International Journal of Food and Fermentation Technology
Citation: *Int. J. Food Ferment. Technol.*, **14**(02): 513-533, December 2024
DOI: 10.30954/2277-9396.02.2024.5

ASSOCIATION FOR AGRICULTURE ENVIRONMENT AND BIOTECHNOLOGY

Research Paper

Effect of Incorporation of Orange Peel Powder and Baking Temperature on Quality of Cookies

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Paper No.: 300 **Received:** 20-08-2024 **Revised:** 07-11-2024 **Accepted:** 25-11-2024

ABSTRACT

In this paper the effect of incorporation of orange peel powder (1,2,3,4,5 %) and baking temperature i.e., 170°C, 180°C and 190°C on the various physicochemical quality characteristics and sensory score was evaluated. The cookies were prepared by replacing the wheat flour with the orange peel powder. The various quality characteristics i.e., TSS, acidity, Reducing sugar, Non-Reducing sugar, Total sugar, ascorbic acid, Hardnessand Browning index along with the sensory attributes i.e. Color, flavor, texture of the developed cookies was evaluated. Response surface analysis was performed with the quality attributes was performed. The superimposed contour plots resulted the best quality characteristics of TSS 41.6 °B, Acidity 0.04%, reducing sugar 0.98%, non-reducing sugar27.08%, total sugar 28.07%, ascorbic acid 31.15%, hardness 2980g, Browning index 8.60 at respectively. The quality characteristics were co-related with the sensory attributes of colour, flavor and texture. The optimum product quality arises at orange peel powder incorporation (%) i.e. 3% and baking temperature (°C) at 190°C. The best sensory scores were colour 8.4, flavor 8.5 and texture 8.6 respectively.

Keywords: Orange peel powder cookies, Reposes Surface Methodology, hardness, browning index, Sensory analysis

Orange is a fruit of the citrus species *Citrus Sinensis* in the family Rutaceae. Important orange varieties cultivated in India are *Nagpur Santra, Coorg Santra, Khasi Santra, Mudkhed, Shrinagar, Butwal, Dancy, Kara (Abohar)* (Zaker, 2016). The global orange production is about more than 122.5 million tons (Jiang *et al.* 2014). Brazil is the world's leading producer, with an output of 36 million tons (2013); similar in total to the next three countries combined (the United States, China, and India). With an approximately 16 million tons produced in 2013, the United states is the second largest producer. Other countries with significant production of orange are China, India, Mexico, Spain and Egypt. India produces 86.08 Lakh tons of oranges (Kumar, 2010). Maharashtra is second largest state after Andhra Pradesh in the country and contributes to about 18.9 % of the total production of Citrus (5.1 tonnes/ha) (Anonymous, 2011).

Citrus fruits have long been valued as a part of nutritious and tasty diet. It is well established that citrus and citrus products are rich source of vitamins, minerals and dietary fibers that are essential for normal growth and development and overall nutritional well-being (Economos and Clay, 1999). Orange juice is the most important products of citrus species worldwide (Hegazy and Ibrahium, 2012), and causes a higher amount of byproducts that could be

How to cite this article: Rangnekar, S.M. and Swami, S.B. (2024). Effect of Incorporation of Orange Peel Powder and Baking Temperature on Quality of Cookies. *Int. J. Food Ferment. Technol.*, **14**(02): 513-533.

Source of Support: None; **Conflict of Interest:** None

used as good source of bioactive compounds (Saenz *et al.* 2007; Kong *et al.* 2010). The orange juice industry uses approximately 50 % of the total fruit, while the peel, rag (membranes and core) and seeds and albedo comprises 60 % of total byproducts (Fernandez – Lopez *et al.* 2009). Orange peel is composed of two distinct parts: external part (flavedo) particularly rich in essential oils and carotenoids and internal spongy part (albedo) rich in pectin and flavonoids. Fig. 1 shows the varies parts of orange peel, though some portion of these by-products is consumed as animal feed, the majority of the processing waste are thrown out, and consequently pollutes the environment. Disposal of byproducts not only leads to loss of potential revenues but also leads to the added and increasing cost of disposal of these products (Jayathilakan *et al.* 2012).

Food industry uses citrus peel as a source of molasses, pectin, oil and limonene (Braddock, 1995), and has been studied because it contains several bioactive compounds, such as flavanones, polymethoxylated flavones, flavonols and phenolic acids and dietary fibers; these compounds have a lot of uses as a natural antioxidants for pharmaceutical, biotechnological and food industries (Bocco *et al.* 1998). Orange peel is a good source of flavonoids that are related to the benefits in human health, such as antioxidant capacity, anticancer, antiviral and antinflammatory activities (Benavente - Garcia *et al.* 1997). Dietary fiber plays an important role in the prevention, reduction, and treatment of chronic diseases such as obesity, diabetes, cardiovascular disease, and gastrointestinal disorders (Andeerson *et al.* 2009; Figuerola *et al.* 2005). The incorporation of dietary fiber into foods increases their fiber content and can result in healthier products. (Ramirez – Santiago *et al.* 2010). The peel of citrus fruit contains essential oils which are well-known antimicrobial agents (Braddock *et al.* 1986; Plessas *et al.* 2007). Orange peel typically contains 5.436 kg of oil per 1000 kg of oranges of which approximately 90% is D-limonene (Braddock *et al.* 1986; Hull *et al.* 1953); a hydrocarbon classified as a cyclic terpene. D-limonene is employed in the manufacture of food and medicines as a flavouring agent and has many applications in the chemical industry as well as cosmetics and domestics household products (Smyth and Lambert, 1998).

The bioflavonoids, hesperidin and naringin present in citrus fruits have been reported to exhibit biological and pharmacological properties like anti-inflammatory, anti: carcinogenic, lipid lowering and antioxidant activities (Bok *et al.* 1999; Choi *et al.* 2001). Hesperedin andnaringin have also been shown to play an important role in preventing the progression of hyperglycemia (Jung *et al.* 2004). Naringin has been reported to serve as a potential therapeutic agent to treat wear- debries- associated osteolysis (Li *et al.* 2014), and Osteoporosis (Wei *et al.* 2007). Some of these bioflavonoids are bitter to the taste and their presence in fruit juices and products developed from it are sometimes inevitable, which lowers the consumer's acceptability. The fresh orange peel contains 319 ± 22.7 mg/100 g of naringin which can be reduced up to 122.04 ± 12.7 mg/ 100g after blanching (Jagannath and Kumar, 2016).

Blanching is a moderate heat treatment commonly used in the food industry to extend the shelf life of commodities by partially inactivating microorganisms and enzymes. More intensive blanching orange peel inhibited the activity of microorganisms and enzymes (Ashbell *et al.* 1988). Prior to drying, most food products are usually subjected to one form of pretreatments among which is hot water blanching. Blanching helps to inactivates enzymes that leads to some quality degradation and improves the acceptability of the final products.(Moreno- Perez *et al.* 1996; Babajide, *et al.* 2006). Blanching also leads to structural softening and hence facilitates moisture removal (Senadeera *et al.* 2000). In case of orange peel the bioflavonoids which are present i.e. hesperidin and naringin are bitter in tastes, to remove the bitterness of the final product and make it consumer acceptable the blanching is required. Blanching lower down the bitterness in orange peel (Jagannath and Kumar, 2016).

Orange peel could be dehydrated for different products such as powders, flakes and slices (Ruiz-

Diaz *et al.* 2003). The development of new processing methods that preserve the equality of peels and improve their sensory acceptance is required to produce new peel foods.

Drying is an important method for preserving and increasing the shelf life of fruits and vegetables to limit microbial growth and create new uses. Numerous researchers have reported the dehydration kinetics of fruits and vegetables such as pomegranate (Doymaz, 2012); orange (Depilli *et al.* 2008; kiwi fruit (Orikasa *et al.* 2014); Mandarin slices (Akdas and Baslar, 2015) limited studies have been reported on steaming and drying of orange peel. Drying reduces water activity in the products, thus hindering the developments of microorganism, is one of the oldest, and therefore best known, methods to preserve fruit and vegetables, and fruit powder can be very easily added to various food products.

Bakery products are an important part of a balanced diet and, today, a wide variety of such products can be found on supermarket shelves. Cookies comprise a major category of snacks by virture of their general acceptability, convenience and long shelf life. The cookies are characterized by moisture and water activity (a_w) higher then 7 % and 0.5 % (Lebuza *et al.* 2002). The short is usually the mixture of several ingredient, made according to fairly complex recipe and in a short time (Manley, 1998). Texture, flavor and appearance are the main attribute of cookies. Fat is very important ingredient of cookies because it contribute texture and pleasuring mouth feel and positively impact flavor intensively perception. In many countries cookies are prepared with fortified and composite flour. Replacing the part of wheat flour with rice flour, soy flour is likely to improve nutritive value of product due to various nutritive supplement like aminoacid profile derived from these raw material (Bakar *et al.* 1987; Cheryan *et al.* 1976). The challenge is to develop cookies, a higher consumed bakery

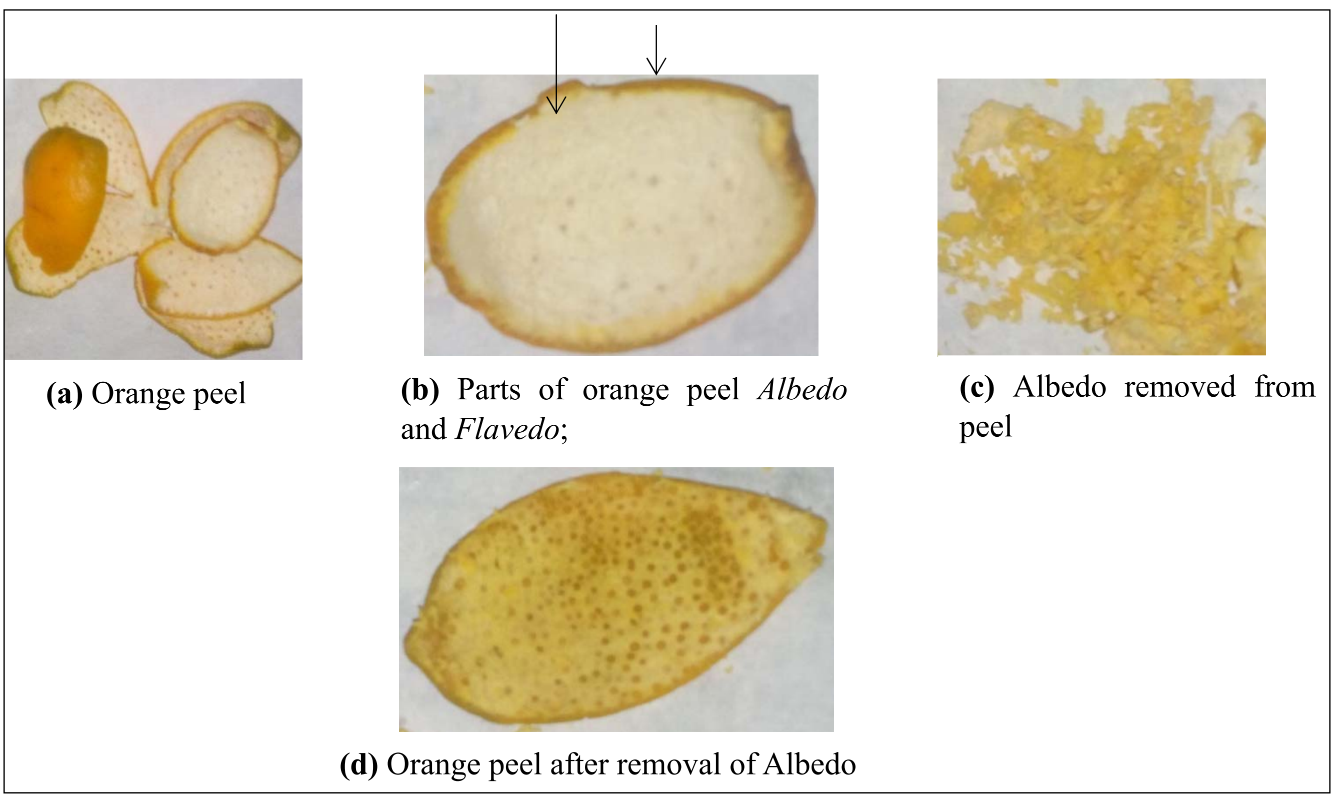

Fig. 1: Orange peel and its parts **(a)** Orange peel; **(b)** Parts of orange peel Albedo and Flavedo; **(c)** Albedo removed from peel; **(d)** Orange peel after removal of Albedo

product, using fruit waste to increase functional ingredients for daily intake. Consumer awareness of the functional characteristics of the food product is increasing, which is influencing their purchasing decisions. (Piteria *et al.* 1988). An alternative for recycling the fruit industrial residue is to submit it to drying processes. Dehydrated orange peel powder could be used in the formulation of cookies. The purpose of the present study was to develop cookies formulations with the good acceptability, and the effect of orange peel powder supplementation with the different baking temperature on physicochemical and sensorial characteristics of obtained cookies.

MATERIALS AND METHODS

Raw material

The firm Oranges was procured for experimentation from the Agricultural produce market committee (APMC) vashi market (Mumbai). The Orange fruits were washed with tap water to remove dirt, dust adhered. The fruits outer layer flavedo was separated manually from albedo. The surface moisture of the orange peel removed with the help of muslin cloth.

Moisture content

Initial moisture content for fresh orange peel; Blanched orange peel and blanched dried orange peel was determined by hot air oven at 105±1°C for 24 h. the final weight of orange peel was taken after 24 h of drying was recorded. (Make: Aditi Associate, India Model: ALO-136) The moisture content of orange peel was determined by the following equation (1) (Chakraverty 1994):

$$\text{Moisture content (d.b) \%} = \frac{W_1 - W_2}{W_2} \times 100 \qquad \ldots(1)$$

Where,

W_1 = Weight of the sample before drying *g* and

W_2 = Weight of the dried sample *g*

Blanching and Drying of Orange peel

Tray drying of orange peel was performed at the Department of Post-Harvest Engineering, Post Graduate Institute of Post-Harvest Management (PHM), Killa-Roha. Tray dryer of capacity 60kg (Make: M/S Sagar Engineering work, Kudal (India) was used for this study. The peels were cut into small pieces of size 10 mm having thickness 3 mm, and blanched in a tap water 82° for 8 min and after blanching was completed the surface moisture was removed. The blanched slices were dried in a thin layer in a tray dryer at 50°C ±1°C. The size of the tray was 500mm × 500mm × 20mm. The blanched orange peel was spread in a single layer in the tray (non-perforated). The drying was carried out from initial moisture content 686.823% (db) to 15.379% (db) for 11 h 30 min. The dried orange peel powder of varied concentration i.e. 1%, 2%, 3%, 4% and 5% respectively used in cookies formation.

Preparation of Orange peel cookies

Fig. 2 shows the process technology for preparation of orange peel cookies. The 28g sugar and 30g vegetable oil were creamed and creaming was continued till it become light and fluffy mass. The mixture was added with the refined wheat flour (41%, 40%, 39%, 38%) and orange peel powder as per the treatments (1%, 2%, 3%, 4%, 5%) to make the flour composition (45%) according to the treatment, and the mixture was added into the earlier creamed mass and they were thoroughly mixed to a homogeneous mixture to form dough. The dough was taken into mould for giving shape to the cookies. The cookies were placed in a baking tray and baked in oven at about 170, 180 and 190°C for 20-25 min, depending upon the temperature condition. The sample were cooled at 25°C temperature and packed in a low density polythene bag and stored at normal temperature. Table 1 shows the experiment level of orange peel cookies. Cookies were compared with the control sample with 40°C dried orange peel powder incorporated in 1% concentration at baking temperature 170, 180 and 190°C.

Statistical analysis was performed using 3 Factorial completely randomized design (FCRD) for sample properties ofTSS, Acidity, Reducing sugar, Non-reducing sugar, Total sugar, Ascorbic acid, Browning index and sensory qualities like colour, flavour, texture of orange peel cookies which was carried out by Microsoft Excel 2007.

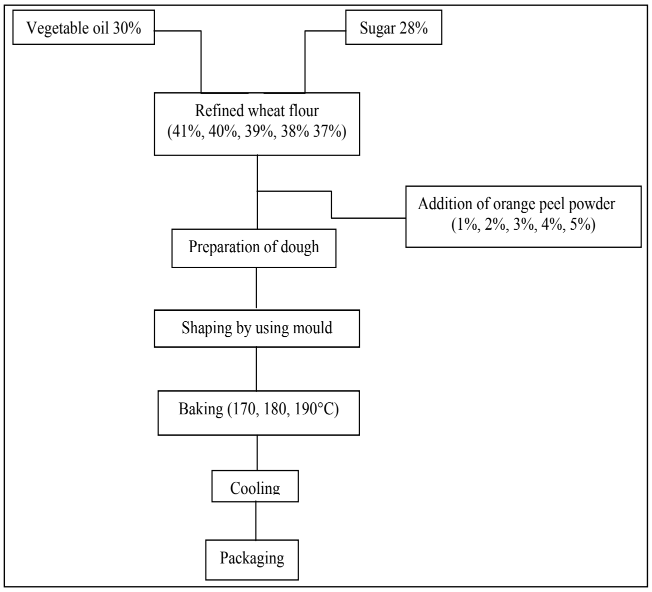

Fig. 2: Process technology for orange peel cookies

Table 1: Experimental level of orange peel cookies

Sample code	Temperature (°C)	Orange peel powder	Refine wheat flour
T_1	170°C	1%	41%
T_2	180°C	1%	41%
T_3	190°C	1%	41%
T_4	170°C	2%	40%
T_5	180°C	2%	40%
T_6	190°C	2%	40%
T_7	170°C	3%	39%
T_8	180°C	3%	39%
T_9	190°C	3%	39%
T_{10}	170°C	4%	38%
T_{11}	180°C	4%	38%
T_{12}	190°C	4%	38%
T_{13}	170°C	5%	37%
T_{14}	180°C	5%	37%
T_{15}	190°C	5%	37%
T_{16} (without blanching)	170°C	1%	41%
T_{17} (without blanching)	180°C	1%	41%
T_{18} (without blanching)	190°C	1%	41%

Evaluation of Quality Parameter for the blanched dried of Orange peel cookies

1. TSS (°B)

The Total Soluble Solids of orange peel cookies of various treatments (T_1-T_{18}) were determined by using Hand Refractometer (M/s Atago Japan, 0-32^{0}B) and the values were corrected at 20^{0}C with the help of temperature correction chart (A.O.A.C., 1975). The equipment was calibrated with the distilled water. The experiments were repeated four times and average value was reported.

2. Titratable acidity

A 10g of orange peel cookies of various treatments (T_1-T_{18}) was performed as per (A.O.A.C., 1975) sample was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The sample of known quantity with 20 ml distilled water was transferred to 100 ml volumetric flask, made up the volume and filtered. A known volume of aliquot (10 ml) was titrated against 0.1N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator (Ranganna, 2003). The results were expressed as per cent anhydrous citric acid equation (2). The experiments were repeated for three times and average value was reported;

Titratable acidity (%) =

$$\frac{\text{Normality of alkali} \times \text{Titre reading} \times \text{Volume made} \times \text{Equivalent weight of acid}}{\text{Weight of sample taken} \times \text{Volume of sample taken for estimation} \times 1000} \times 100 \quad \ldots(2)$$

3. Reducing sugars

The reducing sugars of orange peel cookies were determined by the method described by Ranganna (2003). A 25g of orange peel cookies of various treatments (T_1-T_{16}) was taken in 250 ml volumetric flask. To this, 100 ml of distilled water was added and the contents were neutralized by 1 N sodium hydroxide. Then 2 ml of 45 per cent lead acetate was added to it. The contents were mixed well and kept for 10 minutes. Two ml of 22 per cent potassium oxalate was added to it to precipitate the excess of lead. The volume was made to 250 ml with distilled water and solution was filtered through Whatman (No. 4) filter paper. This filtrate was used for determination of reducing sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' solutions (5 ml each) using methylene blue as indicator to a brick red end point. The results were expressed on per cent basis equation (3).

Reducing sugars (%) =

$$\frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weight of sample}} \times 100 \qquad \ldots(3)$$

4. Non-Reducing sugar

The non-reducing sugar of orange peel cookies was determined by subtracting reducing sugar from total sugars per the equation (4).

Non-Reducing sugar = [(Total sugar % — Reducing sugar) 0.95] … (4)

5. Total sugars

The total sugar of orange peel cookies sample of treatments (T_1-T_{18}) was determined as per Ranganna (2003). For inversion at room temperature, a 50 ml aliquot of clarified deluded solution was transferred to 250 ml volumetric flask, to which, 10 ml of 50 per cent HCl was added and then allowed to stand at room temperature for 24 hrs. It was then neutralized with 40 per cent NaOH solution. The volume of neutralized aliquot was made to 250 ml with distilled water. This aliquot was used for determination of total sugars by titrating it against the boiling mixture of Fehling 'A' and Fehling 'B' (5 ml each) using methylene blue as indicator to a brick red end point. The results were expressed on per cent basis as per equation (5). The experiments were repeated four three times and average value of total sugar have been reported.

Total sugars (%) =

$$\frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weight of sample}} \times 100 \qquad \ldots(5)$$

6. Ascorbic acid

Ascorbic acid of orange peel cookies sample of treatments (T_1-T_{18}) was determined in triplicate by titration. 10g of sample was taken and blended with 3g/dL HPO_3. The total volume was made upto 100 ml with HPO_3. This was followed by titration. An aliquot of 10 ml HPO_3 was taken as extract of the sample. The sample was titrated with the standard dye to an end point (pink color) that was persisted for at-lest 15 second (AOAC, 1995). Results will be expressed as mg of ascorbic acid/100 g of sample.

Mg of ascorbic acid/100 g of sample =

$$\frac{\text{Titre} \times \text{dye factor} \times \text{volume made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{weight of volume of sample taken for estimation}} \qquad \ldots (6)$$

7. Textural properties (hardness)

The Hardness of orange peel cookies was determined by Texture Analyzer (Make: M/S Food Technology Corporation, USA). A cookie was placed and precisely center of the bose plate of the equipment sample holder, and 4 mm diameter cylinder probe (3-point bending rig, 5 kg load cell) was used for the analysis. The compression test was performed up to 3mm; the hardness was recorded by the equipment in terms of force deformation characteristics. The first peak was taken as hardness. The cookie hardness was determined by peak force (N) during compression. The peak force, was measured for three cookies for each combination (Baking temperature 170, 180 and 190°C and orange peel powder 1, 2, 3, 4, 5%).

8. Colour

The orange peel cookies were used to measure the colour value using a colorimeter (M/S Konica Minolta, Japan; Model- Meter CR-400). The equipment was calibrated against standard white tile. Orange peel cookies were taken in the petri dish, the petri dish was placed at the aperture of the instrument. The colour was recorded in terms of *L*= lightness (100) to darkness (0); *a* = Redness (+60) to Greeness (-60); b= yellowness (+60) to blueness (-60). The browning index of the orange peel cookies was determined from the *L, a,* and *b* values as per the equation (7) reported by (Perez-Gago, Serra, & Del Rio, 2006). The brown index (BI) was determined using the following equation:

$$\text{BI} = \frac{100\times(\chi - 0.31)}{0.172} \qquad \ldots(7)$$

$$\chi = \frac{a* + 1.75L*}{5.645L* + a* - 3.012b*}$$

9. Optimization of cookies

The orange peel cookies should have more TSS, acidity, reducing sugar, Non-reducing sugar, Total sugar, ascorbic acid and moderate hardness and browning index. Based on these desirable attribute, the contour plot of each responses were superimposed for the optimum product quality. Based on the desirable common attributes the optimum zone of desirable propertiesm have been obtained.

10. Sensory Evaluation

The sensory attribute of orange peel cookies was evaluated with semi-trained panelists. The panelists were trained for the product testing and were familiar with product sensory evaluation. Cookies samples were placed in plates. The cookies prepared from all the treatments were coded from A to R. There were around 18 different samples out of which 15 were from the different treatments and 3 treatments was of control (without blanching). Which were made from orange peel dried at 40°C for evaluation of sensory parameters i.e. colour, flavour texture .09 scales for colour, 09 scales for flavor attribute and09 scales for texture attribute. The attribute were summed up for total score 27 for each panelist for each treatment. The data were analyzed statistically for the significant of each attribute 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 TSS, acidity, reducing sugar, Non-reducing sugar, Total sugar, ascorbic acid and moderate hardness and browning 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 and correlated the optimum product quality with the subjective quality evaluation.

RESULTS AND DISCUSSION

Evaluation of Quality Parameter for the blanched dried of Orange peel cookies

1. Total soluble solid TSS (°B)

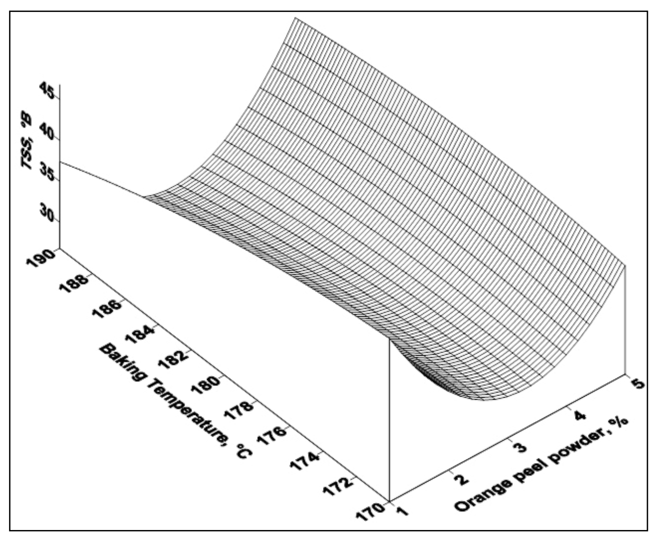

Fig. 2(a): Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on TSS(°B) of Orange peel powder cookies

Fig. 2 (a) shows the surface plot showing the effect of baking temperature (°C) and incorporation of orange peel powder (%) on the TSS (ºB) of orange peel cookies. The TSS varies in the range of 16.7 to 60.6 (ºB) as the orange peel powder (%) increases in the cookies from 1 to 5% the TSS decreases. Similarly as the baking temperature increases TSS decreases. Fig. 2(b) shows the contour plot of effect of baking temperature and incorporation of orange peel powder (%) of cookies on TSS. As both the baking temperature and orange peel powder (%) increases TSS decreases.

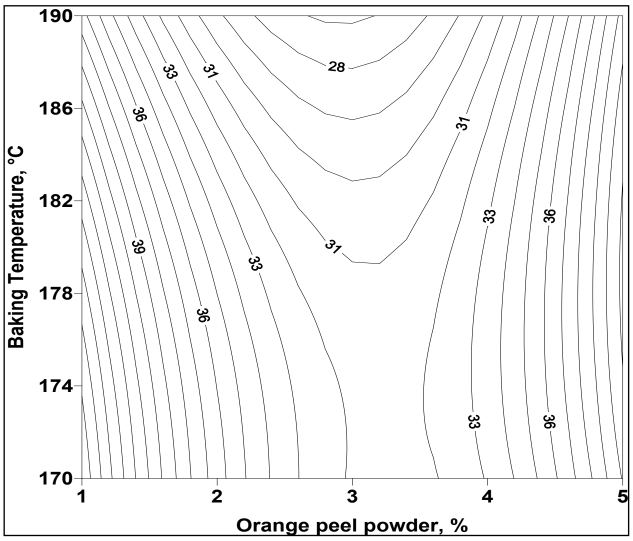

Fig. 2(b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on TSS(°B) of Orange peel powder cookies

Table 2(a) shows the ANOVA for effect of baking temperature (°C) and orange peel powder (%) of cookies on TSS. TSS shows the significant effect at pon baking temperature (°C) and orange peel powder (%) of cookies. The interaction of baking temperature (°C) and incorporation of orange peel powder (%) in cookies also shows significant effect on TSS in cookies. The effect of incorporation of orange peel powder and the baking temperature (°C) on TSS was determined by the second order polynomial equation (1) the equation is well fitted to the experiment data with $R^2 = 0.9388$; MSE = 1.355.

$$T_{SS} = 2.889O_p^2 - 3.752O_p + 1.088 \times 10^{-10} O_p B_T + 4.790B_T - 1.491 \times 10^{-2} B_T^2 - 3.203 \quad \ldots(1)$$

Where, T_{SS}- Total Soluble Solid (°B), O_p is the Orange peel powder(%), B_T is the Baking temperature(°C)

Khapre *et al.* 2015 studied on fig powder cookies, baked at 160°C T_{SS} is 76(°B).

2. Acidity

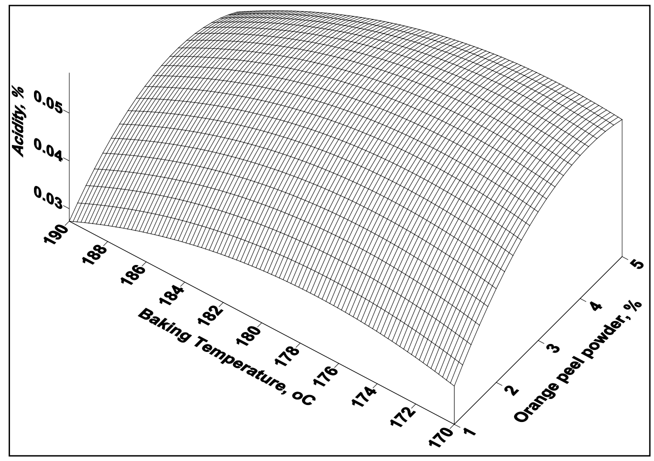

Fig. 3(a): Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on acidity of Orange peel powder cookies

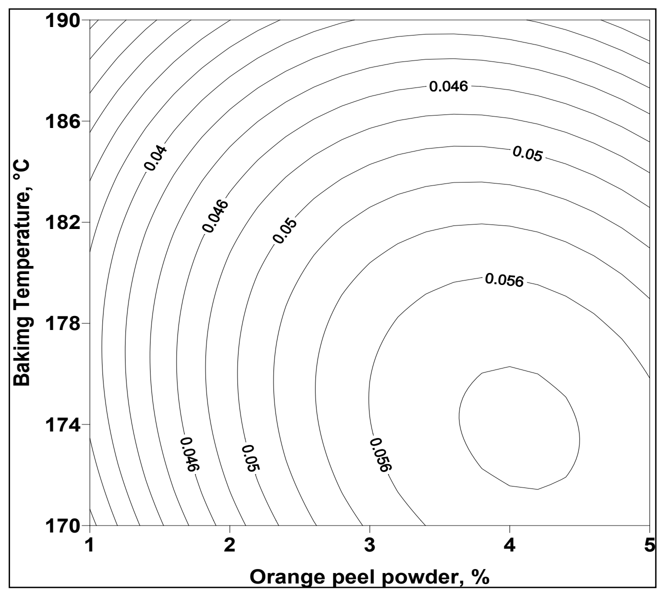

Fig. 3(b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on acidity of Orange peel powder cookies

Fig 3 (a) shows the surface plot showing the effect of baking temperature (°C) and orange peel powder (%) on the acidity of orange peel cookies. The acidity varies in the range of 0.02 to 0.07% as the orange peel powder (%) increases in the cookies from 1 to 5% the acidity increases. Similarly as the baking temperature increases from 170°C to 190°C acidity decreases. Fig. 3(b) shows the contour plot of effect of baking temperature (°C) and orange peel powder (%) in cookies on acidity. As both the baking temperature (°C) and incorporation of orange peel powder (%) increases acidity increases.

Table 2(b) shows the ANOVA for effect of baking temperature (°C) and orange peel powder (%)of cookies on acidity. Acidity shows the significant effect at p on baking temperature (°C) and orange peel powder (%) of cookies. The interaction of baking temperature (°C) and (%) of orange peel powder in cookies also shows significant effect on acidity in cookies. The effect of incorporation of orange peel powder (%) and the baking temperature (°C) on acidity was determined by the second order polynomial equation (2) the equation is well fitted to the experiment data with $R^2 = 0.939$; MSE = 0.000199.

$$A_c = -1.8517 + 0.0209B_T - 5.83 \times 10^{-5} B_T^2 + 0.049O_P - 0.0002O_P B_T - 0.00166 O_P^2 \quad \ldots(2)$$

Where, A_c = Acidity(%), O_P is the Orange peel powder(%), B_T is the Baking temperature(°C)

Devi *et al.* 2012 reported incorporation of high proportion of mango and pineapple fruit powder increases in biscuit acidity also as the temperature increases acidity increases, acidity range from 0.22 to 0.26%. Khapre *et al.* 2015 reported of fig powder cookies containing acidity 0.32%.

3. Reducing Sugar

Fig. 4 (a) shows the surface plot showing the effect of baking temperature (°C) and orange peel powder (%) on the reducing sugar of orange peel cookies. The reducing sugar varies in the range of 0.56 to 2.2% as the incorporation of orange peel powder (%) increases in the cookies from 1 to 5% the reducing sugar increases. There is slight decreases is from 1 to 2 %. Similarly as the baking temperature increases reducing sugar decreases upto 190°C of baking temperature. Fig 4(b) shows the contour plot of effect of baking temperature and incorporation of orange peel powder (%) in cookies on reducing sugar. As both the baking temperature (°C) and incorporation of orange peel powder (%) increases reducing sugar increases.

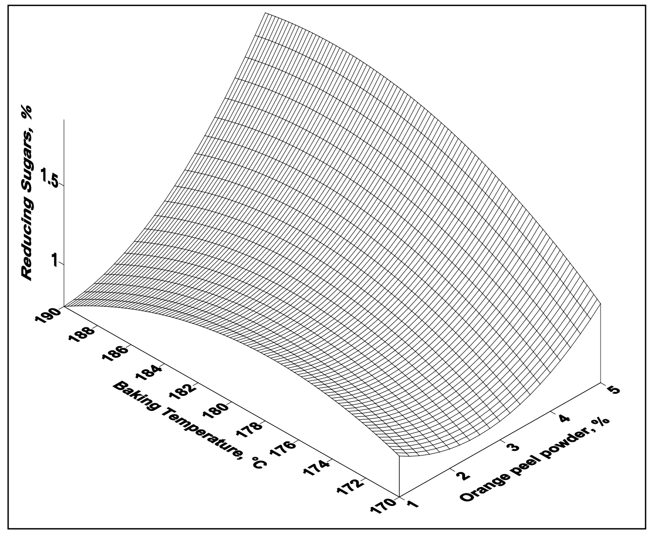

Fig. 4(a) Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Reducing Sugar (%) of Orange peel powder cookies

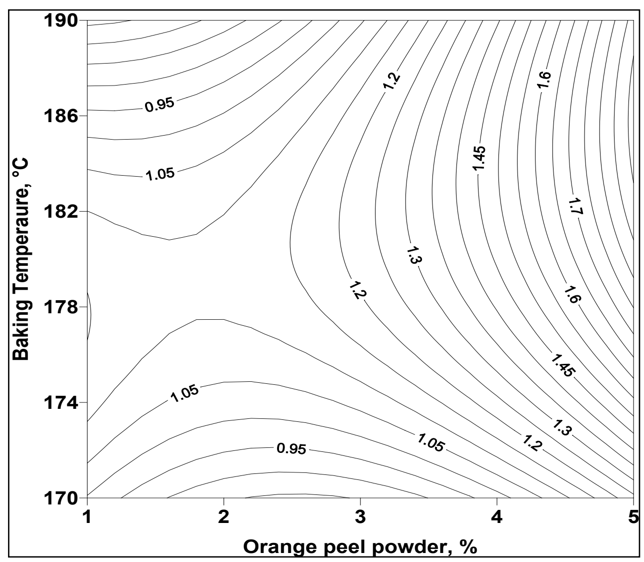

Fig. 4(b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Reducing Sugar (%) of Orange peel powder cookies

Table 2(c) shows the ANOVA for effect of baking temperature (°C) and incorporation of orange peel powder (%) of cookies on reducing sugar. Reducing sugar shows the significant effect at p on baking temperature(°C) and incorporation of orange peel powder (%) of cookies. The interaction of baking temperature and (%) of orange peel powder in cookies also shows significant effect on reducing sugar in cookies. The effect of incorporation of orange peel powder (%) and the baking temperature (°C) on reducing sugar was determined by the second order polynomial equation (3) the equation is well fitted to the experiment data with $R^2 = 0.959$; MSE = 0.0886.

$$R_S = 6.555 \times 10^{-2} O_p^{\,2} - 2.237 O_p + 1.120 \times 10^{-2} O_p B_T + 0.953 B_T - 2.716 \times 10^{-3} B_T^{\,2} - 8.2371 \quad \ldots(3)$$

Where, R_S = Reducing sugar(%), O_p is the Orange peel powder(%), B_T is the Baking temperature(°C)

Sung *et al.* 2017 reported the similar result that as the baking temperature 205°C increases there is decrease in reducing sugar from 121.78±4.67 to 117.61±13.44 there is significant change in reducing sugar in cookies during baking. Hosamani *et al.* 2016 reported that reducing sugar content range from 9.82 to 9.25 as the incorporation of carrot, jackfruit and amlafruit and vegetable powder (%) changes there is change in reducing sugar the reducing sugar decreases due to high baking temperature 200°C. Charissou *et al.* 2007 and Ameur *et al.* 2007 studied that increases in baking temperature 200°C to 300°C there is decrease in reducing sugar.

3.4 Non reducing sugar

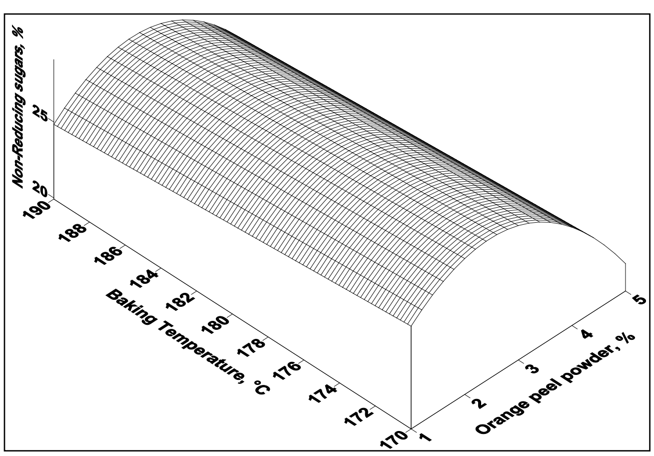

Fig. 4(a): Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Non-Reducing Sugar (%) of Orange peel powder cookies

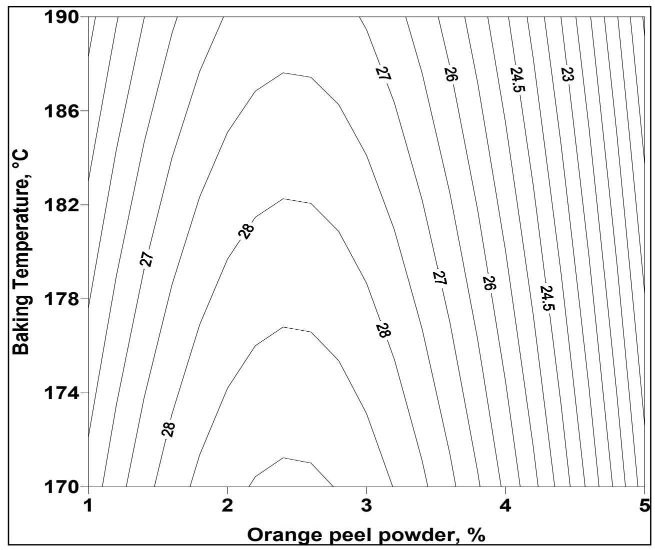

Fig. 4(b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Non-Reducing Sugar (%) of Orange peel powder cookies

Fig. 4 (a) shows the surface plot showing the effect of baking temperature (°C) and orange peel powder (%) on the non-reducing sugar of orange peel cookies. The non-reducing sugar varies in the range of 19.51 to 32.89 % as the orange peel powder (%) increases in the cookies from 1 to 5% the non-reducing sugar increases upto 3% and then followed decreasing trend. As the baking temperature increases non-reducing sugar (%) gradually decreases in non-reducing sugar was observed affected much. Fig 4(b) shows the contour plot of effect of baking temperature and incorporation of orange peel powder (%) in cookies on non-reducing sugar. As both the baking temperature and incorporation of orange peel powder (%) increases reducing sugar decreases.

Table 2(d) shows the ANOVA for effect of baking temperature (°C) and incorporation of orange peel powder (%) of cookies on non-reducing sugar. Non-reducing sugar shows the significant effect at p on baking temperature (°C) and incorporation of orange peel powder (%) of cookies. The interaction of baking temperature (°C) and incorporation of orange peel powder (%) in cookies also shows significant effect on non-reducing sugar of cookies. The effect of incorporation of orange peel powder and the baking temperature (°C) on reducing sugar was determined by the second order polynomial equation (4) the equation is well fitted to the experiment data with R^2 = 0.987; MSE = 1.271

$$NR_S = -1.141O_p^2 + 5.5136O_p + 5.500 \times 10^{-4} O_p B_T - 0.0360B_T - 1.583 \times 10^{-4} B_T^2 + 3.2930 \quad \ldots(4)$$

Where, NR_S = Non-reducing sugar(%), O_p is the Orange peel powder(%), B_T is the Baking temperature(°C)

Hosamani *et al.* 2016 reported that non reducing sugar content changes as the incorporation of carrot, jackfruit and amlafruit and vegetable powder increases, baking temperature do not shows the much effect on non-reducing sugar. Ameur *et al.* 2007 studied that increases in baking temperature 200°C to 300°C there is drastically decrease in reducing sugar range from 13.30 to 1.22%. Sung *et al.* (2017) also studied the similar result that as the baking temperature 205°C increases there is decrease in non-reducing sugar, there is significant change in reducing sugar in cookies during baking. Khapre *et al.* (2015) studied on fig powder cookies baked at temperature 160 °C, non-reducing sugar reaches 22.9%

5. Total Sugar

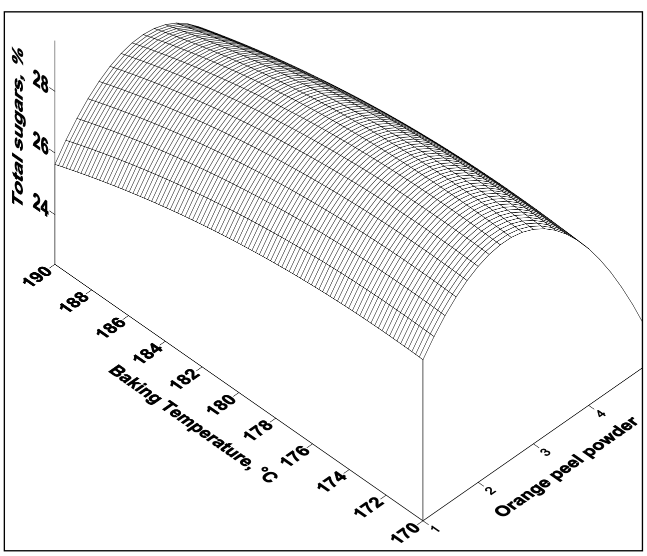

Fig. 6(a): Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Total Sugar (%) of Orange peel powder cookies

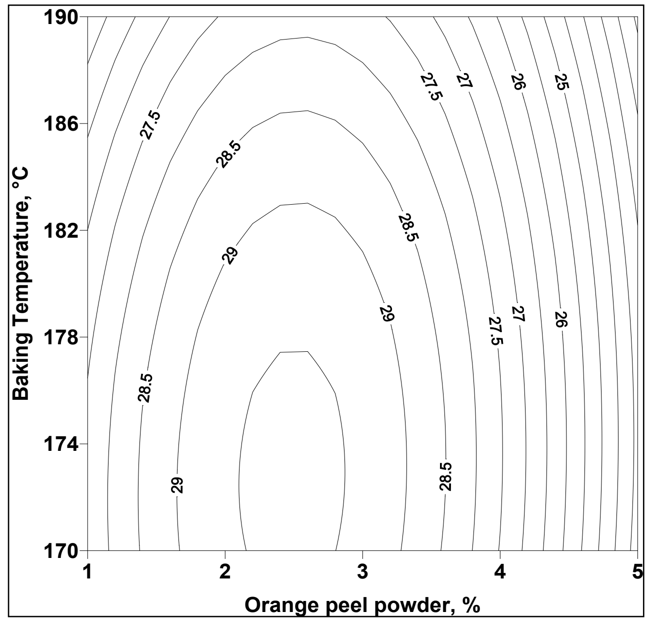

Fig. 6(b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Total Sugar (%) of Orange peel powder cookies

Fig. 6 (a) shows the surface plot showing the effect of baking temperature (°C) and orange peel powder (%) on the total sugar of orange peel cookies. The total sugar varies in the range of 21.62 to 33.63 % as the incorporation of orange peel powder (%) increases in the cookies from 1 to 5% the total sugar increase upto 3 % orange peel and followed by decreasing in trend up to 5% orange peel powder decreases. As the baking temperature increases total sugar decreases. Fig. 5(b) shows the contour plot of effect of baking temperature (°C) and orange peel powder (%) in cookies on total sugar. As both the baking temperature and orange peel powder (%) increases total sugar increases.

Table 2(e) shows the ANOVA for effect of baking temperature (°C) and incorporation of orange peel powder (%) of cookies on total sugar. Total sugar shows the significant effect at p on baking temperature (°C) and incorporation of orange peel powder (%) of cookies. The interaction of baking temperature (°C) and incorporation of orange peel powder (%) in cookies shows significant effect on total sugar in cookies. The effect of incorporation of orange peel powder(%) and the baking temperature

(°C) on total sugar was determined by the second order polynomial equation (5) the equation is well fitted to the experiment data with $R^2 = 0.9892$; MSE = 1.1866

$$T_S = 9.142 \times 10^{-1} O_p^{\,2} + 3.238 O_p + 7.562 \times 10^{-3} O_p B_T + 2.062 B_T - 6.025 \times 10^{-3} B_T^{\,2} - 1.524 \quad \ldots(5)$$

Where, T_S = Total sugar(%), O_p is the Orange peel powder(%), B_T is the Baking temperature(°C)

Norhayati *et al.* 2015 reported that total sugar range from 4.96 to 39.13 g/100g. Ameur *et al.* 2007 reported that as the baking temperature increases from 200°C to 300°C there is degradation of total sugar. Hosamani *et al.* 2016 reported that decrease in total sugar in jackfruit and carrot powder biscuits is due to the interaction of added sugar with the chemical components during the process of baking temperature at 200°C, results total sugar content reached from 9.82 to 9.25%. Charissou *et al.* 2007 and Ameur *et al.* 2007 reported that increases in baking temperature 200°C to 300°C there is decrease in Total sugar.

6. Ascorbic acid

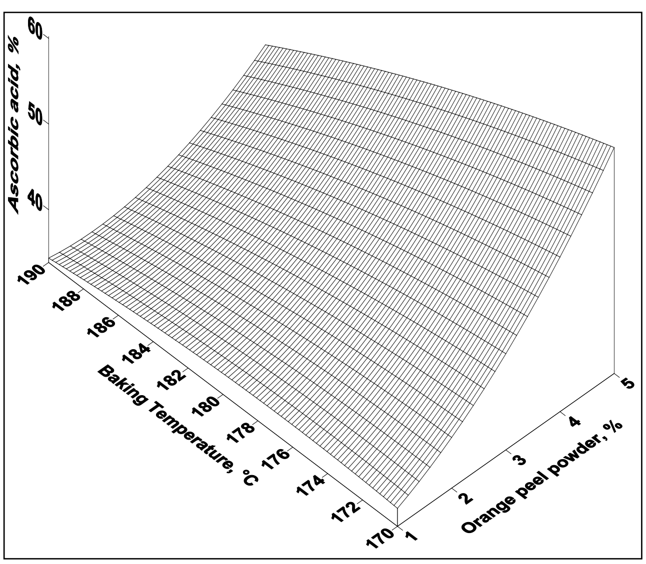

Fig. 7(a): Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Ascorbic acid of Orange peel powder cookies

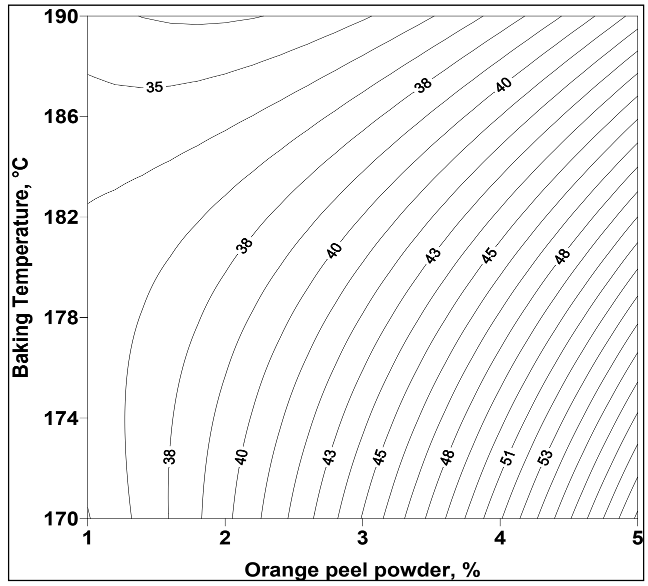

Fig. 7(b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Ascorbic acid of Orange peel powder cookies

Fig. 7 (a) shows the surface plot showing the effect of baking temperature (°C) and orange peel powder (%) on the ascorbic acid of orange peel cookies. The ascorbic acid varies in the range of 29.4 to 59.5 %. As the orange peel powder (%) in the cookies increases from 1 to 5% the ascorbic acid increases. As the baking temperature increases ascorbic acid decreases. Fig 7(b) shows the contour plot of effect of baking temperature(°C) and orange peel powder (%) in cookies on ascorbic acid. As both the baking temperature(°C) and orange peel powder (%) increases ascorbic acid decreases.

Table 2 (f) shows the ANOVA for effect of baking temperature (°C) and incorporation of orange peel powder (%) of cookies on ascorbic acid. Ascorbic acid shows the significant effect at p on baking temperature(°C) and incorporation of orange peel powder (%) of cookies. The interaction of baking temperature (°C) and incorporation of orange peel powder (%) in cookies shows significant effect on ascorbic acid in cookies. The effect of incorporation of orange peel powder(%) and the baking temperature (°C) on ascorbic acid was determined by the second order polynomial equation (6) the equation is well fitted to the experiment data with $R^2 = 0.972$; MSE= 7.278

$$A_a = 7.570 \times 10^{-1} O_p^2 + 3.816 O_p - 2.153 \times 10^{-1} O_p B_T + 4.195 B_T - 1.127 B_T^2 - 3.37 \quad \ldots(6)$$

Where, A_a =Ascorbic acid (%), O_p is the Orange peel powder(%), B_T the Baking temperature(°C).

Pratyush *et al.* 2015 reported that in pumpkin powder fortified cookies there is decrease in vitamin C content because vitamin C is sensitive to heat, light and air. Some of the ascorbic acid is also lost due to high baking temperature provided to the cookies (175ºC) ascorbic acid ranged from 7.68 to 15.37mg/100g. Ogunjobi *et al.* 2010. As the ascorbic acid is representing the vitamin C in orange peel cookies, these are the molabile and sensitive to the heat. Increase in temperature due to increase in baking temperature with deceases in Ascorbic acid might attributed due to their mortality of the vitamin C of orange peel cookies with increase in baking temperature.

7. Hardness

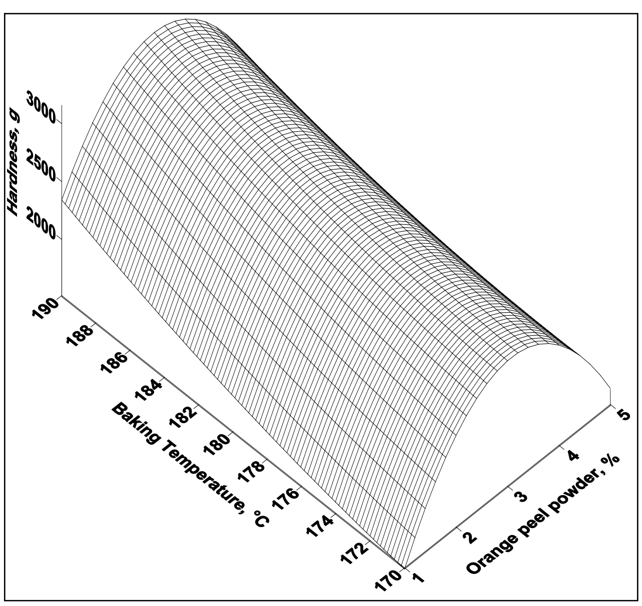

Fig. 8(a): Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (ºC) on Hardness(g) of Orange peel powder cookies

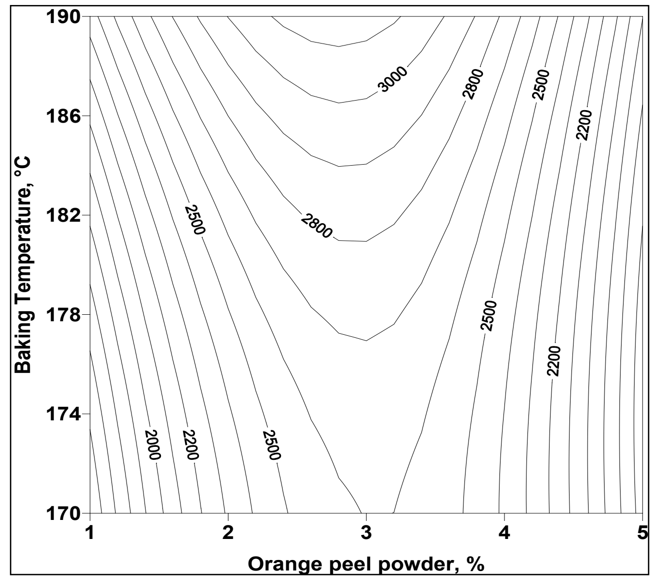

Fig. 8(b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (ºC) on Hardness(g) of Orange peel powder cookies

Fig. 8 (a) shows the surface plot showing the effect of baking temperature (°C) and orange peel powder (%) on the hardness (g) of orange peel cookies. The hardness varies in the range of 1186 to 3778g as the orange peel powder (%) increases in the cookies from 1 to 5% the hardness increases. Hardness increases from 1% to 3% of peel powder and then slightly decreases from 4% to 5 %. As the baking temperature increases hardness increases. Fig 8(b) shows the contour plot of effect of baking temperature and orange peel powder (%) in cookies on hardness. As both the baking temperature and orange peel powder (%) increases hardness increases.

Table 2 (g) shows the ANOVA for effect of baking temperature (°C) and orange peel powder (%) of cookies on hardness. Hardness shows the significant effect at p on baking temperature and orange peel powder (%) of cookies. The interaction of baking temperature (°C) and (%) of orange peel powder in cookies shows non-significant effect on hardness in cookies. The effect of incorporation of orange peel powder(%) and the baking temperature (°C) on hardness was determined by the second order polynomial equation (7) the equation is well fitted to the experiment data with $R^2 = 0.9278$; MSE = 6.24811

$$H_n = -2.545O_p^{\,2} + 2.808O_p - 7.330O_p\, B_T - 3.135B_T + 1.007\, B_T^{\,2} + 2.4401 \qquad \ldots(7)$$

Where, H_n = Hardness (g), O_p is the Orange peel powder(%), B_T is the Baking temperature(°C)

Arifin *et al.* 2009 and Piga *et al.* 2005 shows high hardness due to freshly baked enriched margarines and amaretti cookies due to moderate baking temperature. Mudgil *et al*. 2016 studied different level of baking time and temperature of cookies, hardness of cookies increases with increase in level of baking temperature and time.

8. Browning Index

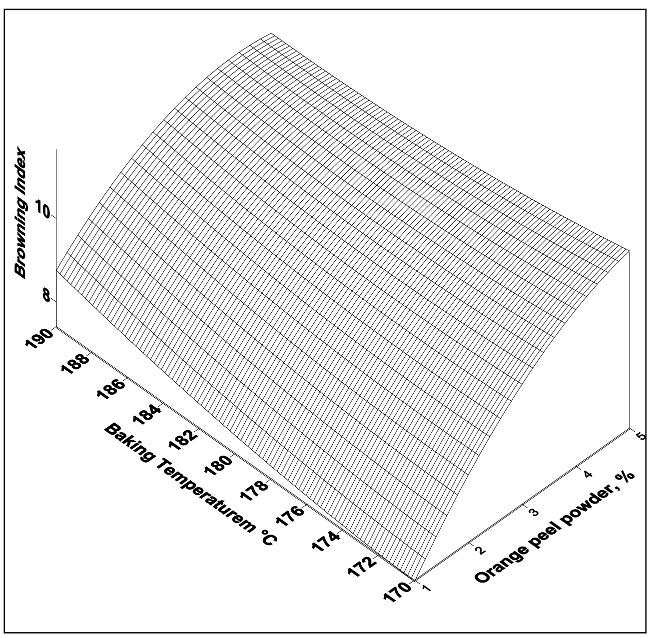

Fig. 9 (a): Surface plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Browning Index of Orange peel powder cookies

Fig. 9 (a) shows the surface plot showing the effect of baking temperature (°C) and orange peel powder (%) on the browning index of orange peel cookies. The browning index varies in the range of 5.146 to 11.370. As the incorporation of orange peel powder (%) increases in the cookies from 1 to 5% the browning index increases. As the baking temperature (°C) increases browning index increases.

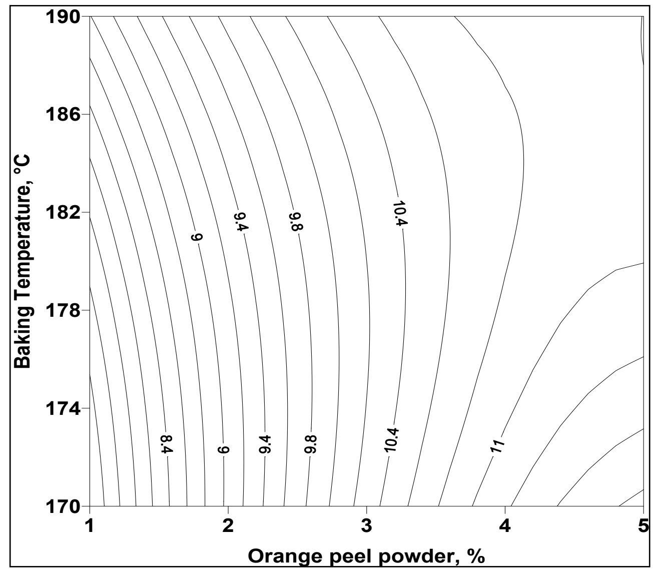

Fig. 9 (b): Contour plot showing the effect of incorporation of Orange peel powder (%) and Baking Temperature (°C) on Browning Index of Orange peel powder cookies

Fig. 9 (b) shows the contour plot of effect of baking temperature (°C)and incorporation of orange peel powder (%) in cookies on browning index. As both the baking temperature and orange peel powder (%) increases browning index increases.

Table 2 (h) shows the ANOVA for effect of baking temperature (°C) and incorporation of orange peel powder (%) of cookies on browning index. Browning index shows the significant and effect at *p* on baking temperature (°C) and incorporation of orange peel powder (%) of cookies. The interaction of baking temperature (°C) and incorporation of orange peel powder(%) in cookies also shows significant effect on browning index in cookies. The effect of incorporation of orange peel powder (%)and the baking temperature (°C) on browning index was determined by the second order polynomial equation (8) the equation is well fitted to the experiment data with $R^2 = 0.986$; MSE = 2.012

$$B_I = 1.717 \times 10^{-1}\, O_p 2 + 6.970O_p - 2.798 \times 10^{-2}\, O_p\, B_T - 0.736B_T + 2.316 \times 10^{-3}\, B_T^{\,2} + 6.373 \qquad \ldots(8)$$

Where, B_I = Browning Index, O_p is the Orange peel powder(%), B_T is the Baking temperature(°C)

Hosamani *et al.* 2016 reported the darkness in biscuits is due to Millard reaction between sugar due to high temperature of baking (200°C). Sung *et al.* 2017 reported the similar result, the browning index value increased with increasing in baking time. Increases baking temperature with time generates the Millard reaction which compared to reducing sugar and non-reducing sugar (% glucose and % sucrose). Kulthe *et al.* 2017 reported colour developed in backed product is caused by Millard reactions between sugars, the Millard reactions is no-enzymatic reaction, baking temperature might affect, cause browning reaction in the cookies and resulting the more browning index.

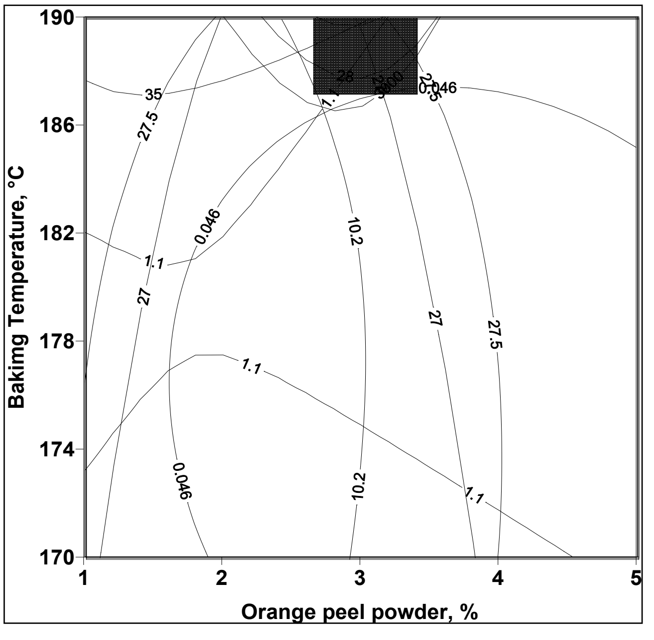

Fig. 10: Superimposed contour plots of desirable properties

9. Optimization of cookies parameter

Fig. 10 shows that superimposed contour plot showing the optimum zone of orange peel powder 2.6 to 3.6% and Baking Temperature 188 to 190°C of orange peel cookies. The desirable properties of orange peel cookies should have more TSS, acidity, Reducing sugar, Non-Reducing sugar, Total sugar more ascorbic acid and moderate Hardness and browning index. The contour plots of all the responses were superimposed to get desirable TSS, Acidity, Reducing sugar, Non-Reducing sugar, Total sugar, Ascorbic acid, Hardness and Browning index. The desirable property occurs at (2.6 - 3.6%) incorporation of orange peel powder in cookies and baked at (188 -190°C) baking temperature. The properties at the zone are TSS 41.6ºBrix, Acidity 0.04%, reducing sugar 0.98%, Non-Reducing sugar 27.08%, Total sugar 28.07%, Ascorbic acid 31.15%, Hardness 2980g and Browning index 8.602.

Sensory Analysis

The data obtained for sensory properties viz. colour, flavor and texture of orange peel cookies as per the nine point hedonic scale were determined by semi-trained panel for treatment T_1 to treatment T_{18} are given in Table 3. The average colour scores of orange peel cookies ranged between 49.4 to 59. Sample code I received the highest colour score among all the codes. Table 4 (a) ANOVA shows the no significant effect at *p* on baking temperature (°C) and incorporation of orange peel powder (%) of cookies on color. The interaction of baking temperature and incorporation of orange peel powder in cookies also shows no significant effect on color of cookies.

The average flavor scores of orange peel cookies ranged between 46.5 to 59.6. Sample code I received the highest flavor score 59.6 among all the codes. Table 4 (b) ANOVA shows the no significant effect at pon baking temperature (°C) and incorporation of orange peel powder (%) of cookies on flavor. The interaction of baking temperature and incorporation of orange peel powder in cookies also shows no significant effect on flavor of cookies.

The average texture scores of orange peel cookies ranged between 52.7 to 60.6. Sample code I received the highest texture score 60.6 among all the codes. Table 4 (c) ANOVA shows the no significant effect at pon baking temperature (°C) and incorporation of orange peel powder (%) of cookies on flavor. The interaction of baking temperature and incorporation of orange peel powder in cookies also shows no significant effect on flavor of cookies.

Table 2: Statistical analysis of orange peel cookies parameters

(a) TSS							
Treatment	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
D_1	44.200	43.267	40.067	20.067	45.600	42.133	39.222
D_2	60.667	28.733	40.067	20.733	44.733	32.333	37.878
D_3	44.400	24.733	41.600	16.733	44.733	28.467	33.444
Mean	49.756	32.244	40.578	19.178	45.022	34.311	36.848
		S.Em ±			**CD at 5%**		
Treatment (T)		0.925			2.645		
Temperature (D)		0.654			1.870		
Interaction (T×D)		1.602			4.597		
(b) Acidity							
Treatment	**T_1**	**T_2**	**T_3**		**T_4**	**T_5**	**Mean**
D_1	0.047	0.060	0.023	0.060	0.067	0.033	0.048
D_2	0.037	0.037	0.070	0.063	0.047	0.047	0.050
D_3	0.023	0.043	0.040	0.057	0.033	0.043	0.040
Mean	0.036	0.047	0.044	0.060	0.049	0.046	0.047
		S.Em ±			**CD at 5%**		
Treatment (T)		0.002			0.007		
Temperature (D)		0.001			0.005		
Interaction (T×D)		0.004			0.012		
(c) Reducing sugar							
Treatment	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
D_1	1.350	0.740	1.123	1.120	1.033	0.560	0.988
D_2	1.317	1.363	1.313	1.253	1.870	0.787	1.317
D_3	1.003	0.733	0.980	1.033	2.200	0.663	1.102
Mean	1.223	0.946	1.139	1.136	1.701	1.136	1.213
		S.Em ±			**CD at 5%**		
Treatment (T)		0.018			0.052		
Temperature (D)		0.013			0.037		
Interaction (T×D)		0.031			0.091		
(d) Non-reducing sugar							
Treatment	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
D_1	23.517	32.893	25.857	27.720	21.087	28.117	26.532
D_2	28.250	22.440	32.173	26.597	19.513	24.827	25.633
D_3	21.017	28.160	27.087	20.587	22.477	28.887	24.702
Mean	24.261	27.831	28.372	24.968	21.026	25.622	25.347
		S.Em ±			**CD at 5%**		
Treatment (T)		0.516			1.476		
Temperature (D)		0.365			1.044		
Interaction (T×D)		0.894			2.566		

(e) Total sugar

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	Mean
D_1	24.917	33.633	26.980	28.840	22.120	28.737	27.538
D_2	29.253	23.803	33.487	26.757	21.383	25.613	26.716
D_3	22.333	28.893	28.067	21.620	24.343	26.685	25.324
Mean	25.501	28.777	29.511	25.739	22.616	27.012	26.526
		S.Em ±			**CD at 5%**		
Treatment (T)		0.513			1.466		
Temperature (D)		0.362			1.036		
Interaction (T×D)		0.888			2.548		

(f) Ascorbic acid

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	Mean
D_1	39.200	37.100	36.787	59.500	56.980	39.200	44.794
D_2	37.100	25.270	38.360	65.800	46.070	37.680	41.713
D_3	29.400	38.640	31.150	39.900	37.870	39.270	36.038
Mean	35.233	33.670	35.432	55.067	46.973	38.717	40.849
		S.Em ±			**CD at 5%**		
Treatment (T)		1.508			4.311		
Temperature (D)		1.066			3.048		
Interaction (T×D)		2.612			7.492		

(g) Hardness

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	Mean
D_1	1523.333	1530.000	2393.333	3313.333	1186.667	2043.333	1998.333
D_2	1553.333	1506.667	2666.667	3976.667	1080.000	2486.667	2211.667
D_3	2273.333	2286.667	3013.333	3776.667	1070.000	2880.000	2550.000
Mean	1783.333	1774.444	2691.111	3688.889	1112.222	2253.333	2217.222
		S.Em ±			**CD at 5%**		
Treatment (T)		23.650			67.599		
Temperature (D)		18.3197			52.362		
Interaction (T×D)		40.964			117.178		

(h) Browning Index

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	Mean
D_1	8.675	8.720	9.868	11.371	10.954	29.778	13.228
D_2	5.147	9.737	11.224	13.002	10.455	29.346	13.152
D_3	10.271	9.267	8.623	10.646	11.245	38.662	14.786
Mean	8.031	9.241	9.905	11.673	10.884	32.596	13.722
		S.Em ±			**CD at 5%**		
Treatment (T)		0.057			0.163		
Temperature (D)		0.040			0.115		
Interaction (T×D)		0.099			0.280		

Table 3: Sensory quality of orange peel cookies

	Sensory Response			
Sample code	**Color**	**Flavor**	**Texture**	**Total**
A	53.2	55.7	52.7	161.6
B	55.4	56.7	57.5	169.6
C	54.8	55.7	56.8	167.3
D	54.9	54.8	57.9	167.6
E	55.4	54.8	57.5	167.7
F	56.2	54.9	57.5	168.6
G	55.8	54.3	57.9	168
H	56.5	56.4	57.5	170.4
I	**59**	**59.6**	**60.6**	**179.2**
J	54.1	55.7	57.6	167.4
K	52	54.6	55.9	162.5
L	53.4	56.7	57.2	167.3
M	53.3	48.5	55.8	157.6
N	51.3	51.3	55.3	157.9
O	49.4	46.5	55.2	151.1
P	53.6	47.1	53.7	154.4
Q	56.7	49.5	56.6	162.8
R	54.9	49.5	53.2	157.6

From the sensory score the color, flavor and texture score is non-significantly at *p*. It can be concluded that treatment with incorporation of 3% orange peel powder in cookies with baking temperature 190°C (code I) has the highest score (colour 59; flavor 59.6; texture 60.6) resulted the best treatment average then all treatments.

Corelation between the objective and subjective scores:

The optimum product at from section 3.1 orange peel powder 3% incorporated in cookies and baked at 190°C temperature the product achieved the desirable qualities i.e. TSS 41.6°Brix, Acidity 0.04%, reducing sugar 0.98%, Non-Reducing sugar 27.08%, Total sugar 28.07%, Ascorbic acid 31.15%, Hardness 2980g and Browning index 8.602643 respectively.

The best sensory score of the product have been obtained from section 3.2 at Orange peel powder 3% incorporated in cookies and baked at 190°C temperature, the product achieved the highest color 59, flavor 59.6 and Texture 60.6

From both Phytochemical properties and the sensory the best product achieved i.e. Orange peel powder incorporated at 3 % and baked at 190 °C.

Table 4: ANOVA of sensory

(a) Colour							
Treatment	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
D_1	53.200	54.900	55.800	59.000	53.400	49.400	54.283
D_2	55.400	55.400	55.800	54.100	53.300	53.600	54.600
D_3	54.800	56.200	56.500	52.000	51.300	56.700	54.583
Mean	54.467	55.500	56.033	55.033	52.667	53.233	54.489
		S.Em ±			**CD at 5%**		
Treatment (T)		8.551			NON SIG		
Temperature (D)		12.093			NON SIG		
Interaction (T×D)		4.936			NON SIG		
(b) Flavor							
Treatment	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
D_1	55.700	54.800	54.300	55.700	48.500	47.100	52.683
D_2	56.700	54.800	56.400	54.600	51.300	49.500	53.883
D_3	55.700	54.900	59.600	56.700	46.500	49.500	53.817
Mean	56.033	54.833	56.767	55.667	48.767	48.700	53.461

		S.Em ±			CD at 5%		
Treatment (T)		8.416			NON SIG		
Temperature (D)		11.902			NON SIG		
Interaction (T×D)		4.858			NON SIG		
(c) Texture							
Treatment	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean**
D_1	52.700	57.900	57.900	57.600	55.800	53.700	55.933
D_2	57.500	57.500	57.500	55.900	55.300	56.600	56.717
D_3	56.800	57.500	60.600	57.200	55.200	53.200	56.750
Mean	55.667	57.633	58.667	56.900	55.433	54.500	56.467
		S.Em ±			**CD at 5%**		
Treatment (T)		8.867			NON SIG		
Temperature (D)		12.541			NON SIG		
Interaction (T×D)		5.119			NON SIG		

CONCLUSION

The best quality of orange peel powder fortified cookies,can be produced with incorporation of orange peel powder 3% and baking temperature at 190**°C.** With physiochemical properties, TSS 41.6ºBrix, acidity 0.04%, reducing sugar 0.98%, Non-Reducing sugar 27.08%, Total sugar 28.07%, ascorbic acid 31.15%, Hardness 2980 g and Browning index 8.602with sensory score color 59, flavor 59.6 and texture 60.6 respectively.

REFERENCES

Akpinar, E.K., Bicer, Y. and Cetinkaya, F. 2006. Modelling of thin layer drying of parsley leaves in a convective dryer and under open sun. *Journal of food engineering,* **75**(3): 308-315.

Ameur L.A., Mathieu O., Lalanne V., Trystram G., Birlouez-Aragon I. 2007. Composition of the effect of sucrose and hexose on furfural formation and browning in cookies baked at different temperatures. *Food chemistry,* **101**: 1407-1416

Arifin, N., Peng, K.S., Long, K., Ping, T.C., Yusoff, M.S.A., Aini, I.N. and Ming, L.O. 2010. Relationship between textural properties and sensory qualities of cookies made from medium- and long- chain triacyglycerol-enrihed margarines. *Journal of science food Agriculture,* **90**: 943-948

Anonymous, 2011. *http://midh.gov.in/technology/State-Wise-Horticulture-Status.pdf.*Date of acess 25/11/2016

Anderson, J.W., Baird, P., Davis, R.H., Ferreri, S., Knudtson, M., Koraym, A. and Williams, C.L. 2009. Health benefits of dietary fiber. *Nutrition reviews,* **67**(4): 188-205.

Ashbell, G., Weinberg, Z.G. and Azrieli, A. 1988. Effect of blanching on loss reduction in orange peel storage, *J. Sci. food Agric.*, **45**: 195-201.

A.O.A.C. 1975. Official methods of analysis. Association of official analytical chemists, Washington D.C., USA.

A.OA.C, 1995. *Official methods of analysis. Association of official analytical chemists, Washington DC.*

Akdas, S. and Baslar, M. 2015. Dehydration and degradation kinetics of bioactive compounds for mandarin slices under vacuum and oven drying conditions. *Journal of Food Processing and Preservation*, **39**: 1098-1107.

Arifin, N., Peng, K.S., Long, K., Ping, T.C., Yusoff, A.S.M., Aini, N.I. and Ming, O.M. Relationship between textural proprrties and sensory qualities of cookies made from medium- and long-chain triacylglycerol-enriched margarines. *Journal of Food Agriculture,* **90**: 943-948

Babajide, J.M., Obadina, A.O., Oyewole, O.B. and Ugbaka, L.N. 2006. Microbial quality of dry yam''gbodo''parboiled with⁄ without adjuncts. *African Journal of Biotechnology,* **5**: 278-281.

Bakar, J. and Hin, Y.S. 1985. High-Protein Rice-Soya Breakfast Cereal. *J. of Food Processing and Preservation,* **8**(3-4): 163-174.

Benavonte – Garcia, O., Castillo, J., Marin, F.R., Ortuno, A. and Rio, J.A. 1997. Uses and properties of *Citrus flavonoids, J. Agric. Food Chem.*, **45**: 4505- 4515.

Braddock, R.J. 1995. Byproducts of citrus fruits. *Food Technol.,* **49**: 74–77.

Braddock, R.J., Temelli, F. and Cadwallades, K.R. 1986. Citrus essential oils – a dossier for material safety data sheets. *Food Technol.,* **40**(11): 114-116.

Bocco, A., Cuvelier, M.E., Richard, H. and Berset, C. 1998. Antioxidant activity and phenolic composition of citrus peel and seed extracts. *J. of Agril. and Food Chem.*, **46**(6): 2123-2129.

Bok, S.H., Lee, S.H., Park, Y.B., Bae, K.H., Son, K.H., Jeong, T.S. and Choi, M.S. 1999. Plasma and hepatic cholesterol and hepatic activities of 3-hydroxy-3-methyl-glutaryl-CoA reductase and acyl CoA:cholesterol transferase are lower in rats fed citrus peel extract or a mixture of citrus bioflavonoids. *The Journal of Nutrition*, **129**(6): 1182-1185.

Choi, M.S., Do, K.M., Park, Y.B., Jeon, S.M., Jeong, T.S., Lee, Y.K. and Bok, S.H. 2001. Effect of naringin supplementation on cholesterol metabolism and antioxidant status in rats fed high cholesterol with different levels of vitamin E. *Annals of Nutrition and Metabolism*, **45**(5): 193-201.

Chakraverty A. 1994. Post Harvest Technology of Cereals, Pulses and Oilseeds. New Delhi Oxford and IBH Publishing Co, Third Edition.

Cheryan, M., McCUNE, T.D., Nelson, A.I, and Ferrier, L.K. 1979. Preparation and properties of soy-fortified cereal weaning foods. *Cereal Chemistry*.

Charissou, A., Ait-Ameur, L. and Birlouez-Aragon, I. 2007. Kinetics of formation of three indicators of the Maillard reaction in model cookies: influence of baking temperature and type of sugar. *Journal of agricultural and food chemistry*, **55**(11): 4532-4539.

Daymaz, I. 2012. Prediction of drying characteristics of pomegranate arils. *Food Anal Methods*, **5**: 841-848.

Devi, M.S.S. and Banumathi, P. 2012. Effect of incorporation of fruit powders in instant biscuit mixes. *Madras Agricultural Journal*, **99**(10/12): 910-914.

Depilli, T., Lovino, R., Maenza, S., Derossi, A. and Sevevini, C. 2008. Study on operating conditions of orange drying procession: Comparison between conventional and combined treatment. *J. food process Preservation*, **32**: 751- 769.

Economas, C. and Clay, W.D. 1999. Nutrition and health benefits of Citrus fruits *In:* Twelfth session of the Intergovernmental Group on Citrus Fruit, 22-25 September 1998, Valencia, Spain.

Figuerola, F., Hurtado, M.L., Estévez, A.M., Chiffelle, I. and Asenjo, F. 2005. Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. *Food Chemistry*, **91**(3): 395-401.

Fernadez-Lopez, J., Sendra-Nadal, E., Navarro, C., Sayas, E. and Viuda-Martos, M. 2009. Fibre powder from orange by-products. *International journal of food science & technology*, **44**(4): 748-756.

Hosamani, R., Jagadeesh, S.L., Suresha, G.J. and Tumumaramatti, S. 2016. Fortification of Carrot, Jackfruit and Aonla Powser to Enhance Nutritional and Sensory Qualities of sweet biscuits. *Journal of Nutritional Health and Food Engineering*, **4**(3): 00130

Hegazy, A.E. and Ibrahium, M.I. 2012. Antioxidant activities of orange peel extracts. *World Appl. Sci. J.*, **18**: 684–688.

Hull, W.Q., Lindasy, C.W. and Baier, W.E. 1953. Chemicals from oranges, *Ind. Engg. Chem*., **45**(5): 876-890.

Jiang, N., Jin, L.F., da Silva, J.A.T., Islam, M.Z., Gao, H.W., Liu, Y.Z. and Peng, S.A. 2014. Activities of enzymes directly related with sucrose and citric acid metabolism in citrus fruit in response to soil plastic film mulch. *Scientia Horticulturae*, **168**: 73-80.

Jayathilakan, K., Sultana, K., Radhakrishna, K. and Bawa, A.S. 2012. Utilization of Byproducts and Waste Materials from Meat, Poultry and Fish Processing Industries: A Review. *Journal of food science and Technology*, **49**(3): 278-293.

Jung, J.U., M.-K.Lee, K.-S. Jeong, and Choi, M.-S. 2004. The hypoglycemic effects of hesperidin and naringin are partly mediated by hepatic glucose-regulating enzymes in C57BL/KsJ-db/db mice. *J. Nutr.*, **134**: 2499–2503.

Jagannath, A. and Kumar, M. 2016. Monitoring blanching induced debit5ering and storage losses of naringin in orange subjected to Osmotic degydration. *International Journal of Fruit Science, pp. 1-3.*

Kumar, B. 2010. Indian Horticulture Database (2009). National Horticulture Board, Ministry of Agriculture, Government of India, Gurgaon, India, pp. 1-275.

Kumar, P., Dorcus, M. and Chitra, S. 2015. *Development and Quality Evaluation of Pumpkin Powder Fortified Cookies*, **3**(4).

Kulthe, A.A., Thorat, S.S. and Lande, S.B. 2017. Evaluation of Physical and Textural Properties of Cookies Prepared from Pearl Millet Flour. *Int. J. Curr. Microbiol. App. Sci.*, **6**(4): 692-701

Khapre, A.P., Satwadhar, P.N. and Deshpande, H.W. 2015. Studies on standardization of fig fruit (*Ficuscarica* L.) powder enriched cookies and its composition *Asian J. Dairy & Food Res.*, **34**(1): 71-74.

Kong, K.W., Ismail, A.R., Tan, S.T., Prasad, N., Murthy, K. and Ismail, A. 2010. Response surface optimisation for the extraction of phenolics and flavonoids from a pink guava puree industrial by-product. *International Journal of Food Science and Technology*, **45**(8): 1739-1745.

Li, N., Z. Xu, P.H. Wooley, J. Zhang, and S.-Y.Yang. 2014. Therapeutic potentials of naringin on polymethyl-methacrylate induced osteoclastogenesis and osteolysis, in vitro and in vivo assessments. *Drug Des. Dev. Ther.*, **8**: 1–11.

Labuza, T.P., Panda, F., Roos, Y., Sury, R., Roe, K., Sherwin, C., Puhek, T., Patist, A. and Zoerb, A. 2002. *In:* http://faculty.che.umn.edu/fscn/Ted_Labuza/PDF_files/Presentations/XRDCookiesFull.pdf

Manley, D. 1998. Biscuit, Cookie, and Cracker Manufacturing, Manual 1: Ingredients (Vol. 1). Woodhead Publishing.

Moreno-Perez, L.F., Gasson-Lara, J.H. and Ortega-Rivas, E. 1996. Effect of low temperature-long time blanching on quality of dried sweet potato. *Drying technology*, **14**(7-8), 1839-1857.

Mudgil, D., Barak, S. and Khatkar, B.S. 2017. *Cookies texture, spreed ratio and sensory acceptability of cookies as a function of soluble dietary fiber, baking time and different water levels. (2017) LWT-Food Science and Technology 30154-8.*

Ogunjobi, M.A.K. and Ogunwolu, S.O. 2010. Physicochemical and sensory properties of cassava flour biscuits supplemented with cashew apple powder. *Journal of food technology*, **8**(1): 24-29.

Orikasa, T., Kaide, S., Okamoton, S., Imaizumi, T., Muramatsu, Y., Takeda, J., Shina, T. and Tagawa, A. 2014. Impacts of hot air and |Vacuum drying on quality attributes of kiwi fruit slices. *J. food Engg.,* 51-58.

Piteria, M.F., Maia, J.M., Raymundo, A. and Sousa, I. 2006. Extensional flow behavior of natural fiber-filled dough and its relationship with structure and properties. *J. Non-Newtonian Fluid Mech.*, **137**: 72-80.

Plessas, S., Bekatorou, A., Koutinas, A.A., Soupioni, M., Banat, I.M. and Marchant, R. 2007. Use of Saccharomyces cerevisiae cells immobilized on orange peel as biocatalyst for alcoholic fermentation. *Bioresour, Technol.*, **98**(4): 860-856.

Piga, A., Catzeddu, P., Farris, S., Roggio, T., Sanguinetti, A. and Scano, E. 2005. Texture evolution of "Amaretti" cookies during storage. *Europe Food Research Technology*, **221**: 387-391

Pratyush, K., Masia, D. and Sonkar, C. 2015. Development and quality Evaluation of Pumpkin Powder Cookies, **3**: 2395-4752.

Ramirez-Santiago, C., Ramos-Solis, L., Lobato-Calleros, C., Peña-Valdivia, C., Vernon-Carter, E.J. and Alvarez-Ramírez, J. 2010. Enrichment of stirred yogurt with soluble dietary fiber from Pachyrhizuserosus L. Urban: Effect on syneresis, microstructure and rheological properties. *Journal of Food Engineering*, **101**(3): 229-235.

Ruiz- Diaz, G., Martinez- Monzo, J., Fito, P. and Chiralt, A. 2003. Modelling of dehydration – rehydration of orange slices in combined microwave / air drying.

Ranganna, S. 2003. Handbook of analysis and quality control for fruits and vegetable products. Tata McGraw-Hill Publishing Company Limited. New Delhi, pp. 11-12.

Saenz, C., Estévez, A.M. and Sanhueza, S. 2007. Utilización de residuos de la industria de jugos de naranjacomofuente de fibradietéticaen la elaboración de alimentos. *Archivoslatinoamericanos de Nutrición,* **57**(2): 186-191.

Saradha Devi, M.S. and Banumathi, P. 2012. Effect of Incorporation of Fruit Powders In Instant Biscuit Mixes. *Madras Agriculture Journal,* **99**(10-12): 910-914.

Sung, W.C. and Chen, C.Y. 2017. Influence of Cookies Formulation on the Formation of Acrylamide. *Journal of Food and Nutrition Research,* **5**(6): 370-378.

Senadeera, W., Bhandari, B.R., Young, G. and Wijesinghe, B. 2000. *Physical property changes of fruits and vegetables during hot air drying. In Drying technology in agriculture and food science (pp. 149-166). Science Publishers.*

Wei, M., Yang, Z., Li, P., Zhang, Y. and Sse, W.C. 2007. Anti-osteoporosis activity of naringin in the retinoic acid-induced osteoporosis model. *Am. J. Chin. Med.,* **35**(4): 663–667.

WenChieh Sung, Chih Ya Chen. 2017. Influence of Cookies Formulation on the Formation of Acrylamide**.** *Journal of Food and Nutrition Research,* **5**(6): 370-378.

Zaker, M.A., Sawate, A.R., Patil, B.M. and Sadawarte, S.K. 2016. Studies on effect of orange peel powder incorporation on physical, nutritional and sensorial quality of cookies, *International Journal of Research & Technology,* **5**(9): 78-82.