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Standardization of Frying Condition for Preparation of *Chhena Jhilli*: A Traditional Cheese-based Sweet of Odisha

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Study aimed to standardize the frying conditions and ingredient selection for preparing *Chhena jhilli,* a cheese-based deep-fried sweet. The research compared the quality parameters (colour, texture, sensory evaluation, and functional characteristics) of samples prepared with either semolina or refined wheat flour mixed with cottage cheese, fried under different temperature (160, 170 and 180°C) and time (3, 4, and 5 minutes) combinations. Results showed that as frying temperature and time increased, the hardness of the samples consistently increased, while moisture content decreased. An improvement in total colour change and overall acceptability was observed when the frying temperature increased from 160°C to 170°C but declined at 180°C. Functional properties, such as volume expansion ratio and oil absorption capacity, also increased with higher temperatures, though the increase was not significant between samples fried at 170°C and 180°C. The analysis concluded that the optimal *Chhena jhilli* sample was prepared using a 5:1 cheese-to-semolina ratio, fried at 170°C for 5 minutes, and dipped in 40°Brix sugar syrup. This sample achieved the highest sensory score (8.42) and closely resembled market samples in terms of colour, hardness, volume expansion, and moisture content. The study's insights are highly valuable for the food processing industry, providing a foundation for efficient, scalable, and high-quality *Chhena jhilli* production that meets both domestic and global demand.

Keywords: Cheese based sweet, Hardness, Overall acceptability, Volume expansion ratio, Oil absorption capacity

Introduction

India is the world's largest producer of milk, contributing 18.5% of global production, out of which 50-55% of the milk produced gets utilized to make conventional milk-based confectionery.[1] The demand of milk based dessert products is increasing at a rapid rate in the Asian countries, which is mainly confined to the cottage scale in the unorganized sector.[2] A significant amount of milk produced gets utilized to make various traditional sweets, such as *Rabri, Burfi, Kalakand, Rasmalai, Gulabjamun, Rasogolla and Chhena jhilli.* Among them, *Chhena jhilli* is a traditional and popular sweet originating from Odisha, India. It is usually made by mixing specific amount of cottage cheese (*Chhena*), refined wheat flour or semolina, sugar, baking powder and cardamom powder. The mixture is formed into walnut-sized spherical balls, which are then deep-fried in heated oil until they turn into golden brown colour followed by dipping in warm sugar solution for a few hours.

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An essential step in making *Chhena jhilli* is deep fat frying which are the earliest methods of food preparation that most likely came from the Mediterranean region because of the influence of olive oil.[3] Due to high temperature and quick heat transfer, frying is an effective cooking technique[4] which influenced the sensory attributes like flavor and taste depending on the temperature and time of frying.[5] While frying, oil is absorbed into the product and water is lost through evaporation which created pores on the surface and channels in the interior portions. Frying causes structural and physicochemical changes with formation of a firm crust and the food gradually turns brown during the frying process.

Chhena is high in protein (24%), fat (30%), moisture content (60%) and energy (719 kcal) with substantial water activity (0.8). The average shelf life of *Chhena* is just 3 to 12 days at 24°C and 7°C, respectively. The process of boiling does not eliminate thermophilic or thermoduric bacteria.[6] Furthermore, the *Chhena* and the products made from it become contaminated in the environment as a result of post-handling practices. Due to the heat destruction

of bacteria and enzymes as well as the decreases in water activity on the surface of the food by frying, its shelf life is increased.

Sensory qualities are crucial in determining a products acceptability across the entire product development process.[7] Volume growth, porous structure, fissures and crevices are the quality parameters studied for *Gulabjamun* and chickpeas fried into *boondi*.[8] The texture and colour of crust may change as a result of numerous interactions and browning reaction which is influenced by temperature of oil and duration of frying.[9] The quality parameters of products obtained by frying have been studied and modeled for variety of foods, including chicken strips[10], donuts[11], gluten-free *gulabjamun*[12], Sheerqurma[13], chhena roll[14] and *Chhena jhilli*[15]. The texture and colour characteristics of fried food items such as meatballs, potato French fries, gulabjamun etc. have been the subject of numerous studies. The thermal and physical characteristics of tortilla chips were investigated by Moreira *et al.*[16] in relation to frying time. The desired qualities of *Chhena jhilli* include its smooth surface, spherical shape, uniform brown colour and gritty texture which are influenced by ingredients used and processing condition.

Due to high perishability, lack of standard process technology, proper packaging and storage, the shelf life of *Chhena jhilli* is only about two days which restricts its supply to the other parts of the country. Currently, the unorganized dairy industry produces the majority of *Chhena jhilli* on a modest scale. For commercial production of *Chhena jhilli* by organized dairy industry and to ensure a consistent-quality end product, standardization of the process protocol for making *Chhena jhilli* is highly essential. The literature survey however reveals a lack of research on the standardization of process parameters for making *Chhena jhilli*. Therefore, the objective of this study was to standardize the processing parameters for making *Chhena jhilli* using two distinct ingredients such as refined wheat flour and semolina and frying under different conditions to obtain an acceptable product.

Materials and Methods

Raw Materials

Good quality cottage cheese, semolina (suji), refined wheat flour (maida), sugar and other ingredients like cardamom powder and baking powder were procured from local market. Good quality commercial grade cane sugar was used for preparing sugar syrup and refined sunflower oil was used as frying medium for *Chhena jhilli* preparation.

Preparation of *Chhena Jhilli*

The *Chhena* and semolina mixed with 5:1 proportion were thoroughly kneaded and strained through a stainless steel mesh. The other ingredients such as cardamom powder, baking powder and sugar (10 g each) per kg of cheese were also mixed and kneaded by hand to eliminate lumps. About 20 g of dough was taken at a time and formed into spherical shaped ball petties. Similarly, the dough was also made using *Chhena* with refined wheat flour and shaped into spherical ball petties.

An oil fryer with temperature control (EzyCook Electric Fryer 6 litre: EF-6L) was used for frying of ball petties formed. In the deep fat fryer, 3 L of refined sunflower oil was heated to the designated temperature and the ball petties were fried for the required time period. In the present study, frying was done at three different temperatures of 160°C, 170°C and 180°C for 3, 4 and 5 minutes duration each. Fried *Chhena jhilli* balls were strained out from the oil and wiped with tissue paper to remove the adhered surface oil. The balls were let to cool to room temperature and steeped in 40°Brix sugar solution at 102°C for 30 minutes. The detailed experimental process flow chart for *Chhena jhilli* preparation is shown in Fig. 1.

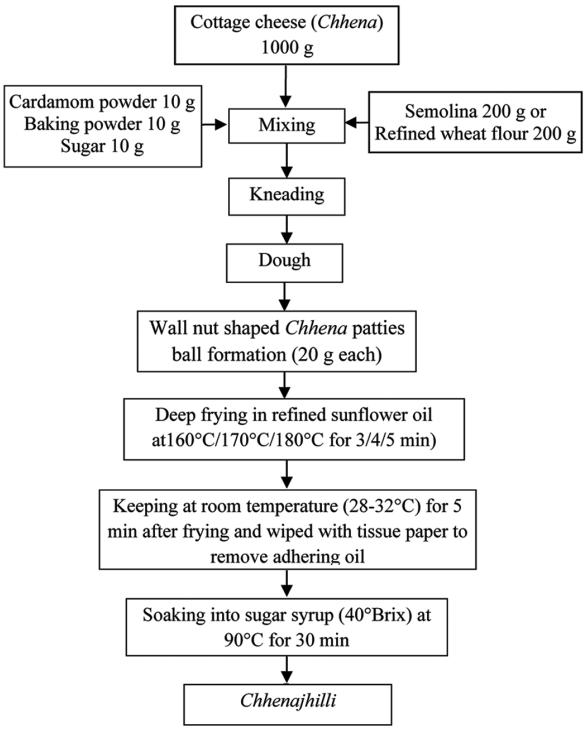

Fig. 1 — Process flow chart for preparation of *Chhena jhilli* from semolina mixed with *Chhena*/refined wheat flour

Physico-chemical Analysis

The physico-chemical parameters such as moisture content, colour, texture, volume expansion and oil absorption capacity of the *Chhena jhilli* samples prepared with different ingredients and frying conditions were determined. Further, the market samples were also analysed for comparison.

Determination of Moisture Content

The moisture content of the *Chhena jhilli* was examined using the approved AOAC (2000) methodology.[17] A hot air oven (Uni-tech, India) with a temperature accuracy of ±℃ was used to determine the moisture content. About 25 to 30 g of samples were taken and dried in a hot air oven at 100℃ for 24 hours. Based on the reduction in weight of the sample, moisture content was calculated.

Colour Measurement

Colour of *Chhena jhilli* was assessed using Universal software (version 4.10) and a Hunter lab Colorimeter CR-20 (Konica Minolta, INC., Japan). The manufacturer's recommended black and white tile was used to calibrate the device. The dual beam xenon flash bulb provided the illumination. Samples were set up on a level surface and colour values were measured at three different locations in triplicate to compute the average.[15] Values were obtained in terms of L* (lightness, ranging from 0 (black) to 100 (white), a* (ranging from +60 (red) to -60 (green), and b* (ranging from +60 (yellow) to -60 (blue)).

$$\text{Total change in colour } (\Delta E) = \sqrt{[L^* - L_0)^2 + (a^* - a_0)^2 + (b^* - b_0)^2}$$

Texture Measurement

The texture profile of *Chhena jhilli* was measured in a texture analyzer (TA-HT plus, Stable Micro Systems, UK). *Chhena jhilli* samples were compressed using P75 pressure plate (75 mm dia.) at a test speed of 10 mm/s with 75% strain using a 50 kg load cell.[18] The sample's overall hardness was determined by measuring the maximum force value that was obtained during the compression test. Several textural properties, including hardness, cohesiveness, adhesiveness, springiness, gumminess, and chewiness, were computed from the force-time curves obtained. The Texture Expert Exceed software (v 2.55) was used for the analysis.

Volume Expansion

The volume expansion of *Chhena jhilli* due to frying as well as steeping were determined. Volume expansion is defined as the increase in the volume of the sample due to processing with respect to original volume. Volume of dough balls before frying, fried *Chhena* balls and sugar solution steeped samples were determined by toluene displacement method.[19] As the *Chenna balls* were floated in toluene, a sinker was used to determine the displaced volume. The weight of sample and the sinker was taken separately. The weight of the beaker with toluene was taken. Then the sample and the sinker were tied with a string, and inserted into the beaker with toluene so that it did not touch the side wall and bottom surface and the weight was taken. The volume of the sample and volume expansion were determined using the following formulae

$$\text{Volume of sample} = \frac{(Wsample+sinker)_{displacedtolune} - (Wsinker)_{displacedtolune}}{Densityofliquid\ (tolune)}$$

$$\text{Volume expansion } (\%) = \frac{|V_f - V_i|}{V_i} \times 100$$

V_i = Initial volume V_f = Final volume

Oil Absorption Capacity

Oil absorption capacity (OAC) is defined as the difference in the weight of sample before and after oil absorption with respect to initial weight. Initial weight of dough and fried *Chhena* petties were taken. Fried *Chhena* petties and dough were dried in hot air oven at 100℃ for 24 h and final weight of the dried samples was taken. Oil absorption capacity was calculated by taking the weight difference of the dried samples with respect to initial weight of dough.

Oil absorption capacity = Difference in final weight of dried samples/Initial weight of dough

Sensory Evaluation

A consumer test panel consisting of ten judges chosen from different faculties and research scholars of the university conducted the sensory evaluation of *Chhena jhilli* obtained from different ingredients and frying conditions. The panel used a nine-point hedonic scale, which is recommended by the Bureau of Indian Standards (IS:6273 1971). The colour, texture, and taste of the samples were evaluated using a nine-point scale that ranged from '9 = really liked' to '1 = really disliked'. The samples were presented randomly to the participants. The overall acceptability of the samples was determined by composite scoring method based on the scores given by the panelists for each attribute.[20,21]

Statistical Analysis

The experiments were conducted in triplicates for generating sufficient data for analysis. One-way

analysis of variance (ANOVA) and the "Tukey" comparison function were used to evaluate the significant difference between the pair of data using MINITAB-2013 (v.17.1.0).

Result and Discussion

Standardization of the Process Protocol for Preparation of *Chhena Jhilli*

The present investigation was to study the impact of frying temperature and time and the ingredient type on quality of *Chhena jhilli* so as to standardize the conditions for its preparation. The variables like moisture content, hardness, surface colour, volume expansion ratio were measured for fried samples before dipping in syrup, whereas the sensory parameters were measured after dipping the samples in syrup as this was the marketable form of finished product. However, hardness and volume expansion were measured for both the samples *i.e.* before and after dipping the balls in syrup.

Effect of Frying Temperature and Time on Quality Parameters of *Chhena Jhilli* Prepared using Semolina

Moisture Content

All the quality variables of *Chhena jhilli* as influenced by frying temperature and time are presented in Table 1. It was observed that moisture content of the cheese balls varied from 30.46 ± 0.73% (db) to 19.42 ± 1.7% (db) for different frying conditions (Fig. 2). With increase in frying temperature and time, the moisture content of the sample decreased gradually which was due to the obvious reason of evaporation of moisture as the cheese balls got exposed to increased heat content of the frying medium. This trend is in agreement with results of Sharanabasava *et al.*[22] and Neethu *et al.*[23]. However, the moisture content of fried balls of market sample was found to be in the range of 22-26% (db) (Table 3).

Hardness

The texture of the samples were represented by hardness which varied from 127.80 ± 1.649 to 199.39 ± 2.065 N for different frying conditions studied with the market sample possessing the value of 179.08 ± 2.97 N (Table 1 and Fig. 3). With increase in frying temperature and frying time, the hardness values of samples showed an increasing trend. Significant ($p<0.05$) difference was observed in hardness of samples fried at 160°C for different frying time. However, samples fried at 170 and 180°C for any given time did not exhibit any significant difference. These results are

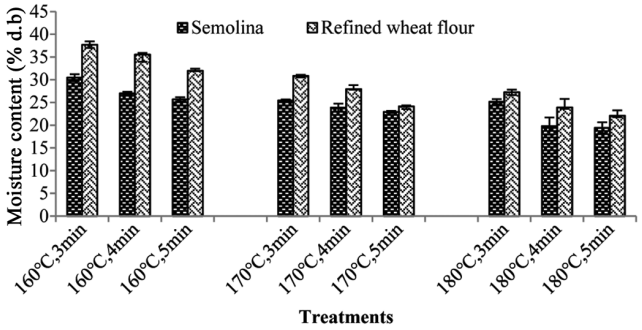

Fig. 2 — Effect of frying temperature and time on moisture content of *Chhena jhilli*

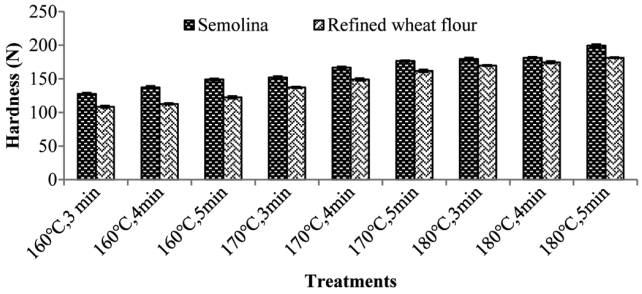

Fig. 3 — Effect of frying temperature and time on hardness of *Chhena jhilli*

Table 1 — Effect of frying temperature and time on quality characteristics of *Chhena jhilli* having semolina as ingredient

Frying temperature (°C)	Frying time (min)	Moisture Content % (d.b)	Hardness (N)	Volume expansion before steeping (%)	Volume expansion after steeping (%)	Oil absorption capacity (%)	Change in colour (ΔE)	Overall acceptability
160	3	30.46 ± 0.74^{a}	127.80 ± 1.64^{f}	23.56 ± 0.95^{f}	50.04 ± 1.04^{d}	14.12 ± 0.17^{bc}	20.69 ± 0.72^{a}	6 ± 0.50^{b}
	4	27.00 ± 0.33^{b}	137.34 ± 2.06^{e}	27.63 ± 0.63^{e}	53.27 ± 1.14^{d}	14.69 ± 0.26^{ab}	14.16 ± 0.51^{c}	6.09 ± 0.48^{b}
	5	25.68 ± 0.68^{bc}	149.11 ± 1.60^{d}	31.45 ± 0.80^{d}	57.45 ± 0.68^{cd}	15.36 ± 0.64^{a}	13.31 ± 1.22^{cd}	6.94 ± 0.73^{ab}
170	3	25.41 ± 0.23^{bc}	152.07 ± 2.07^{d}	30.97 ± 0.93^{d}	56.69 ± 0.69^{cd}	13.0 ± 0.19^{cde}	13.09 ± 1.04^{cd}	6.41 ± 0.65^{b}
	4	23.87 ± 0.87^{bc}	166.77 ± 1.42^{c}	34.61 ± 0.83^{c}	60.342 ± 1.17^{bc}	13.3 ± 0.46^{cd}	10.87 ± 0.85^{d}	7.08 ± 0.70^{ab}
	5	22.92 ± 0.22^{c}	176.58 ± 1.23^{b}	36.99 ± 0.94^{ab}	62.363 ± 0.78^{ab}	13.72 ± 0.21^{bcd}	6.43 ± 0.99^{e}	8.42 ± 0.41^{a}
180	3	25.14 ± 0.56^{bc}	179.52 ± 2.05^{b}	35.59 ± 0.58^{bc}	61.577 ± 0.50^{b}	11.32 ± 0.69^{f}	11.06 ± 0.80^{d}	7.5 ± 0.49^{ab}
	4	19.86 ± 0.57^{d}	181.48 ± 1.22^{b}	38.61 ± 0.62^{a}	63.529 ± 0.76^{ab}	12.06 ± 0.16^{ef}	14.68 ± 0.66^{d}	6.91 ± 0.68^{ab}
	5	19.42 ± 1.17^{d}	199.39 ± 2.06^{a}	38.8 ± 0.83^{a}	66.081 ± 0.54^{a}	12.7 ± 0.14^{de}	17.05 ± 0.77^{b}	6.55 ± 0.95^{b}

Volume expansion w.r.t dough volume, value represents means±standard deviation; values with different letter within the same column as superscript are significantly different at $P<0.05$

in accordance with Mondal and Dash[15] for *Chhena jhilli* and Madhura *et al*.[24] for *Gulabjamun.*

Volume Expansion

The cheese balls were found to be expanded after frying and their volume further increased after steeping. The volume expansion range of samples were 23.57 ± 0.96% to 38.8 ± 0.83% before steeping *i.e.* after frying and 50.04 ± 1.047% to 66.08 ± 0.54% after steeping in sugar solution (Figs 4 and 5). During frying, the ingredient particle of the balls and the entrapped air in it during kneading got heated and expanded, due to which the volume of the balls were increased. During frying vacant space is created inside the ball due to evaporation of moisture, which is filled up by sugar syrup during steeping operation leading to volume expansion. Due to high temperature and short time frying of cheese balls, the upper layer loses moisture rapidly. Thus, few upper layers combined to form a crust which was relatively harder than the core component.[24]

Change in Colour

The colour of *Chhena jhilli* is changed from golden to brown colour gradually during frying, which is one of the most appealing factor for the consumers. Therefore, the surface colour of the *Chhena jhilli* sample was measured and were compared with that of market sample. The 'L', 'a' and 'b' values of market sample were considered as base values from which total change in colour (ΔE) of samples was calculated. The 'L' and 'b' values gradually decreased both with frying temperature and time (Fig. 6), whereas 'a'

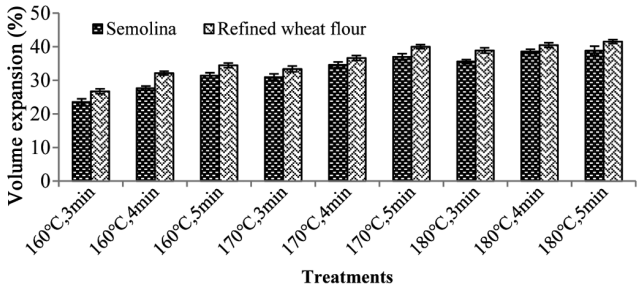

Fig. 4 — Effect of frying temperature and time on volume expansion before steeping of *Chhena ball*

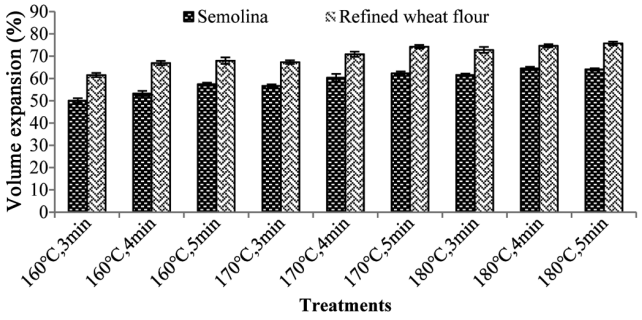

Fig. 5 — Effect of frying temperature and time on volume expansion after steeping of *Chhena ball*

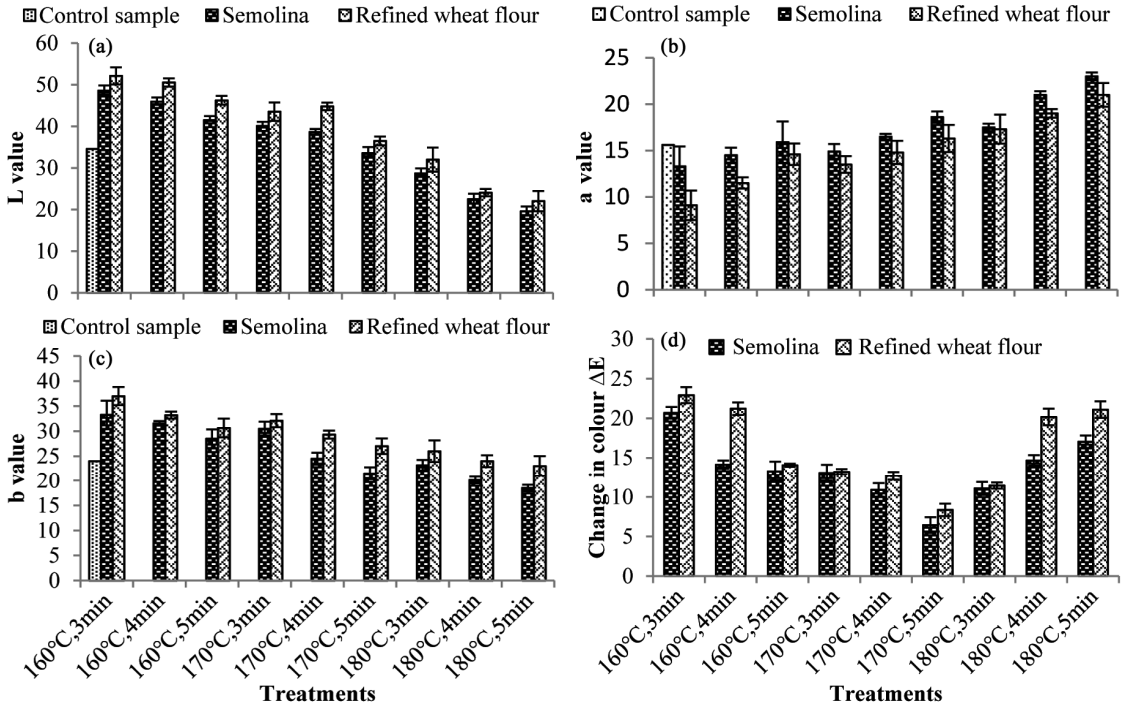

Fig. 6 — Effect of frying temperature and time on colour characteristics of sample (market) and *Chhena jhilli* prepared using semolina and refined wheat flour as base ingredient

value increased with both of those parameters. The L, a and b values of market sample was determined to be 34.6, 15.6 and 24.0 respectively. Since the total colour change is a combined effect of all these attributes, 'ΔE' represented delineation of sample colour from the colour of market sample. Therefore, lesser the value of ΔE, better is the sample colour acceptance. The least colour change from market sample was observed in sample fried at 170℃ for 5 minutes (6.43). Samples fried at 180℃ were dark brown in colour, whereas the balls fried at 160℃ exhibited light brown surface with random white colour patches on it for which it could not fetch consumer appeal through sensory evaluation. In general, the light colour samples had lesser 'a' values and higher 'b' values and vice-versa for deep brown colour samples.

Oil Absorption Capacity

The oil absorption capacity of the samples under the experiment greatly varied from about 11 to 17% (Fig. 7). However, that of market sample was very high (>22%). Since excess oil in this type of food product is considered unhealthy, the sample with minimum values should be preferred. The minimum OAC was found with the sample fried at 180℃ for 3 minutes (11.32 ± 0.69%). This is in contrast to results presented in Sharanabasava *et al.*[22] for *Gulabjamun* and Mondal and Dash[15] for *Chhena jhilli*.

Sensory Quality

In order to assess the subjective acceptability of the product among consumers the sensory evaluation was carried out for subjective attributes like colour, flavor, texture and taste. The overall acceptability estimated by composite scoring was found to be highest (8.42 out of maximum of 9) for the samples fried at 170℃ for 5 minutes. Examining the scores of individual attributes, it was observed that sample fried at 170℃ for 5 minutes scored better in colour, taste and texture indicating that the panelists preferred this product because of less change in colour and gritty texture of this sample (Fig. 8). Overall analysis of data through (ANOVA) indicated that the sample fried at 170℃ for 5 minutes obtained highest sensory acceptance (8.42 ± 0.41) and was subjected to minimum colour change (6.43 ± 0.99).

However, other parameters such as hardness, VER after frying and steeping were found to possess the second most accepted values. Moisture content of the product was within the market sample range. OAC of market sample was much more than that of the sample values. Thus, for preparation of *Chhena jhilli* using semolina, it is recommended to fry the cheese balls at 170℃ for 5 minutes.

Effect of Frying Temperature and Time on Quality Parameters of *Chhena Jhilli* Prepared using Refined Wheat Flour

Moisture Content

Table 2 presented all the quality variables of *Chhena jhilli* as influenced by frying temperature and time. It was observed that moisture content of the fried cheese balls were in the range of 37.69 ± 0.73% (db) to 22.07 ± 0.31% (db) as shown in Fig. 2. With increase in both frying temperature and time, the moisture content of the sample decreased gradually which was due to the obvious reason of evaporation of moisture as the cheese balls got exposed to increased heat content of the frying medium.

Hardness

The texture of the experimental samples were objective indexed by hardness which varied from 108.53 ± 1.72 to 181 ± 0.83 N, whereas the market sample possessed value of 179.08 ± 2.97 N (Fig. 3). With increase in frying temperature and frying time, the hardness values of samples increased which was probably due to reduction in moisture content. However, no significant ($p<0.05$) difference was observed in

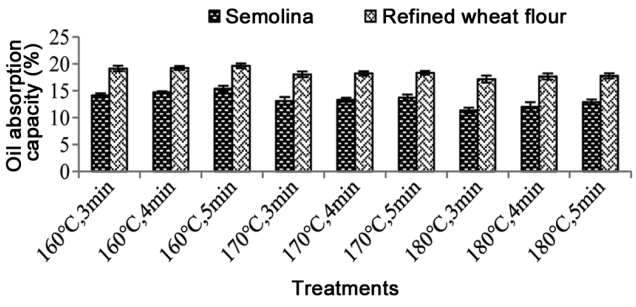

Fig. 7 — Effect of frying temperature and time on oil absorption capacity of *Chhena jhilli*

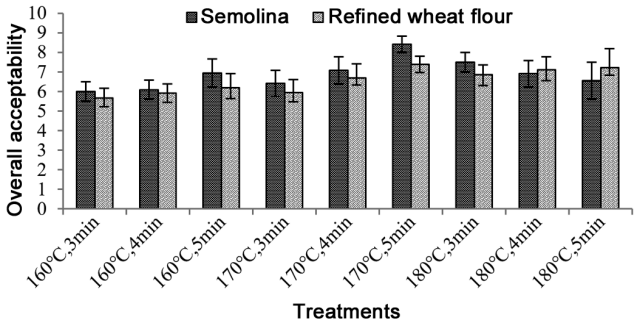

Fig. 8 — Effect of frying temperature and time on Sensory quality (OA) of *Chhena jhilli*

Table 2 — Effect of frying temperature and time on quality characteristics of *Chhena jhilli* having refined wheat flour as ingredient

Frying temp. (°C)	Frying time (min)	Moisture content (d.b)%	Hardness (N)	Volume expansion before steeping (%)	Volume expansion after steeping (%)	Oil absorption capacity (%)	Change in colour (ΔE)	Overall acceptability
160	3	37.69 ± 0.73^{a}	108.53 ± 1.72^{g}	26.73 ± 0.74^{f}	61.52 ± 0.93^{e}	19.13 ± 0.61^{abc}	22.92 ± 1.01^{a}	5.67 ± 0.43^{c}
	4	35.53 ± 1.58^{b}	112.81 ± 1.28^{g}	32.13 ± 0.55^{e}	66.923 ± 0.95^{d}	19.22 ± 0.45^{ab}	21.21 ± 0.79^{ab}	5.91 ± 0.45^{bc}
	5	31.95 ± 0.08^{c}	122.62 ± 2.04^{f}	34.45 ± 0.69^{d}	68.00 ± 1.47^{cd}	19.62 ± 0.16^{a}	14.08 ± 0.19^{c}	6.19 ± 0.54^{abc}
170	3	30.82 ± 0.33^{c}	137.34 ± 1.23^{e}	33.35 ± 0.88^{de}	67.32 ± 0.80^{d}	18.03 ± 0.43^{bcd}	13.23 ± 0.34^{cd}	5.95 ± 0.48^{bc}
	4	27.94 ± 0.14^{d}	149.15 ± 2.12^{d}	36.64 ± 0.72^{c}	70.88 ± 1.14^{bc}	18.23 ± 0.089^{abcd}	12.69 ± 0.52^{cd}	6.7 ± 0.36^{abc}
	5	24.13 ± 0.59^{e}	161.86 ± 1.90^{c}	40.0 ± 0.60^{ab}	74.25 ± 0.78^{a}	18.38 ± 0.061^{abcd}	8.35 ± 0.78^{e}	7.39 ± 0.42^{a}
180	3	27.24 ± 0.63^{d}	169.71 ± 0.96^{b}	38.87 ± 0.80^{b}	72.81 ± 1.32^{ab}	17.14 ± 0.082^{d}	11.42 ± 0.39^{d}	6.85 ± 0.54^{abc}
	4	23.89 ± 0.31^{ef}	174.61 ± 1.91^{b}	40.45 ± 0.70^{ab}	74.66 ± 0.71^{a}	17.63 ± 0.17^{cd}	20.17 ± 1.04^{b}	7.1 ± 0.54^{ab}
	5	22.07 ± 0.31^{f}	181.49 ± 0.83^{a}	41.54 ± 0.61^{a}	75.75 ± 0.82^{a}	17.75 ± 0.13^{bcd}	21.1 ± 1.03^{ab}	7.23 ± 0.40^{ab}

Volume expansion w.r.t dough volume, value represents means ± standard deviation; values with different letter within the same column as superscript are significantly different at $P<0.05$

hardness of samples fried for 3 and 4 minutes at any frying temperature. Samples fried at 160°C for all three frying time exhibited very low range of hardness as compared to those fried at 170°C and 180°C. These resuts are in accordance with Mondal and Dash[15] for *Chhena jhilli* and Madhura *et al*.[24] for *Gulabjamun.*

Volume Expansion

The volume expansion ratio of samples fried under different conditions varied between 26.73 ± 0.74 to 41.54 ± 0.61% before steeping and 61.52 ± 0.93 to 75.75 ± 0.82% after steeping in sugar syrup (Fig. 4 and 5).

Change in Colour

The colour change was minimum (8.35±0.78) in the sample fried at 170°C for 5 minutes. Samples fried at 180°C were dark brown in colour whereas the balls fried at 160°C exhibited golden yellow surface with random white colour patches on it for which this sample could not fetch consumer appeal (Fig. 6). In general, the light coloured samples had lesser 'a' values and higher 'b' values and vice-versa for deep brown colour samples.[15]

Oil Absorption Capacity

The oil absorption capacity of balls exhibited a declining trend with increase in frying temperature. This might be due to gradual decrease in the moisture content of the samples. However, with increase in frying time, the percentage of oil absorbed was seen to be increased. This is obviously due to the dipping of balls in oils for more time during which extra oil got penetrated to the balls (Fig. 7). However, no significant difference in oil absorption capacity was observed among the samples fried at 170°C and 180°C, irrespective of frying time.

Sensory Quality

The overall acceptability estimated by composite scoring was found to be maximum (7.39 out of maximum of 9) for the samples prepared with refined wheat flour and fried at 170°C for 5 minutes. It was also observed that *Chhena jhilli* samples prepared with refined wheat flour as an ingredient and fried at 170°C for 5 minutes fetched maximum overall acceptability, minimum colour change and maximum volume expansion after frying and steeping. Samples fried at 180°C for 4 or 5 minutes exhibited no significant difference with respect to overall acceptability, volume expansion ratio (VER), oil absorption capacity (OAC), hardness and moisture content. However, their colour change values are 20.17 ± 1.04 and 21.1 ± 1.03 as against 8.35 ± 0.78 in sample fried at 170°C for 5 minutes (Fig. 8). Therefore, the *Chhena jhilli* having refined wheat flour (RWF) as base ingredient is recommended to be fried at the same 170°C for 5 minutes in order to get maximum number of desirable qualities.

Comparison of Quality Characteristics of *Chhena Jhilli* Produced with Different Base Ingredient

The study displays (Fig. 2–8) different quality characteristics of *Chhena jhilli* prepared using semolina and refined wheat flour (RWF) as base ingredient having other ingredients such as cheese, sugar, baking powder, cardamom powder and the preparation methodology the same. It is observed from the graphs as well as Table 3 for market sample that both the samples using semolina and refined heat flour (RWF) as base ingredient are acceptable when fried at 170°C for 5 minutes.

The selected samples containing semolina and refined wheat flour (RWF) fried at 170°C for 5 minutes were found to possess moisture content of 22.92 ± 0.22 & 24.13 ± 0.59 (%db); hardness of 176.58 ± 1.23 N & 161.86 ± 1.90 N; VER before steeping values of 36.99±0.94 & 40.0 ± 0.60%; VER after steeping values of 62.36 ± 0.78 & 74.25 ±

Table 3 — Quality characteristics of market sample and prepared standardized sample of *Chhena jhilli*

Sl. No.	Quality parameters	Market sample		Standardized sample	
		Before steeping	After steeping	Before steeping	After steeping
1	Moisture content, %db	24.23 ±1.64	100.86 ± 3.79	22.9 ± 0.22	115.56 ± 1.62
2	Hardness, N	179.08 ±2.97	34.96 ± 3.62	176.6 ± 1.23	28.9 ± 1.24
3	Volume expansion ratio, %	40 ± 3.26	63 ± 2.94	36.99 ± 0.94	62.3 ± 0.78
4	Oil absorption capacity, %	22.43 ± 0.16	NA	13.72 ± 0.21	NA
5	Change in colour (ΔE)	0 (taken as base) $L_0 = 34.6$, $a_0 = 15.6$, $b_0 = 24$	—	6.6 ± 0.99	—
6	Overall acceptability		9.0	—	8.42 ± 0.41

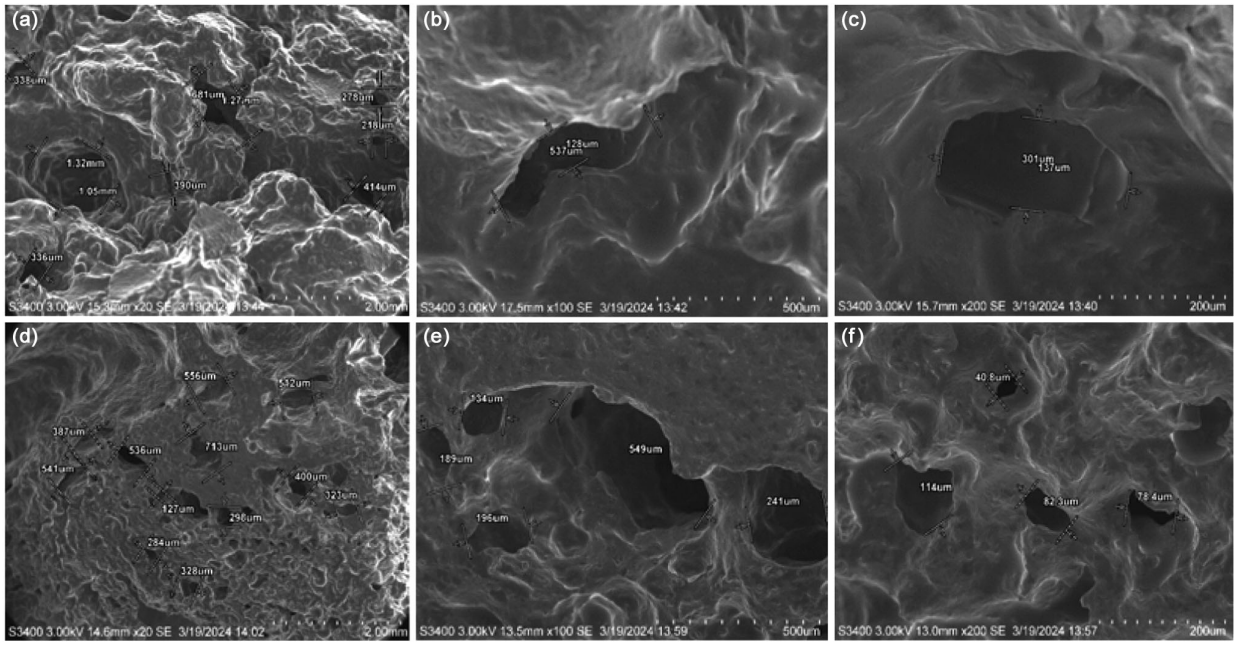

Fig. 9 — Photomicrograph of pore size of *Chhena jhilli* at magnification of (a) 20 X (b) 100 X (c) 200X for semolina and (d) 20X (e) 100 X (f) 200 X for refined wheat flour

0.78%; oil absorption capacity (OAC) of 13.72 ± 0.21 & 18.38 ± 0.06; Colour changes values of 6.43 ± 0.99 & 8.35 ± 0.78 and overall acceptability (OA) scores of 8.42 ± 0.41 & 7.39 ± 0.42, respectively. The difference in properties between semolina and refined wheat flour based *Chhena jhilli* was probably due to the difference in particle size and surface area availability of the ingredients.

From sensory evaluation, maximum overall acceptability was estimated to be 8.42 ± 0.41 by 9 point hedonic scale for the samples prepared with semolina fried at 170°C for 5 minutes. *Chhena jhilli* prepared from base ingredient using semolina was found to possess lower oil absorption capacity, lesser colour change and better textural property as compared to those of samples prepared with refined wheat flour (RWF).

The moisture content, hardness and volume expansion ratio after steeping of *Chhena jhilli* samples obtained from the standardized method using semolina and fried at 170°C for 5 minutes were found to be 115.56 ± 1.62% (d.b.), 28.9 ± 1.24 N and 62.3 ± 0.78%, respectively which were within the range of values obtained for market sample (Table 3). Therefore, *Chhena jhilli balls* prepared using 1000 g *Chhena* added with 200 g semolina and fried at temperature of 170°C for 5 minutes followed by dipping in 40°Brix sugar solution (30 minutes) was most acceptable.

Scanning Electron Microscopy (SEM) of *Chhena Jhilli* Prepared with Semolina and Refined Wheat Flour

The scanning electron micrograph at magnification of 20X, 100X and 200X for samples containing semolina and refined wheat flour (RWF) are shown as Fig. 9. The above figure displays the magnified views of individual particles and their arrangements. Larger pores can be seen in samples having semolina as ingredient (Figs. 9a to 9c) as compared to the sample containing refined wheat flour (Fig 9d to 9f). This indicated that semolina containing *Chhena jhilli* were more porous offering a soft texture inside which is a

desirable trait. This corroborates the analytical results given in the previous section.

Conclusions

The present study focused on selecting appropriate ingredients and optimizing frying conditions for *Chhena jhilli* preparation, along with analyzing its quality parameters. Findings indicated that increasing frying temperature and time led to a reduction in moisture content, while hardness and volume expansion increased. Additionally, oil absorption capacity rose with frying time but decreased when the temperature was elevated to 170°C. Both semolina and refined wheat flour samples exhibited similar trends in these parameters. Sensory evaluation revealed that samples made with semolina and fried at 170°C for 5 minutes achieved the highest overall acceptability, scoring 8.42 ± 0.41 on a 9-point hedonic scale, compared to a score of 7.39 ± 0.42 for refined wheat flour samples. Overall, *Chhena jhilli* made with 1000 g Chhena, 200 g semolina, 10 g cardamom powder, 10 g baking powder, and 10 g sugar, fried at 170°C for 5 minutes and dipped in a 40°Brix sugar solution for 30 minutes, was most preferred as compared to those of samples prepared with refined wheat flour (RWF). The standardization on *Chhena jhilli* would not only preserve conventional delicacy but also enhance its commercial potential by blending tradition with scientific techniques, paving the way for this Odia specialty to reach a larger audience.

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