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Study on the selected engineering properties and sensory evaluation of tikur blended *Chhana podo* during infrared radiation assissted baking

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SUMMARY :

Chhana podo is a popular dairy product of the Indian sub-continent, prepared from cow milk standardized to 4 per cent fat and 8.5 per cent SNF. This energy rich product is commonly prepared by baking of *Chhana*, sugar, tikur, baking powder in ratio of 20:6:1:0.3 at temperature of 120°C-130°C with IR of 180-200 Volts. *Curcuma angustifolia Roxb*. (Tikur) is a low fat sweetner which reduces the risk of cardio-vascular diseases and diabetes. Addition of tikur to *Chhana podo* gives a brown crust with white or light brown inner body, moist crumb, moderately spongy cake like texture with a typical cooked flavour and rich taste. Baking time and temperature are two important process considerations influencing the heat and mass transfer, moisture content and product quality during baking. In this study the effect of IR on selected physico and textural characteristics of *Chhana podo* were studied at different combinations. The selected conditions for baking of *Chhana podo* 130°C and 200 V for 120 min with IR on at 60 min. and the parameters *viz.*, crumb and crust moisture contents and specific volume were determined as 22.74 per cent, 14.94 per cent and 1.23 cm^3/g, respectively. Textural attributes such as hardness, chewiness and gumminess increased with baking time and IR temperature while springiness, cohesiveness and resilience increased upto 80 min due to the filling-up of pores water and liquid by fat and expanding water, but decreased thereafter.

KEY WORDS : Chhana podo, Baking temperature, Moisture, Tikur, Effect of IR, Quality attribute

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India ranks first in milk production, accounting for 18.5 per cent of world production, achieving an annual output of 146.3 million tonnes during 2014-15 as compared to 137.69 million tonnes during 2013-14 recording a growth of 6.26 per cent whereas, the food and agriculture organization (FAO) has reported a 3.1

per cent increase in world milk production from 765 million tonnes in 2013 to 789 million tones in 2014. About 50-55 per cent of milk is converted into a variety of indigenous dairy products, mainly using the heat processes like heat and acid coagulation, heat desiccation and fermentation. The rest 46 per cent of milk produced in India was consumed as liquid milk.Traditional dairy products of India have long major commercial significance as they account for over 90 per cent of milk products consumedin the country (Aneja *et al.,* 2002). Roughly 7 per cent of total milk is converted into heat-acid coagulated products. *Chhana podo*, a popular dairy dessert of the Indian subcontinent, mainly most popular in Orissa and also constitutes the north Indian traditional dairy sweet product was oneamong these heat-acid coagulated products.

Traditionally, *Chhana podo* is prepared by mixing *Chhana*, semolina, refined wheat flour and sugar, then slowly baking the dough by keeping redhot burnt wood on the top and bottom of a vessel for about 2–4 h (Ghosh *et al.,*1998). It is characterised by a brown crust with white or light brown inner body with a typical cooked flavour and rich taste. It also has a moist crumb, moderately spongy cakelike texture and softbody and is sweetish, due to the addition of sugar.

Baking is the crucial step in the preparation of *Chhana podo*. It is a complex process in which physical and biochemical changes occur simultaneously, making the product palatable. Generally, surface colour, crust development and textural changes occur might be considered as critical indices for completion of baking. Formation of crust occurs (on the top surface) as maximum evaporation of moisture takes place there. Similarly, as moisture decreases in the crust, the temperature increases, facilitating the development of colour and flavour in the product. A porous structure is also created in the product as moisture diffuses outward to the surface of the product. Consequently, changes in hardness occur in the dough, which is vital in determining both product quality and process efficiency.These physicochemical changes occur simultaneously and are responsible for the formation of product crust and crumb having special sensory characteristics for texture, crispiness, surface colour and flavour (Zanoni *et al.*, 1995c). Baking time and temperature are two important process considerations influencing the heat and mass transfer, moisture content and product quality during baking.

Modernization changes in lifestyle and food habits have resulted in excessive amount energy intake contributing to the weight gain and major health problems like obesity, diabetes and cardio-vascular diseases, since the traditional dairy products are quite high in fat and sugar content. Sothere is high demand for low fat and low sugar versions which mainly restricts the calorie intake and to meet dietary requirements of obese persons, cardio-vascular diabetes and persons on weight management diets.

So the existing products can be modified by utilizing alternative sweetners and fat replacers with improved safety, functionality and stability. One such product is the powder obtained from the grains of *Curcuma angustifolia* Roxburgh. (Tikhur), Zingiberaceae. *Curcuma angustifolia* is also known as Indian Arrow root, 'Koova powder' in Malayalam and 'Koovapodi'in Tamil Nadu.

Therefore, in this context, a research work was undertaken to manufacture the product from raw milk, with low sugar content and artificial sweetner for lowering calorie content of the product. It is necessary to understand the physical and textural changes that occur during baking in order to effectively control the baking conditions that affect the quality of this product and to minimise energy consumption. Therefore, the aim of this work was to study the effects of time and temperature on the moisture content, specific volume and texture of *Chhana podo* during baking.

EXPERIMENTAL METHODS

Preparation process of *Chhana podo*:

Chhana was prepared as per the procedure outlined by Ghosh *et al*. (2002) with slight modifications. Raw milk for the experiments was collected from the farm of the National Dairy Research Institute, Bangalore. The milk fat and solids-not-fat (SNF) contents were determined using the Gerber method (BIS, 1981) and lactometer reading (BIS, 1982), respectively. Citric-acid solution at 2 per cent concentration was added slowly to coagulate the milk. The solution was gently stirred without breaking the coagulum and the pale green coloured whey was separated from it. The coagulum was then filtered through a fine muslin cloth and the *Chhana* thus, obtained was hung (along with the cloth) at ambient temperature and pressure for 45 min to drain out the whey. The process was shown step by step in the following flow chart.

The dough for *Chhana podo* was prepared by blending *Chhana*, sugar, tikhur, baking powder in ratio of

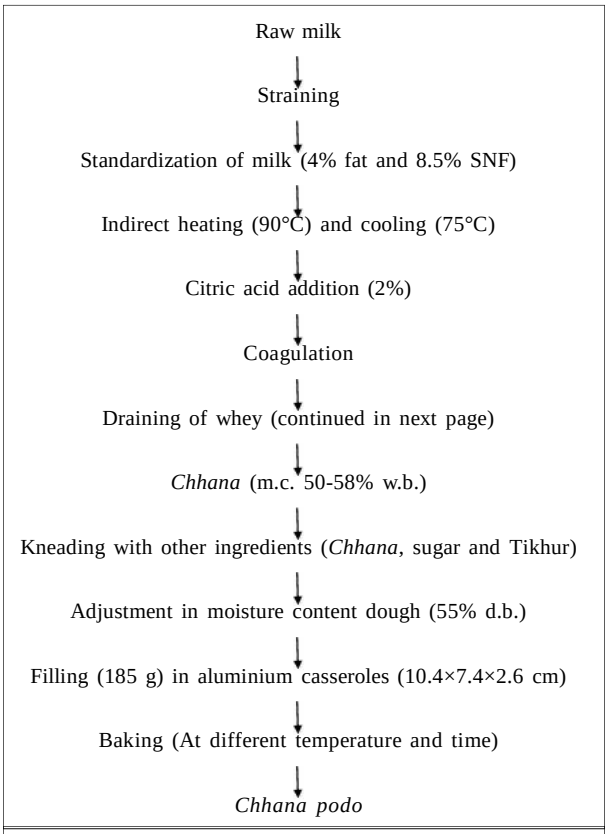

Fig. A : Process flow chart for the preparation of *Chhana podo*

20:6:1:0.3. All the ingredients were kneaded in a planetary dough blender (Lalith Industries, Bangalore, India) for 5 min with a hook-type beater.10 such casseroles were arranged on two stainless steel trays. Baking was carried out at different combinations such as with and without heater, Infra-red rays, fan respectively at different time. Baking was carried out in an electrical resistance oven (Dollar Equipment Pvt. Ltd., Bangalore, India) at temperatures of 120°C and 130°C using IR voltage of 180V and 200V. These temperatures were selected based on exploratory trials and baking was for 120 min at each temperature. The experiments were carried out and all measurements such as crumb and crust moisture, specific volume and textural properties were carried out at 20-min intervals.

Method for determination of crust - crumb moisture content:

In this method, about 2g of *Chhana podo* on the top and middle portion (*i.e.*, namely crust and crumb) of the sample were weighed separately (to 0.1 mg accuracy) in a precision balance and was taken into a dish, which was previously dried to 75 °C and weighed. About 5 ml of distilled water was used to smash and spread the sample evenly with help of glass rod for uniform evaporation. The dish was then heated in the electrical oven maintained at 102±1°C for 5 hr. Then the dish was cooled in the Desiccator and weighed. The mean weight was recorded. The moisture content of the dough was determined by the AOAC method (AOAC, 2000). All moisture measurements were run in triplicate and expressed in dry basis (kg/kg of dry solids).

In both these methods, the moisture percentage was determined by the following equation.

$$\text{Moisture (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where,

W_1 = Initial weight of the crucible, (g)

W_2 = Initial weight of the crucible with the sample before drying, (g)

W_3 = Initial weight of the crucible with the sample after drying, (g).

Method for determination of oven spring:

Oven spring was determined by recording the height of the dough and height of the baked *Chhana podo* samples. The thickness or height of the *Chhana podo* was measured using digital Vernier Callipers (Model: CD- 6" CSX, Mitutoya Corporation, Kawasaki, Japan). 8 readings were taken from different sides of *Chhana podo* for ach sample and the average thickness was noted. The determination of oven spring is helpful in determining the raise in the level of product after baking for each variability.

Method for determination of weight loss in *Channa podo* dough:

The initial weight of the dough taken and final weight after baking was noted. The percentage weight loss was determined using the formula:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of sample} - \text{Weight of the baked sample}}{\text{Initial weight of the sample}} \times 100$$

Method for measurement of thermal properties:

Thermal properties such as specific heat, thermal conductivity, thermal diffusivity and density of the baked *Chhana podo* dough at different time-temperature combinations were measured using KD2 Pro-analyser at every 20 min interval. Before performing the

experiment, the probe was calibrated and verified for its performance using two hole Delrin block supplied by the manufacture. The probe was inserted into the centre of the product. For each product taken at 20 min interval, 5 readings were noted and an average reading is taken.

Determination of specific volume:

The release of moisture from the product results in expansion of the baked product.The specific volume was determined after baking process using volume displacement method (BIS, 1982b) in which mustard seed was used instead of rapeseed. The fresh rapeseed used for volume displacement had diameter in the range of 1.0-1.25 mm. Here the porosity of the mustard seeds was negligible.

The specific volume was calculated as:

$$\text{Specific volume } (\frac{cm^3}{g}) = \frac{V_{sample}}{M_{sample}}$$

The density of seed was calculated as follows.

– A 500 ml graduated cylinder was weighed and filled with mustard seeds upto 500 ml mark.

– It was weighed again. The average of three readings was taken. The density of seed is taken as below.

$$\rho_{seed} = \frac{\text{Mass of cylinder filled with mustard seeds} - \text{Mass of empty cylinder}}{500}$$

The volume measurement by rapeseed method was done as follows.

–The empty weight of casserole ($M_{casserole}$). Then the casserole was filled with mustard seeds and the top surface was leveled using glass rod or ruler. It was weighed and noted.

–The weight of *Chhana podo* with the casserole (M_{sample}) was also noted after cooling the product to room temperature.

– The casserole containing the product was filled with mustard seeds and the surface was leveled using glass rod or ruler. It was weighed and readings were noted as M_{total}.

–The volume of sample (V_{sample}) was calculated using the following equations:

$$M_{seed} = M_{total} - M_{sample} - M_{casserole}$$

$$V_{seed} = \frac{M_{seed}}{\rho_{seed}}$$

$$V_{sample} = V_{casserole} - V_{seed}$$

Determination of textural properties:

The probe was calibrated to a distance of 50 mm above the sample surface.The product at different stages of baking was cut into pieces of 2.5 cm.The sample was positioned in centrally over the platform and computer was allowed to the programme by activating “run a test” option. The TPA test involved two bite compression with a depth of 8.5 cm with a time lapse of 120 sec between the two bites to yield the force time curve. For TPA the samples are weighed, each sample drawn at 20 min interval, were cut into squares of 25 × 25 × 17 mm size. The sample made into cube shape. Six replicas of each sample are tested at each intervaland the mean TPA values of the observations were calculated

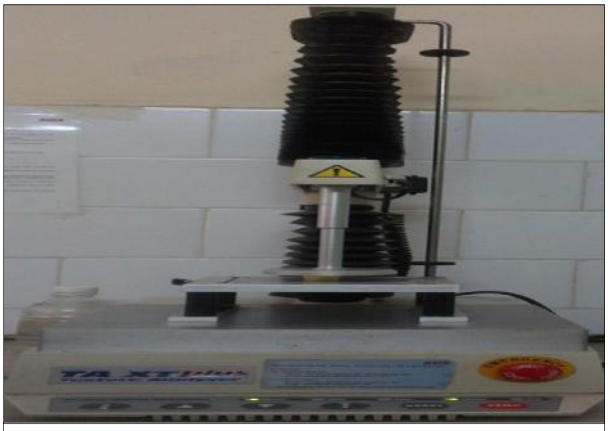

Fig. B : Texture analyser

The different properties obtained from this analysis are hardness, cohesiveness, springiness, chewiness, gumminess and resilience were determined from the force-time curve as was

– Hardness was calculated as the maximum peak force during the first compression of the product.

– Springiness is how well a product physically springs back after it has been deformed during the first compression. It is the relationship between the heigher that the food recovers during the time that elapses between the end of the first bite and the start of the second bite.

– Cohesiveness represents how well the product withstand a second deformation relative to how it behaved under the first deformation. Cohesiveness was calculated as the ratio of the positive force area during the second compression to that during for first compression.

– Chewiness was calculated as a product of gumminess and springiness.

– Gumminess was calculated as a product of hardness and cohesiveness.

– Resilience was calculated as the ratio of the first up stroke (decompression) to the down stroke (compression). It is a measurement of how the sample recovers from deformation.

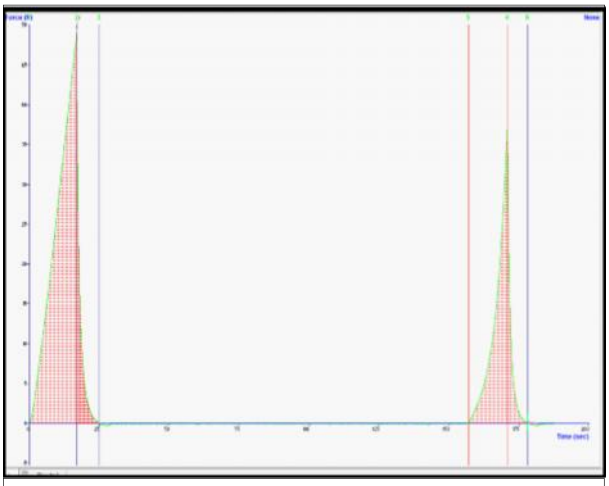

Fig. C : Graph of force-time deformation curve

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect on crumb moisture content:

Chhana podo is rich in proteins, it is similarly hypothesized that during baking, protein denaturation and dewatering occurred, which was absorbed by starch for gelatinization. These physico-chemical processes brought about the change in distribution of water content. Due to the temperature rise at the surface and heat transfer towards the centre, diffusion of water occurred. The moisture content of crumb decreased with increase in baking time and temperature. For the study condition HEATER 130° C+ FAN ON + 200V with IR ON from last 60 min of baking, moisture loss in crumb decreased from 55 per cent in fresh dough to 22.7386 per cent after 120 min of baking. It was found that temperature had a predominant influence than time on crumb moisture content. The moisture loss in crumb occurs in decreasing trend as shown in the given graph with baking time on absicca and moisture content on ordinate.

Effect on crust moisture content:

The crust moisture content of *Chhana podo* decreased with baking time. Similarly for above condition It decreased exponentially from 55 per cent (d.b) in fresh dough after baking for 80, 100, 120 min, respectively in podo to 16.0863, 14.9981 and 14.9405 at different time temperature combinations. The moisture loss in crust occurs in decreasing trend as shown in the given graph with baking time on absicca and moisture content on ordinate for the study condition HEATER 130°C+ FAN ON + 200V with IR ON from last 60 min of baking.

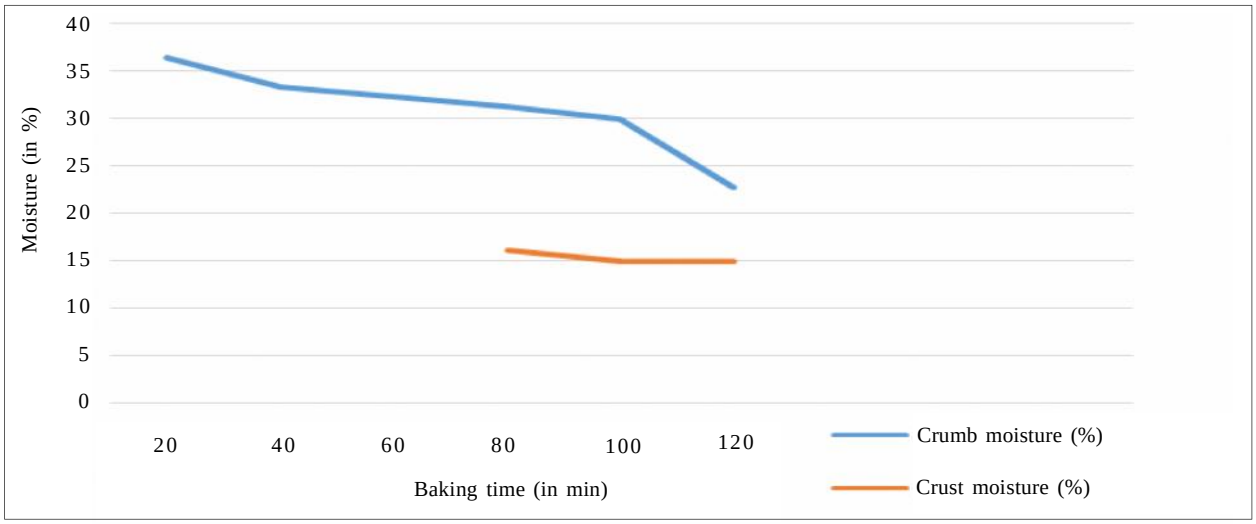

Fig. 1 : Graph of baking time Vs crust and crumb moisture content

Effect of oven spring on baking -rise in the height of *Chhana podo*:

The oven spring occurred due to evaporation of moisture from the crust. It increased with baking time and temperature.Normally the height of fresh *Chhana podo* was 24.04375, 25.0175, 26.485, 27.92375, 28.51375 and 27.215 mm at 20, 40, 60, 80, 100 and 120 min, respectively. But after baking the *Chhana* podo dough for 120 min, the dough attains an average height for the study condition HEATER 130° C+ FAN ON + FROM 60 MIN IR ON 200V.

Effect of baking on weight loss in *Chhana podo*:

The weight loss in *Chhana podo* baked at all temperatures increased with baking time. Increase in temperature lead to increase in vapour presure inside the product, which favoured diffusion of moisture to result in higher weight loss.The weight loss occurs in the *Chhanna podo* dough also with increase in the baking time. The weight loss (in %) in the *Chhana podo* after baking are 2.16, 4.86, 9.73, 12.43, 18.37 and 23.78 at 20, 40, 60, 80, 100 and 120 min, respectively. The increasing trend of weight loss can be shown graphically with weight loss (in %) on ordinate and baking time (in min) on absicca. A graph was plotted for the study, HEATER 130° C+ FAN ON + FROM 60 MIN IR ON 200V.

Effect of baking on thermal properties of *Chhana podo*:

Thermal conductivity of *Chhana podo* was moderately dependent on temperature. The thermal diffusivity and the apparent density of the crust and the crumb as a function of porosity. The apparent density of the crust and the crumb had a linear relationship with the porosity. The Thevariation in thermal properties at different temperatures for the study condition HEATER 130° C+ FAN ON + 200V with IR ON from last 60 min of baking are as shown in Table 1.

Effect on specific volume:

The specific volume of *Chhana podo* after baking for 120 min increased from 0.81158 cm³/kg in fresh dough to 1.23243cm³/kg after baking for 120 min for the study, HEATER 130° C+ FAN ON + 200V with IR ON from last 60 min of baking.The variation in specific volume at different temperatures could be due to the differences in rate of gas (vapour) evolution, transport of water vapour through the dough and the differences in the extent of starch gelatinization at different baking times and temperatures. The high internal pressure of water vapour

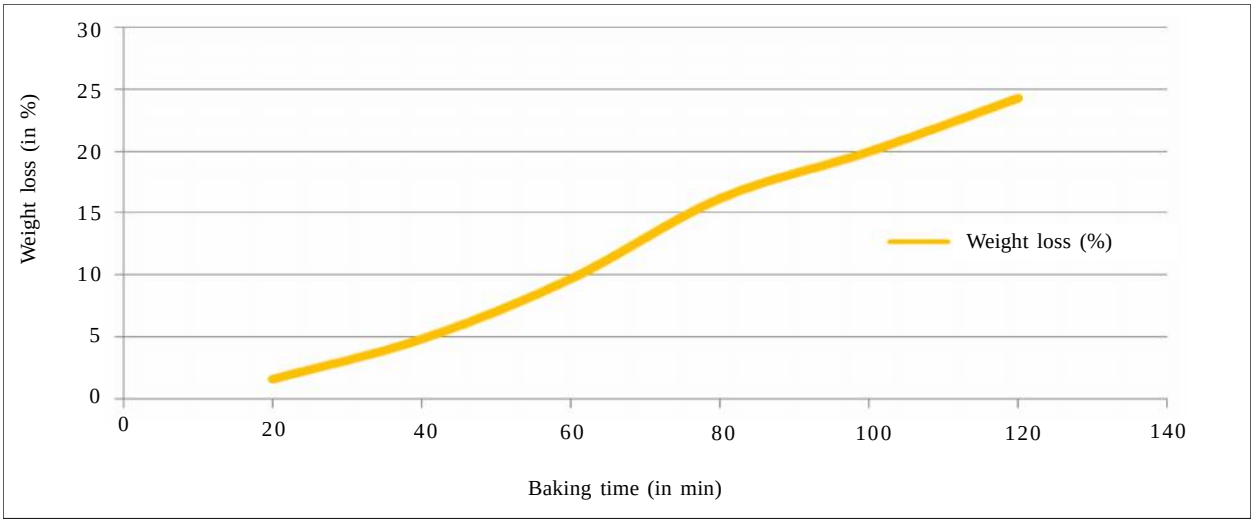

Fig. 2 : Graph of baking time Vs weight loss of *Chhana podo*

Table 1: Table showing the thermal properties

Time (min)	Density (ρ) (°C.cm/W)	Conductivity (K) (W/m.k)	Specific capacity (C_p) (MJ/m³.k)	Diffusivity (D) (mm²/s)
20	383.32	0.263	2.3166	0.1134
120	378.78	0.2692	2.1202	0.1272

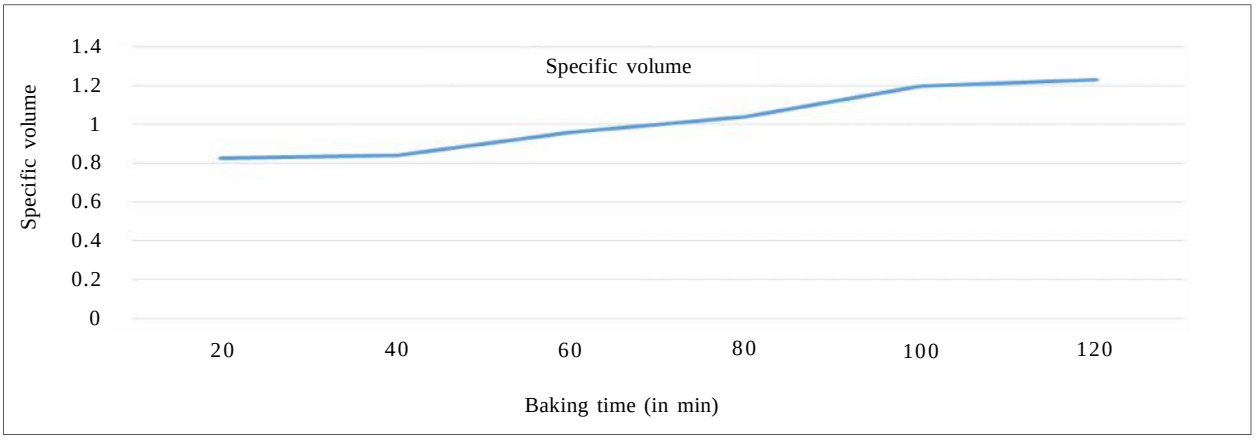

Fig. 3 : Graph of baking time Vs specific volume

within the crumb at higher baking temperatures imparted a puffing effect, which increased the product volume.

Effect on textural properties:

The textural properties of *Chhana podo* were studied for the condition HEATER 130° C+ FAN ON + 200V with IR ON from last 60 min of baking.

The hardness values of *Chhana podo*, obtained from the texture profile analysis curve, were markedly affected by both baking time and temperature. Hardness increased from 31.775N, 56.876N, 75.178N and 99.971N in the product baked at 60, 80, 100 and 120min, respectively for the such an increase in hardness with baking time and temperature.

Springiness of *Chhana podo* increased 64.62 at 60 min to 66.44 at 80 min and then decreased gradually to 61.04 and 51.31 at 100, 120 min, respectively for the condition under study. As baking started and temperature of the dough increased, the pores were filled up as mentioned before and the product tended to behave more solid-like, increasing the springiness to the maximum. As the dough viscosity changed due to gelatinisation of starch and denaturation of protein. As a result new gas cells were formed and the structure of the dough became too weak to withstand the compressive force and hence, springiness started to decline. The following graph shows changes in textural properties of *Chhana podo* during baking. Here the textural properties were taken on ordinate and baking time on absicca.

Cohesiveness is determined by the strength of the internal bonds in the food structure and is dependent on moisture content. Similar to springiness, it increased for upto 80 min of baking and then decreased consistently. Cohesiveness was not affected by baking temperature. However, the higher the moisture content of *Chhana podo* then the higher was the cohesiveness. For condition

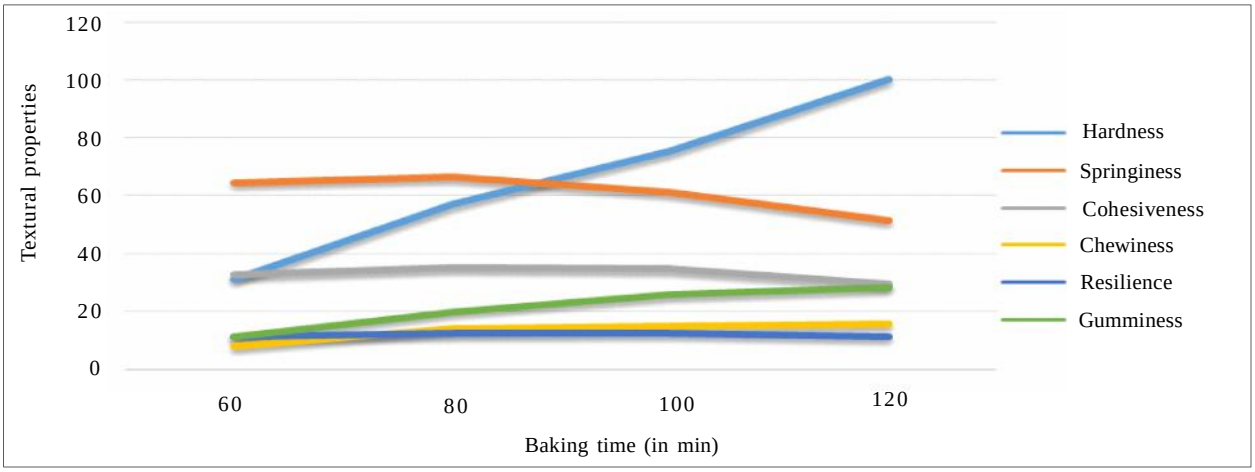

Fig. 4 : Graph of baking time Vs textural properties of *Chhana podo*

under study, cohesiveness varies from 32.71, 35.29, 34.78 and 29.50 for baking temperatures of 60, 80, 100 and 120 min.

Chewiness, on the other hand, increased with both baking time and temperature. It increased in dough to 7.909N, 14.05N, 15.15N and 15.784N when *Podo* baked at 60, 80, 100 and 120 min, respectively for baking condition under study. Al-Muhtaseb *et al.* (2013) reported that increase in chewiness in cake with baking was due to changes in protein.

Resilience increased initially upto 100 min of baking and then decreased. For the condition of baking under study, the obtained values are 11.88, 12.2, 12.36 and 11.25 for baking time of 60, 80, 100 and 120 min.

Gumminess was also influenced by baking time and temperature which increased from the initial value of 11.305N, 20.043N,25.8N and 28.385N when *Podo* was baked for 60, 80, 100 and 120 min, respectively for the condition of baking which under study. The increase in gumminess with baking time could be attributed to the reduction in moisture content. Similar findings were postulated by Al-Muhtaseb *et al.* (2013) for cake and Shrivastav and Kumbhar (2011) for paneer.

Sensory evaluation using fuzzy logic:

To optimize the baking conditions, subjective evaluation of the product was done.*Chhana podo* samples, after baking for 80, 100 and 120 min at 120^{o} C and 130^{o}C, were subjected to sensory evaluation on a Fujji-logic scale. Four samples, with suji, one part tikur, two part tikur and three part tikur were selected and presented to the judges for evaluation. In this study, the part is taken based on tikur to sugar ratio. The study was done in the dairy technology and dairy engineering section of the institute and the trained panel consisted of scientists and doctoral students.All panel members had considerable experience in preparing and evaluating dairy products. The panel members were also instructed about the sensuous characteristics like colour and appearance, flavour, texture and juiciness of the product.The respective samples were for the experiment HEATER 130^{o} C+ FAN ON+FROM 60 MIN IR ON 200Volts for a baking time of 90 min with total power consumption of 29KWH. The sensory scores were taken and analysed on fujji logic scale.

From the obtained analysis, it was observed that sample of sujji (sample 1), sample of one part tikhur (sample 2), sample of two part tikhur (sample 3) which is the sample under current study "HEATER 130^{o} C+ FAN ON+FROM 60 MIN IR ON 200 Volts" were considered as "good" by the panel members. Among those three samples, the higher score was given to sample 3, which was mostly liked by panelists as such because sample 1 need some baking and sample 2 was over cooked on the surface but it not cooked properly in the middle portion. Next the sample with three part tikhur (*i.e.*, sample 4)

Table 2: Sum of sensory scores for quality attributes of *Chhana podo*

Scale factors	Sample 1	Sample 2	Sample 3	Sample 4
Not satisfactory	0.0303	0.0491	0.0290	0.0717
Fair	0.2764	0.3084	0.2606	0.3851
Satisfactory	0.6280	0.6442	0.5942	0.7200
Good	0.6887	0.6711	0.6916	0.6310
Verygood	0.3650	0.3276	0.4019	0.2349
Excellent	0.0668	0.0469	0.0879	0.0176

Table 3 : Sum of sensory scale factors of *Chhana podo*

Scale factors	Colour	Flavour	Texture	Juiciness
Not at all necessary	0	0	0	0
Somewhat necessary	0	0	0	0.0444
Necessary	0.2982	0.2944	0.0255	0.5162
Important	0.9382	0.9302	0.4473	0.9545
Highly important	0.6444	0.6714	0.9564	0.4061
Extremely important	0.0634	0.0750	0.3889	0.0150

was considered as "satisfactory" by the panel members as they commented that the sample was little dried.

The arbitrarily identified samples were ranked in order for colour and appearance, flavour, texture and juiciness for the calculation of the range of critical limits of moisture content, specific volume, hardness and total colour difference. The scores obtained were statistically analysed on fujji logic scale.

Sum of sensory scale factors of *Chhana podo*:

The panel members considered that flavour, juiciness, colour and appearance was important for the baking of *Chhana podo*. Texture was found to be highly important for the *Chhana podo*. Thus, baking conditions were optimized based on minimizing the hardness and total colour difference and maximizing the moisture contents of crust and crumb within the critical limits. The specific volume parameter was selected to be "in the range." The independent factors were kept within the experimental range (120–130°C and 80–120 min).The solution with the highest desirability value was selected as optimum conditions of baking.

Conclusion:

The baking conditions of *Chhana podo,* both baking time and temperature were found to be significant in affecting the crumb and crust moisture contents, specific volume and textural properties. In general, the effect of baking temperature was more significant than the effect of baking time on the quality parameters.

The effects of baking time and temperature on physico and textural properties of *Chhana podo* were evaluated. Hardness, chewiness and gumminess of *Chhana podo* increased linearly with baking time and temperature while springiness, cohesiveness and resilience increased upto 80 min of baking due to filling up of pores by melting fat and expanding water and decreased consistently thereafter. The results on physical properties could be useful for modelling the heat and mass transfer during baking. These process parameters are highly helpful in quality assessment of *Chhana podo* with the usage of low fat sweetner, tikhur.

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