice bread from 0.5 to 2.5% the

cohesiveness decreases. As the baking temperature (°C) increases cohesiveness increases. Fig 15(b) shows the contour plot of effect of pomegranate peel powder (%) and baking temperature (°C) in slice bread on cohesiveness. As both the pomegranate peel powder (%) and baking temperature (°C) increases cohesiveness increases upto 1.5% pomegranate peel followed by decreasing trend. The effect of incorporation of pomegranate peel powder (%) and the baking temperature (°C) on cohesiveness was determined by the second order polynomial equation (19) the equation is well fitted to the experiment data with  $r^2 = 0.82$  and  $MSE=0.007$

$$C_{oh} = -1.344 + 0.02656Y - 6.4000Y^2 - 0.321X - 9.534XY + 0.090X^2 \dots(19)$$

Where,

$C_{oh}$  = Cohesiveness

X = Pomegranate peel powder (%), and

Y = Baking temperature, (°C)

Table2(g) shows the ANOVA for effect of pomegranate peel powder (%) and baking temperature (°C) of slice bread on cohesiveness. It indicates that the effect of

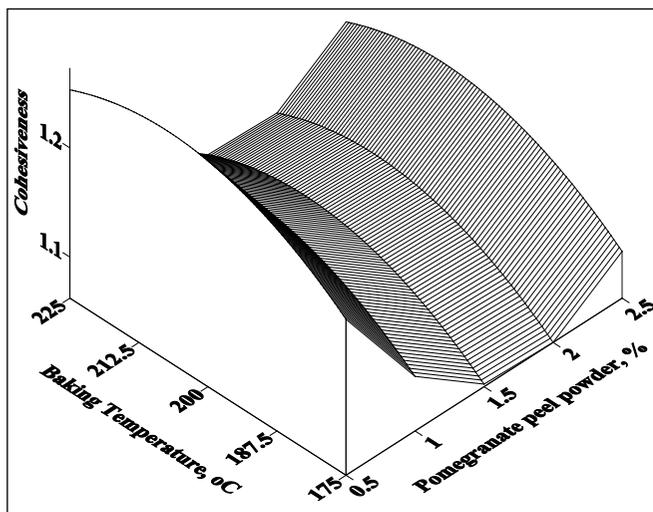


Fig. 15 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Cohesiveness of the Slice bread prepared from pomegranate peel powder and rice bran

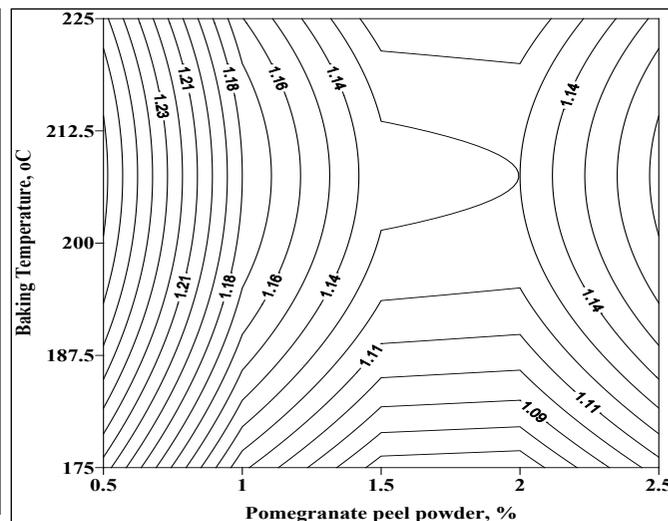


Fig. 15 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature (°C) on the Cohesiveness of the Slice bread prepared from pomegranate peel powder and rice bran

incorporation of pomegranate peel powder is non-significant effect at p. Effect of baking temperature ( $^{\circ}\text{C}$ ) on cohesiveness of slice bread is non-significant effect at p01. Also the interaction of pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on slice bread shows non-significant effect on cohesiveness in slice bread at p01.

Cohesiveness refers to the strength of internal bonds that keeps the sample cohesive. Sayed Ahmed (2014) reported that the addition of pomegranate peel powder in formulation of bread samples significantly affected the textural properties of the breads, cohesiveness of bread samples were significantly ( $p < 0.05$ ) decreased by increasing of pomegranate peel powder level in their formulas from  $0.49 \pm 0.04$  respectively in 7.5% pomegranate peel powder bread formula. Basinskiene *et al.* (2008) reported that bread with bran additions had significantly harder, less springy and cohesive crumb texture.

### 13. Whiteness Index

Fig. 16 (a) shows the surface plot showing effect of pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the whiteness index of Slice

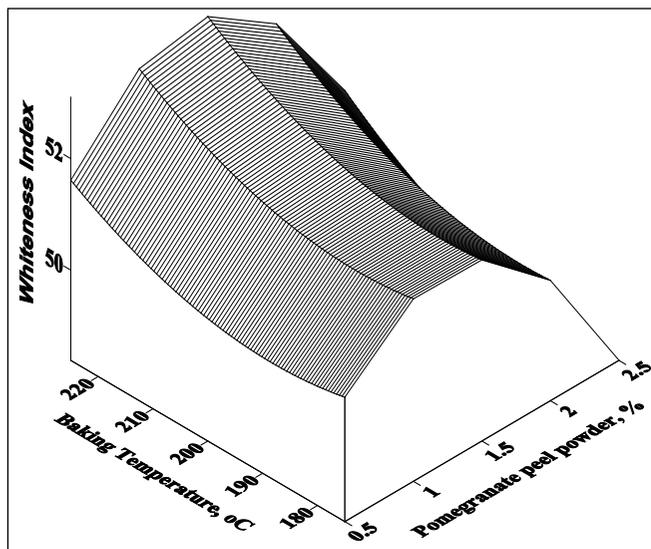


Fig. 16 (a) Surface plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Whiteness index of the Slice bread prepared from pomegranate peel powder and rice bran

bread prepared from pomegranate peel powder and rice bran. The whiteness index varies in the range of 50.56-52.02. As the pomegranate peel powder (%) increases in the slice bread from 0.5 to 2.5% the whiteness index increasing up to 1.5% followed by decreases trend upto the 2.5%. As the baking temperature increases whiteness index increases. Fig 16 (b) shows the contour plot of effect of pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) in slice bread on whiteness index. The effect of incorporation of pomegranate peel powder (%) and the baking temperature ( $^{\circ}\text{C}$ ) on whiteness index was determined by the second order polynomial equation (20) the equation is well fitted to the experiment data with  $r^2 = 0.790$  and  $\text{MSE} = 2.255$

$$WI = 79.702 - 0.328Y + 8.602 \times 10^{-4} Y^2 + 3.623X + 9.443XY - 2.129X^2 \quad \dots(20)$$

Where,

$W_i$  = Whiteness index

$X$  = Pomegranate peel powder (%), and

$Y$  = Baking temperature, ( $^{\circ}\text{C}$ )

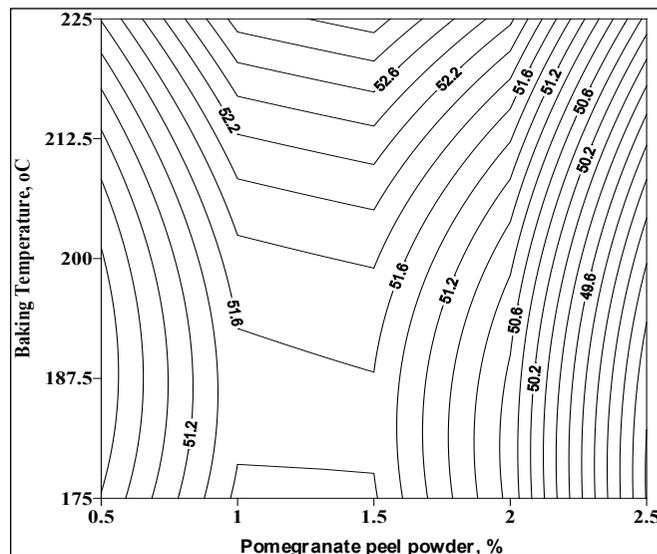


Fig. 16 (b) Contour plot of effect of incorporation of Pomegranate peel powder (%) and baking temperature ( $^{\circ}\text{C}$ ) on the Whiteness index of the Slice bread prepared from pomegranate peel powder and rice bran

Table 2 (g) shows the ANOVA for the whiteness index of slice bread prepared from pomegranate peel powder and rice bran. It indicated that the effect of incorporation of pomegranate peel is significant effect at p. Effect of baking temperature (°C) on whiteness index of slice bread is significant effect at p. Also the interaction of pomegranate peel powder (%) and baking temperature (°C) on whiteness index of slice bread shows significant effect at p on whiteness index in slice bread.

Based on whiteness index ( $W_1$ ), the darkest bread crumb ( $W_1 = 45.19$ ) was found in the bread sample with 40 %, wholegrain buckwheat flour while wheat bread had the highest whiteness index whitest crumb ( $W_1 = 71.93$ ). All bread samples had a higher level of red (a) and yellow (b) pigment in the crust than in the crumb (Selimović *et al.* 2014). Swami *et al.* 2015 was observed that as percent yeast concentration increases from 2.0 to 2.8% the whiteness index first increase then decreases. Similarly, as the baking temperature of bread increases whiteness index first increases then decrease and again increase.

0.75% and Baking Temperature 218.75 to 225°C of slice bread prepared from pomegranate peel powder and rice bran. The desirable properties of slice bread prepared from pomegranate peel powder and rice bran should have more protein, more moisture content, moderate fat, moderate fiber, moderate carbohydrate, moderate springiness, moderate chewiness, moderate adhesiveness, low ash, low hardness, low gumminess, low cohesiveness. The contour plots of all the responses were superimposed to get desirable protein, moisture content, fat, fiber, ash, carbohydrate, hardness, gumminess, whiteness index. The desirable property occurs at (0.50 – 0.75%) incorporation of pomegranate peel powder in slices bread and baked at (218.75 -225°C) baking temperature. The properties at the zone are moisture content 33.073 %, protein 13.380%, fat 1.523%, fiber 0.889 %, ash 0.64%, Hardness 33.667g, springiness 0.637 g chewiness 18.000 g gumminess 30.000 g adhesiveness 3.967 J, cohesiveness 1.290 g and whiteness index 3.86.

**Sensory Analysis**

The data obtained for sensory properties viz. colour, flavor and texture of pomegranate peel and rice bran as per the nine point hedonic scale determined by semi-trained panel for treatment  $T_1$  to treatment  $T_{15}$  are given in Table 3.

The Table 3 (a) shows that the sensory colour score. The average sensory colour scores was in the range 6.9 to 7.4. Control bread was sensory colour score 7.6. Highest colour score was observed at  $T_{11}$  and lowest was observed at  $T_9$ , shows ANOVA for colour of sensory analysis. The effect of pomegranate peel incorporation (%) shows the significant effect at p on colour of slice bread. Similarly baking temperature (°C) has significant effect at p. The combined effect of pomegranate peel powder and baking temperature (°C) on colour of slice bread was significant effect at p

The Table 3 shows that the sensory flavor score. The average sensory flavor scores was in the range 6.7 to 7.1. Control bread was sensory flavour score 7.3. Highest flavor score was observed at  $T_{11}$  and lowest was observed at  $T_9$ . Table 3 (a) shows ANOVA for

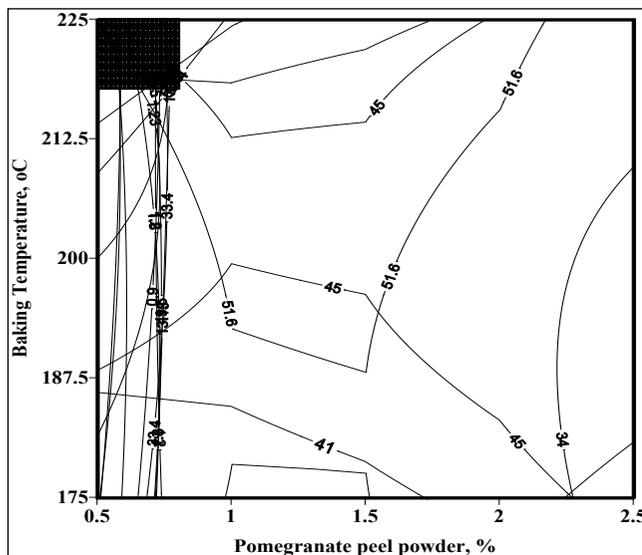


Fig. 17: Superimposed contour plots of desirable properties

Optimum slice bread composition for the pomegranate peel powder and rice bran and baking temperature (°C). Superimposed contour plot showing the optimum zone of pomegranate peel powder 0.50 to

**Table 3:** Sensory quality of slice bread prepared from pomegranate peel powder and rice bran

Treatments	Flour combination PP:RB	Sample code	Baking Temp.	Colour	Flavor	Texture	Taste	Total
T <sub>1</sub>	9.5:0.5	(A)	175°C	6.9	7.11	6.57	7.47	28.11
T <sub>2</sub>	9.0:1.0	(B)	175°C	7.2	6.8	6.83	7.31	28.30
T <sub>3</sub>	8.5:1.5	(C)	175°C	7.3	7.1	7.00	7.44	28.89
T <sub>4</sub>	8.0:2.0	(D)	175°C	7.2	7.0	7.0	7.9	29.3
T <sub>5</sub>	7.5:2.5	(E)	175°C	7.2	7.0	6.9	8.0	29.1
T <sub>6</sub>	9.5:0.5	(F)	200°C	7.2	7.1	6.7	7.8	28.9
T <sub>7</sub>	9.0:1.0	(G)	200°C	7.2	6.9	6.7	7.5	28.4
T <sub>8</sub>	8.5:1.5	(H)	200°C	7.1	6.7	6.7	7.4	28.1
T <sub>9</sub>	8.0:2.0	(I)	200°C	6.8	7.0	7.4	7.7	29.2
T <sub>10</sub>	7.5:2.5	(J)	200°C	7.2	7.1	7.0	7.4	28.8
<b>T<sub>11</sub></b>	<b>9.5:0.5</b>	<b>(K)</b>	<b>225°C</b>	<b>7.4</b>	<b>7.0</b>	<b>7.6</b>	<b>8.1</b>	<b>30.2</b>
T <sub>12</sub>	9.0:1.0	(L)	225°C	7.1	6.8	6.7	7.6	28.4
T <sub>13</sub>	8.5:1.5	(M)	225°C	7.1	6.8	6.8	7.4	28.2
T <sub>14</sub>	8.0:2.0	(N)	225 °C	6.9	7.1	7.5	7.7	29.4
T <sub>15</sub>	7.5:2.5	(O)	225 °C	7.2	7.0	6.7	7.5	28.6
T <sub>16</sub>	Control	(P)	225 °C	7.6	7.3	7.5	7.5	30

flavor of sensory analysis. The effect of pomegranate peel incorporation (%) shows the significant effect at p on the flavor of slice bread. Similarly baking temperature (°C) has significant effect at p. The combined effect of pomegranate peel powder and baking temperature (°C) has significant effect at p on the flavor of slice bread.

The Table 3 shows that the sensory texture score. The average sensory texture scores was in the range 6.5 to 7.6. Control bread was sensory texture score 7.5 Highest texture score was observed at T<sub>11</sub> and lowest was observed at T<sub>1</sub> Table 3 (a) shows ANOVA for texture of sensory of slice bread. The effect of pomegranate peel incorporation (%) shows the significant effect at p on the texture of slice bread. Similarly baking temperature (°C) has significant effect at p on the texture of slice bread. The combined effect of pomegranate peel powder and baking temperature (°C) has significant effect on texture of slice bread at p.

The Table 3 (d) shows that the sensory taste score. The average sensory taste scores was in the range 7.3

to 8.1. Highest taste score was observed at T<sub>11</sub> and lowest was observed at T<sub>2</sub> Control bread was sensory taste score 7.5. Table 3 (a) shows ANOVA for taste of sensory of slice bread. The effect of pomegranate peel incorporation (%) shows the significant effect on the taste of slice bread at p. Similarly baking temperature (°C) has significant effect on the taste of slice bread at p. The combined effect of pomegranate peel powder and baking temperature (°C) has significant effect on the taste of slice bread at p.

From the sensory score the slice bread prepared from pomegranate peel powder and rice bran incorporation of pomegranate peel powder (%) and baking temperature are significant effect at p. Color, flavor and texture It can be concluded that treatment T<sub>11</sub> with incorporation of 0.5% Pomegranate peel powder and Rice bran 9.5 in slice bread with baking temperature 225°C has the highest score ( colour 7.41; flavor 7.05; texture 7.64, Taste 8.18) resulted the best treatment average then all treatments.

### Correlation between the objective and subjective scores

The optimum product at from section 3.1 the desirable property occurs at (0.5%) incorporation of pomegranate peel powder in slices bread and baked at (225°C) baking temperature. The properties at the zone are moisture content 33.073 %, protein 13.380%, fat 1.523%, fiber 0.889 %, ash 0.64%, Hardness 33.667g, springiness 0.637 g chewiness 18.000 g gumminess 30.000 g adhesiveness 3.967 J, cohesiveness 1.290 g and whiteness index 3.86.

The best sensory score of the product have been obtained from section 3.2 at Rice bran 9.5% and Pomegranate peel powder 0.5 % incorporated in slice bread and baked at 225°C temperature, the product achieved the highest color 7.41. Flavor 7.05 and Texture 7.64

From nutritional, textural properties and the sensory the best product achieved i.e. pomegranate peel powder incorporated at 0.5 % and rice bran incorporation 9.5% and baking temperature at 225 °C.

### CONCLUSION

The best quality of pomegranate peel powder and rice bran slice bread, can be produced with incorporation of pomegranate peel powder 0.5% and baking temperature at 225°C. with physiochemical, textural properties are moisture content 33.073 %, protein 13.380%, fat 1.523%, fiber 0.889 %, ash 0.64%, Hardness 33.667g, springiness 0.637 g chewiness 18.000 g gumminess 30.000 g adhesiveness 3.967 J, cohesiveness 1.290 g and whiteness index 3.86 respectively.

### REFERENCES

AOAC. Official Methods of Analysis. 15<sup>th</sup> ed. Method 934.06. 1990 Association of Official Analytical Chemists, Arlington, VA, USA.

A.O.A.C. 1995. Official method of analysis II<sup>nd</sup> Ed. Association of Official Analytical Chemists, Washington, D.C. 16:37.

AOAC. Official Methods of Analysis. 15<sup>th</sup> ed. Method 934.06. 2010 Association of Official Analytical Chemists, Arlington, VA, USA.

Association of Japanese Agricultural Scientific Societies, 1975. Rice in Asia, Tokyo: University of Tokyo Press, 660.

Altunkaya, A., Hedegaard, R.V., Brimer, L., Gökmen, V., and Skibsted, L.H. 2013. Antioxidant capacity versus chemical safety of wheat bread enriched with pomegranate peel powder. *Food & Function*, **4**(5): 722-727.

Bandal, S., Talib, M. and Parate, V. 2014. Utilization of banana and pomegranate peel flour in fortification of bread. *International Journal of Engineering Research and Technology*, **3**: 100-1105.

Basinskiene, L., Garmuviene, S. and Juodeikiene, G. 2008. Effects of enzymes and extruded wheat bran in fibre-enriched bread baking. *Foodbalt*, pp. 15-19.

Devatkal, S.K., Thorat, P. and Manjunatha, M. 2012. Effect of vacuum packaging and pomegranate peel extract on quality aspects of ground goat meat and nuggets. *J. Food Sci. Technol.*, DOI: 10.1007/s13197-012- 0753-5.

Dewettinck, K., Van Bockstaele F., Kuhne B., Van de Walle D., Courtens T.M. and Gellynck X. 2008. Nutritional value of bread: Influence of processing, food interaction and consumer perception. *Journal of Cereal Science*, **48**: 243-257.

Dhillon, G.K. and Amarjeet, K. 2013. Quality evaluation of bread incorporated with different levels cinnamon powder. *International Journal Food Science Nutrition Diet*, **2**(7): 70-74.

Eriksson, E., Koch, K., Tortoe, C., Akonor, P. and Oduro, Y. 2014. Evaluation of the physical and sensory characteristics of bread produced from three varieties of cassava and wheat composite flours. *Food and Public Health*, **4**(5): 214-222.

Feili, R., Wahidu Zaman Z., Wan, N.W.A. and Tajul, A.Y. 2013. Physical and Sensory Analysis of High Fiber Bread Incorporated with Jackfruit Rind Flour. *Food Science and Technology*, **1**(2): 30-36.

Giannou, V., Kessoglou, V. and Tzia, C. 2003. Quality and safety characteristics of bread made from frozen dough. *Trends in Food Science and Technology*, **14**(3): 99-108.

Hu, G., Huang, S., Cao, S. and Ma, Z. 2009. Effect of enrichment with hemicellulose from rice bran on chemical and functional properties of bread. *Food Chemistry*, **115**: 839-842.

Iqbal, S., Haleem, S., Akhtar, M., Zia-ul-Haq, M. and Akbar, J. 2008. Efficiency of pomegranate peel extracts in stabilization of sunflower oil under accelerated conditions. *Food Res. Int.*, **41**: 194-200.

Ismail, T., Akhtar, S., Riaz, M. and Ismail, A. 2014. Effect of pomegranate peel supplementation on nutritional, organoleptic and stability properties of cookies. *International Journal of Food Sciences and Nutrition*, **60**(6): 661-666.

James, C.S. 1995. Experimental Methods. In: Analytical Chemistry of Foods, Champman and Hall, New York, 28.

Kanatt, S.R., Chander, R. and Sharma, A. 2010. Antioxidant and antimicrobial activity of pomegranate peel extract

- improve shelf life of chicken products. *Int. J. Food Sci. Technol.*, **45**: 216–222.
- Kim, S.P., Yang, J.Y., Kang, M.Y., Park, J.C. and Nam, Z.H. 2011. Composition of liquid rice hull smoke & anti-inflammatory effect in mice. *Journal of Agriculture and Food Chemistry*, **59**: 4570-4581
- Li, Y., Guo, C., Yang, J., Wei, J., Xu, J. and Cheng, S. 2006. Evaluation of antioxidant properties of pomegranate peel extract in comparison with pomegranate pulp extract. *Food Chemistry*, **96**(2): 254-260.
- Mehder, A.O.A. 2013. Pomegranate Peels Effectiveness In Improving The Nutritional, Physical And Sensory Characteristics of Pan Bread. *Current Science International*, **2**(2): 8-14.
- Miguel, M.G., Neves, M.A. and Antunes, M.D. 2010. Pomegranate (*Punica granatum* L) a medicinal plant with myriad biological properties a short review. *Journal of Medicinal Plants Research*, **4**: 2836- 2847.
- Mirdehghan, S.H. and Rahemi, M. 2007. Seasonal changes of mineral nutrients and phenolics in pomegranate (*Punica granatum* L.) fruit. *Sci. Horti.*, **111**: 120–127.
- Morton, J. 1987. Pomegranate (*Punica granatum* L) In: JF Morton (ed) fruits of warm climates. Julia F Morton Mizmi, F.I, pp. 352- 355 [http:// www.hort.purde.edu /new crop/Morton/Pomegranate.html](http://www.hort.purde.edu/new_crop/Morton/Pomegranate.html) (accessed July 19, 2010)
- Ndife Joel., Abdulraheem, L.O. and Zakari, U.M. 2011. Evaluation of the nutritional and sensory quality of functional reads produced from whole wheat and soy bean flour blends. *Afr. J. Food Sci.*, **5**(8): 466-472.
- Naveena, B.M., Sen, A.R., Kingsly, R.P., Singh, D.B. and Kondaiah, N. 2008. Antioxidant activity of pomegranate rind powder extract in cooked chicken patties. *Int. J. Food Sc. Technol.*, **43**: 1807–1812.
- Naveena, B.M., Sen, A.R., Vaithyanathan, S., Babji Y. and Kondaiah, N. 2008. Comparative efficacy of pomegranate juice, pomegranate rind powder extract and BHT as antioxidants in cooked chicken patties. *Meat Science*, **80**(4): 1304-1308.
- Oloye, D.A. 2006. Sensory Evaluation of and acceptance of composite bread from wheat, cassava starch and cassava flour blends. Unpublished *PGD Thesis* in Food Science and Technology Department, Federal University of Technology, Akure.
- Osuji, C.M. 2006. Importance and use of additives in bread making. A paper presented at a training workshop on the use of cassava/wheat composite flour and non-bromate additives for making bread and other confectionaries. Held at Michael Okpara University of Agriculture, Umudike.
- Qureshi, A.A., Mo, H., Packer, L. and Peterson, D.M. 2000. Isolation and identification of novel tocotrienols from rice bran with hypocholesterolemic, antioxidant, and antitumor properties. *Journal of Agriculture and Food Chemistry*, **48**: 3130-3140.
- Sangle, J.K., Sawate, A.R., Patil, B.M. and Kshirsagar, R.B. 2017. Nutritional and sensory quality of wheat bread supplemented with stabilized rice bran. *Food Science Research Journal*, **8**(1): 112-118.
- Swami, S.B., Thakor, N.J. and Murudkar, P.R. 2015. Effect of Yeast Concentration and Baking Temperature on Quality of Slice Bread. *Journal of Food Research and Technology*, **3**(4): 131-141.
- Sayed Ahmed, E.F. 2014. Evaluation of pomegranate peel fortified pan bread on body weight loss. *Int. J. Nutr. Food Sci.*, **3**(5): 411-420.
- Selimović, A., Miličević, D., Jašić, M., Selimović, A., Ačkar, Đ. and Pešić, T. 2014. The effect of baking temperature and buckwheat flour addition on the selected properties of wheat bread. *Croatian Journal of Food Science and Technology*, **6**(1): 43-50.
- Sekhon, K.S., Dhillon, S.S., Singh, N. and Singh, B. (1997). Functional Suitability of Commercially Milled Rice Bran in India for Use in Different Food Products. *Plant Foods for Human Nutrition*, **50**(2): 127- 140.
- Srivastava, P., Indrani, D. and Singh, R.P. 2014. Effect of dried pomegranate (*Punica granatum*) peel powder (DPPP) on textural, organoleptic and nutritional characteristics of biscuits. *International Journal of Food Sciences and Nutrition*, **65**(7): 827-833.
- Sivam, A.S., Sun Waterhouse, D., Quek, S. and Perera, C.O. 2010. Properties of bread dough with added fiber polysaccharides and phenolic antioxidants: A review. *Journal of Food Science*, **75**: 163–174.
- Tharshini Ganeshan, Veenu Sangwan and Suman. 2018. Formulation and chemical characterization of bread supplemented with pomegranate peel powder. *International Journal of Chemical Studies*, **6**(2): 386-390.
- Therdthai, N., Zhou, W. and Adamczak, T. 2002. Optimisation of the temperature profile in bread baking. *Journal of Food Engineering*, **55**: 41–48.
- Van Hoed, V., Depaemelaere, G., Vila Ayala, J., Santiwattana, P. and Verhe, R. 2006. Influence of chemical refining on the major and minor components of rice bran oil. *Journal of American Oil Chemistry*, **83**: 315-321.
- Ventura, J., Alarcón-Aguilar, F., Roman-Ramos, R., Campos-Sepulveda, E., Reyes-Vega, M.L., Boone-Villa, V.D. and Aguilar, C.N. 2013. Quality and antioxidant properties of a reduced-sugar pomegranate juice jelly with an aqueous extract of pomegranate peels. *Food Chemistry*, **136**(1): 109-115.