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An Indigenous Automated Chapatti Maker; Optimization of Process and Sensory Evaluation of Cooked Chapatti

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Abstract— Chapatti is the basic need of Asian countries and a major product of wheat. With the advancements in every field of life, food production is also shifting towards automation. This study was conducted for the development of the chapatti making process by fabricating an automatic chapatti maker, especially for hotels and public mess. The new compatible, low cost, hygiene, easy to operate machine was fabricated and optimized for chapatti baking conditions. The developed machine was optimized for the production of 600 chapattis per hour. The effect of dough sheet thickness (1.5 to 3mm), baking temperatures (180 to 240^{0}C), baking time (60 to150Sec), puffing temperature (290 to 320^{0}C) and puffing time (15 to 30Sec) were evaluated on the overall quality of chapatti. The baking temperature and time showed a significant affect (α ≤0.05) on the moisture content of chapatti and the puffing conditions also showed a significant effect on the puffing height. The machine was optimized for best results at 2.5 mm thickness of chapatti baked at 200^{0}C for 120Sec (Side1for 40Sec and side 2 for 80Sec), puffed at 310^{0}C for 25 seconds. The developed machine was fabricated with food-grade materials; hence it can be a good alternative to produce hygienic and high-quality chapatti on a large scale.

Index Terms— Automation, Chapatti maker, Wheat, Hygiene production, Baking, Puffing Height

I. INTRODUCTION

Food varies from specie to specie and also from region to region. The same specie as bread is the major staple food of western countries, similarly, wheat chapatti is the main food eaten in Asian countries, especially in the sub-continent region (India, Pakistan, Bangladesh). Interestingly, South Asia contains the world's second-largest populated country, India. This bulging population has compelled the agriculture growers to produce more and more food crops, especially wheat. Wheat has been used in different products, for example, chapatti, paratha, phulka, baked roti and bread. But the processing of wheat on a large scale into flour and then flour into chapatti has also become a challenge (Banerji, Ananthanarayan, & Lele, 2018).

Chapatti is either a leavened or unleavened type of flatbread, regularly prepared from whole wheat flour. Chapatti has been prepared by fraternization of the flour with the water and with other ingredients to develop dough, which has been sheeted and baked for a short period. Traditionally, sheets were placed on tandoor to bake it which was a time-consuming process. Tandoori roti has been served in eateries, lodgings, modern canteens and homes and picking up ubiquity in the landmasses of Asia. Oven or Tandoor is an in-ground stove comprising of an earthen pot encompassed by blocks and warmed by burning the coal. This process is difficult and dangerous because chapatti needs to be placed manually inside a hot (350^{0}C) Tandoor (Lagrain, Wilderjans, Glorieux, & Delcour, 2012).

Almost 80% of wheat production in India is consumed in the form of chapatti a flat baked product and other customary foods products. Chapatti well-preserved in ready-to-eat form is preferably suited for working situations where cooking services become incomplete or non-existent. The shelf life of newly baked chapattis is around 24-36h and they become unhealthy for feeding due to the growth of mould and texture decline depending on storage conditions (Singh, Kaur, Singh, & Singh, 2000).

Due to advancements in emerging technologies, it is easy to recognize the influence of flour ingredients on the bread production process. The effect of rheological properties, wheat variety, extraction rate, mixing schedule, sheeting dimension, ingredient level, fermentation, baking schedules and proofing schedules have been optimized from time to time to enhance the textural quality and sensory appearance of flatbread (Don, Mann, Bekes, & Hamer, 2006). The required quality attributes of a chapatti include higher puff ability, pliability, creamish brown colour, soft texture and slender chewiness with a good aroma of baked wheat. Generally, the chapatti of creamish colour with small brown spots and highly puffed within two separate layers is liked the most (Anil Panghal, Chhikara, & Khatkar, 2019). The growing demand for convenience food production due to urbanization has created a need to automate the chapatti processing to market it in good quality packs, like bread. Fresh chapattis are pliable, elastic and soft but they become rigid and tough after a few hours which is an important consideration to make chapattis on a large mechanized scale (Shaikh, Ghodke, & Ananthanarayan, 2007).

Due to continuous progress in living standards and eating habits, food production has been more concerned about the quality of food being processed. The increase in population has also become a problem that made it difficult to serve the good quality food to a large number of people in a specific time interval (Lunch or dinner) such as at gatherings, meetings, restaurants and mess. The food production industry has also developed different methods and machines for the production, processing and storage of food to deal with these challenges (Inamdar, Sakhare, & Prabhasankar, 2015).

In old days chapattis were produced in an oven or kiln made of mud or clay where coal was burnt as a fuel source which causes many problems. The automatic chapatti maker, a machine that can automatically convert the wheat dough balls into sheets and optimally bake these sheets into chapatti, was fabricated with food-grade materials to solve the issues of good quality chapatti production for example, safe and hygienic production of fresh chapatti at large scale. This was one of its kind's unique designs, and developed first time in Pakistan. The use of LPG as a combustion source made it environment and labour friendly as compared to traditional Oven (Tandoor) which utilizes wood or coal as an energy source. The developed machine was fully controlled through its main control panel (speed and temperatures of baking plates and mechanical press). This machine can be utilised at hotels, restaurants, mess, ceremonies and langars in Asian countries where large scale production of chapatti is required at a very short interval of time such as dinner or lunch (Jin et al., 2013).

II. MATERIAL AND METHODS

2.1. Raw material Procurement

The Ukraine wheat (Protein, 12.3%, Starch 69.07%, Wet gluten 24.5%, Zeleny 43.83 ml, Hardness 59.31 and Specific weight 80.67 kg/hl) was purchased from Dumer flour mills, Faisalabad and proximate analysis was performed using Near-Infrared (NIR) grain analyzer (IM 9500, Perten). The raw material for the fabrication of the machine was purchased from the local market of Faisalabad, Gujranwala and Lahore, Pakistan. Food grade steel (SS-304) was used for the fabrication of all parts which were in direct contact with the dough balls or chapatti, including the casings of the oven. Glass wool (Conductivity, 0.03W/mK) was used to insulate the outer walls. The plates were coated with non-stick Teflon (Polytetrafluoroethylene a synthetic food grade fluoropolymer). Teflon plastic (50.8* 300, 10mm thickness) was used to make the scrappers to shift the chapattis from one baking plate to another.

2.2. Design Calculations and Considerations

Following important calculations were done before the fabrication of the chapatti maker (Segui, 2012). The construction of the machine frame was done with stainless steel (SS-304) tubes (50.8*50.8mm and 4mm thickness) in cube shape were used with the following design calculations.

Cross sectional Area= $A_c= (50.8)^2 - (42.8)^2 = 748.8\ mm^2$

$I=\frac{bh3}{12}=\frac{50.84}{12}-\frac{42.84}{12}=275338.7\ mm^4$ (2.1)

Where I= Moment of Inertia

$S_x=\frac{I}{C}=\frac{275338.7}{(50.8/2)}= 10840.1\ mm^3$ (2.2)

Where S_x= Second moment of inertia and C= Distance from centre of section to extreme fibre

$UDL=\frac{(540 \times 9.81)}{1.219}=5297.4\ N/m$ (2.3)

UDL= uniformly distributed load of machine

Ultimate Moment capacity for Beam-1

$M_u=\frac{wl2}{8}=\frac{(1.4\times5297.4\times1.2192)}{8}=1377.6\ Nm$ (2.4)

Where, M_u= Ultimate Moment, L=Length of Beam-1 and 1.4= Safety factor for steel design

$M_y=fySx = 215\times10840.108= 2.331\times10^6\ Nmm=2331\ Nm$ (2.5)

Where, F_y= Yield strength of material, M_y= Yielding moment

$F_y= 215\ N/mm^2$ (For steel)

$Mu \leq 0.9My$ (2.6)

0.9*2331=2098

$1377.6 \leq 2098$

Ultimate Moment capacity for Beam-2

Mu= PL/4= (1.4*5297.4/2)*1.219)/4 = 1130.06Nm (2.7)

Where, P=Point load and L= length of beam

$1130.06 \leq 2098$ N-m

Revolutions per minute (RPM) of baking plates

The following equation was used to calculate the RPM of baking plates, assuming no slip in the gears(Khurmi & J. K. Gupta)

$N_2=\frac{(N1\times d1)}{d2}=\frac{(60\times50.8)}{88.9}=35$ RPM (Approximately) (2.8)

Where,

N_2= Speed of the follower in rpm (35), N_1= Speed of the drive-in rpm (60), D_2= Diameter of the follower (88.9 mm), D_1= Diameter of the driver (50.8 mm)

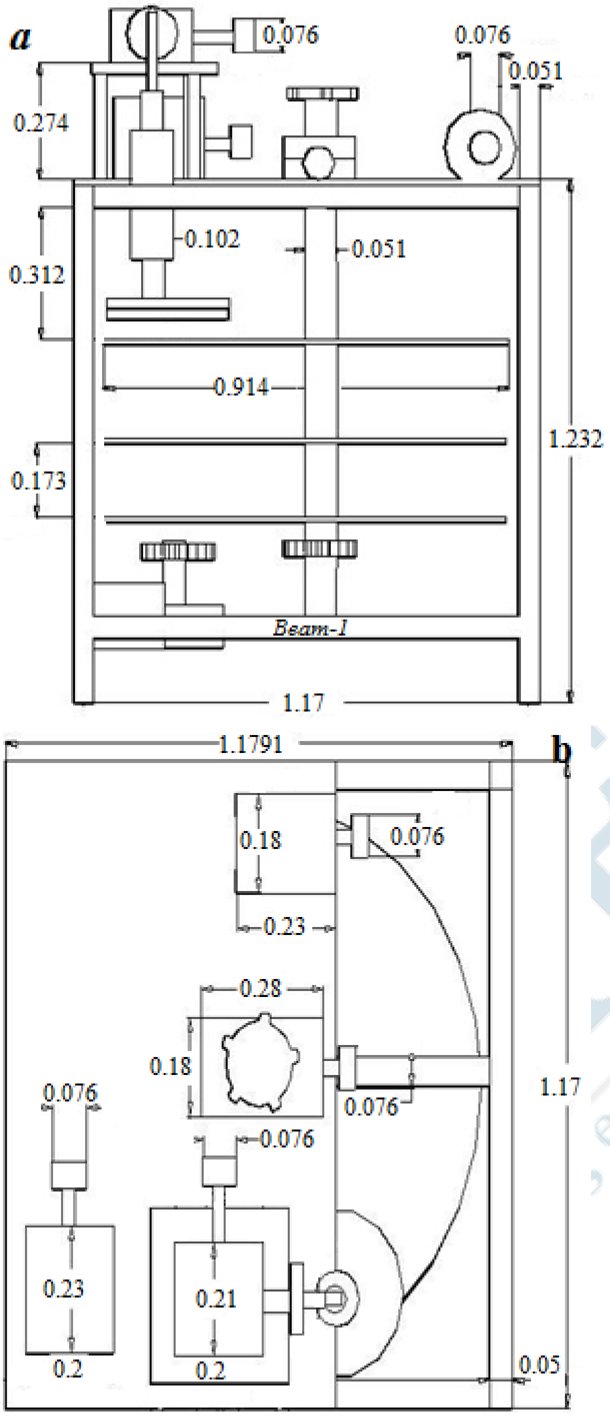

Fig. 1. a) Machine structure design (front view) with all the equipment fitting in the frame. b) Pressing assembly and rotating mechanism for first baking plate (top view of the machine). All the dimensions were measured in SI units (meter).

2.3. Preparation of dough and dough balls

The dough for chapatti was prepared by mixing 1 kg of wheat flour with the 650gm of water for 10 minutes in a local mixer (RPM-40) and rested for 15 minutes. About 80g of the dough was rolled manually and placed on the first plate under the pointed gauge (No oiling and polythene were required to avoid stickiness as there was a heater in pressing assembly to maintain its temperature). The dough ball was pressed into a specific thickness through pressing assembly (A Panghal & Khatkar, 2007).

2.4. Machine operation and baking of chapatti

The dough ball was placed on the first plate that moves the ball under the mechanical press and stops for a while, mechanical press converts the ball into a flat chapatti. Cooking of chapatti was started from the first plate, the shifter shifts the chapatti to the second plate and after one cycle on this plate, chapatti is moved to the third plate. The main shaft was divided into two parts rotating in opposite directions with different motors to shift the chapatti to the next plate. All plates were being heated from the downside and the last plate was being heated from both sides as puffing heaters were installed above the last plate to puff the chapatti. The Control panel controls the speed of the overall machine, temperature of baking plates, speed of baking plates and press and also the gas supply was controlled according to temperature by solenoid valves.

The chapatti cannot be heated from both sides for equal intervals of time because that does not allow the proper puffing of chapatti as both sides become rigid. Each baking plate was maintained at the same temperature (180,200,220 and 240^{0}C) and one side of the chapatti was heated for 20, 30, 40 and 50 seconds while the other side was heated on two baking plates for double intervals of time (40,60,80,100Sec). Hence, the overall heating time for each sample was 60, 90,120 and 150 seconds.

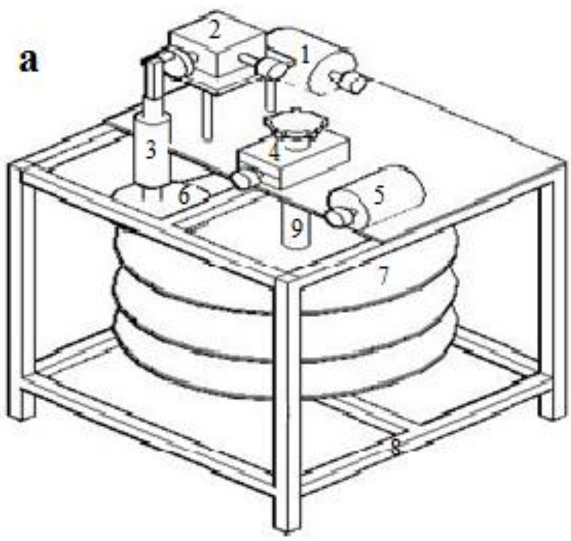

Fig. 2. a) Machine parts shown in the drawing where, 1: Motor for mechanical press, 2: Gearbox for mechanical press, 3: Hydraulic press arm, 4: Gearbox for baking plates, 5: Motor for baking plates, 6: Mechanical Press plate, 7: Baking Plates, 8: Beam-2, 9: Shaft supporting the baking plates. b) Complete view of the machine shown in operating conditions.

2.5. Quality analysis and sensory evaluation

The moisture content of chapatti was calculated through a two-stage drying technique. The 8g of sample was taken from fresh chapatti and dried in a hot air oven at 105^{0}C for 4 hours. This air-dried sample was ground and 3g of this sample was again dried in the same conditions (Shaikh et al., 2007). The height of puff has been considered as a scale of good quality of chapatti which was measured immediately after puffing and recorded in centimetres (cm). The device used to measure the pliability consisted of an iron channel with a vertical moveable clamp for fixing a strip of chapatti. The one end of the base was attached to a moveable graduated scale to measure the bent height of the chapatti. The 2x7 cm strip of chapatti was used to measure the pliability which was allowed to bend under its weight. The difference between the horizontal height at the centre of the clamp where the chapatti strip was fixed and the height of the bent chapatti was taken as the index of pliability and expressed in cm (Anil Panghal et al., 2019).

The chapatti samples were evaluated based on their appearance, aroma, taste, puffing height and pliability by 15 panellists from the food department, University of Agriculture Faisalabad. The laboratory room was odourless, with good lighting and airflow. The panellists were trained to rinse their mouths with water before the evaluation of each sample. The quality characteristics considered and the maximum score for each were height on puffing 10, pliability 10, appearance 10, aroma 10 and taste 10 so the total scores for overall quality were equal to 50. The pliability from 0-1.5 cm was scored from 1 to 4; 1.6-2.0cm was scored from 5 to 7 and 2.1-2.5cm was scored from 8 to 10. Similarly, the puffing height was given a score of 1 to 4 for 0-3cm, 5 to7 for 3.1-6cm and 8 to10 for 6.1-9cm of puffing height (Cheng & Bhat, 2015; Shaikh et al., 2007).

2.5. Statistical Analysis

The effect of baking time, temperatures, puffing time and the temperature was evaluated and optimized using a completely randomized design (CRD) and the significance of the results was tested using Tukey's test. All experiments were performed in triplicates and results were analyzed on SPSS software (Version 16, Chicago, IL, USA).

III. Results and Discussion

3.1. Effect of baking time and temperature on the moisture content of chapatti

The baking of chapatti at relatively low temperatures increased the baking time and also resulted in chapatti with undesirable greyish spots. However, increasing the baking time to get the desired light brown coloured spots often resulted in a tough chapatti, with a somewhat dry mouth feel (Mir et al., 2014). Baking the chapatti with an even brownish texture and good puffing height has been important characteristics which depend on the heating time and temperature. Baking both sides of chapatti for the same time resulted in variations in the colour of the spots on the two sides. Side 1 was baked first and found to have darker spots than side 2. Even the eating quality of the two layers of the chapatti was different since side 1 was always baked for double-time intervals as side 2. The overall good baked chapatti was obtained because side 2 of the chapatti was facing the puffing heater (at 310^{0}C for 25Sec) that also bakes this side. In a previous study, the effect of wheat verities on the overall quality of chapatti was studied. The chapatti was baked using a roti maker at 260–280^{0}C where one side was baked for 20 sec and another side was baked for 40 sec and puffing was done for 5–7Sec (Kundu, Khatkar, & Gulia, 2017). In this study, the total baking time (120Sec) was higher than the above-mentioned study (60 sec) but the baking temperature was reduced to 200 ^{0}C(the optimized baking temperature). This reduction in baking temperature increases the softness in the chapatti due to slow heating which ultimately gives the good puffing height of chapatti. In some other studies, a similar method was developed to bake the chapatti at 210^{0}C for one side for 40Sec and the other side for 100Sec (Cheng & Bhat, 2015; Anil Panghal et al., 2019).

The Anova results for baking temperatures (180, 200, 220 and 240^{0}C) and baking times (60, 90, 120 and 150Sec) were significant and shown in Table 4.1. The required optimum moisture content for good chapatti varies from 28 to 32% depending on the composition of flour used to prepare the chapatti (Cheng & Bhat, 2015; Khaliduzzaman, Shams-Ud-Din, & Islam, 2010). The optimum baking temperature of 200^{0}C gives the moisture content of chapatti around 32.5±0.5% with overall good quality chapatti. The further increase in temperature reduces the moisture content and renders the chapatti less soft while the decrease in temperature gives a higher amount of moisture in the chapatti that causes it to look and feel like unbaked chapatti. Increasing the total baking time from 60 to 150Sec significantly changed the colour from dull grey to dark brown and the taste from raw to slightly caramelize. A significant difference was obtained while baking the chapatti from 60 to 150Sec with a decrease in moisture content from 39.0±0.5 to 22.6±0.7% was observed respectively. The desired moisture content was obtained for baking the chapatti at 200 ^{0}C for 120Sec. A significant improvement was observed in appearance, eating quality and taste when the chapatti was baked at 200^{0}C. However, baking at 220^{0}C resulted in an inferior quality chapatti, hence; the baking temperature of 200^{0}C was considered as optimum temperature.

A similar trend of reduction in moisture content of chapatti from different flours was also observed in some previous studies (Khaliduzzaman et al., 2010; Rasool, Anjum, & Butt, 2005).

Table 1

Effect of baking time (Sec) and temperature (^{0}C) on the moisture content (%) of chapatti

Source	Sum of Squares	Df	Mean Sum of Square	F	Sig.
Model	2149.5	15	143.3	347.4	.000
Time	1816.7	3	605.6	1468.1	.000
Temperature	235.9	3	78.6	190.6	.000
Time * Temperature	96.9	9	10.7	26.2	.000
Error	13.2	32	.413		
Corrected Total	2162.7	47			

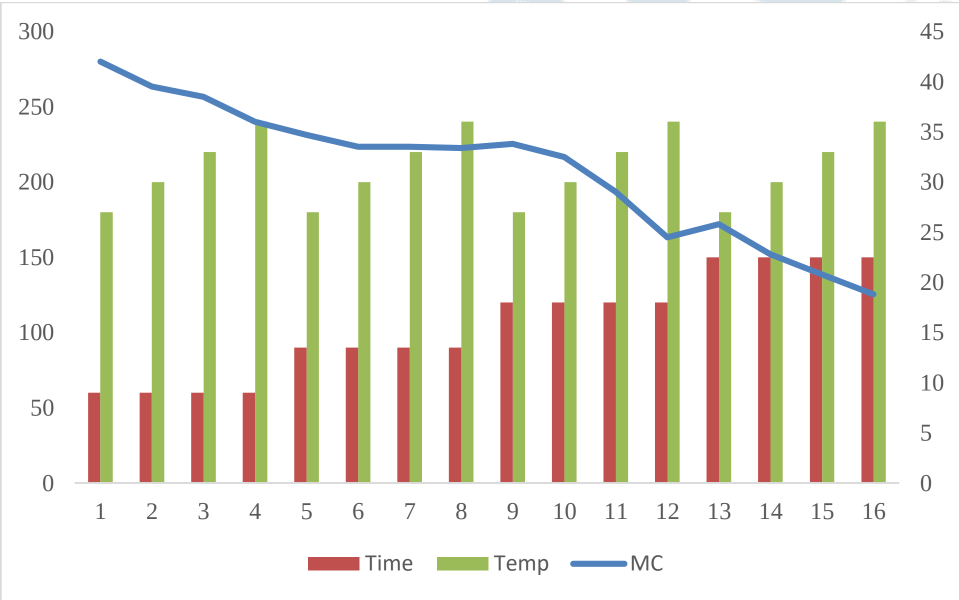

Fig.3. Moisture content (%) Evaluation of chapatti due to the effect of baking time (sec) and temperature (^{0}C)

3.2. Effect of puffing time and temperature on the puffing height of chapatti

The ideal chapatti must have desired characteristics including colour, pliability, brown spots, mouthfeel, shear value, chewiness, tearing resistance, baked wheat aroma, softness and puffing height. Puffing of chapatti is the most desired quality during its baking and people like the flatbread with good puffing height (Anil Panghal et al., 2019). Actually, in the puffing process, the two crusts of chapatti are detached due to instant steam formation and accumulation during the baking. Puffing height has been reported as an important characteristic to evaluate the quality of chapatti and it can be correlated to the gluten and protein content of flour (Cheng & Bhat, 2015).

Puffing time was found to be a critical parameter, as even a slight variation in time influenced the quality greatly, particularly concerning colour and pliability. A significant difference was observed among the puffed heights of chapatti at different temperatures (290, 300, 310 and 320^{0}C). In general, full puffing was observed within 25 sec (at 310^{0}C) of placing the baked chapatti under heaters. Instant puffing resulted from subjecting the chapatti to flash heat from all sides facilitating the instantaneous formation of steam. Continuation of puffing for 25Sec was necessary to get chapatti with the desired appearance. The height of the puffed chapatti increased significantly with baking time up to 120Sec, possibly because of a hardening of the surface, resulting in better retention of the steam during puffing. Baking the two sides a different times did not improve the uniformity of the chapatti baking which was obtained by heating the chapatti under a puffing heater. However, it was found necessary to bake the two sides of chapatti for varied

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International Journal of Science, Engineering and Management (IJSEM)

Vol 10, Issue 2, February 2023

periods to obtain the desired appearance and puff. Different trials were carried out for baking side 1 for a longer period than side 2 gave an optimally baked chapatti, but it had a somewhat raw taste (Parimala & Sudha, 2015). In addition, the chapatti had a rough surface and low pliability. When side 2 of the chapatti was baked for a longer period than side 1, it had the desired uniform light brown spots as well as an optimally baked taste. To further improve the quality of chapatti varying the baking periods showed that baking side 1 for 40Sec, side 2 for 80Sec (at 200^{0}C) and puffing for 25Sec (at 310^{0}C) was the optimum conditions.

The puffing height of chapatti also depends on the temperature used in the puffing heater as the temperature increased up to 310^{0}C there was an increase in the height of the puffed chapatti. However, a further rise in temperature did not increase the puffed height significantly. The puffing was only partial when the temperature was 290^{0}C. Poor puffing at lower temperatures was caused by a slower rate of steam formation. This low temperature might cause a greater loss of moisture during the long period of baking. Thus, the steam formed was sufficient to get maximum puffing. The temperature of 310^{0}C was found to be optimum for 25Sec, resulting in maximum puffing height (7.2±0.3cm). A further increase in the temperature however resulted in undesired charred spots on the chapatti. Similar results were also reported in some previous studies where puffing of chapatti was done at 290-320^{0}C for 25Sec (Cheng & Bhat, 2015; Mir et al., 2014; A Panghal & Khatkar, 2007).

Table 2

Effect of puffing time and temperature on the puffing height of chapatti (cm)

Source	Sum of Squares	Df	Mean Sum of Square	F	Sig.
Model	40.591^a	15	2.706	56.475	.000
Time	7.936	3	2.645	55.204	.000
Temperature	4.622	3	1.541	32.155	.000
Time * Temperature	28.034	9	3.115	65.005	.000
Error	1.533	32	.048		
Corrected Total	42.125	47			

Table 3

Evaluation of puffing height (cm) under the effect of puffing time and temperature

Temperature (^{0}C)				
Time (Sec)	**290**	**300**	**310**	**320**
15	6.2±0.3$_a$	6.8±0.3$_a$	7.1±0.5$_a$	6.4±0.2$_a$
20	5.8±0.6$_a$	6.2±0.4$_a$	6.6±0.4$_a$	7.3±0.1$_b$
25	5.1±0.3$_b$	8.0±0.1$_b$	8.6±0.3$_b$	7.2±0.6$_b$
30	7.3±0.8$_c$	5.6±0.4$_a$	5.3±0.8$_c$	6.2±0.5$_a$

Different subscripts in the same column show a significant ($p \leq 0.05$) difference

3.3. Effect of dough sheet thickness on the overall quality of chapatti

In general chapatti of overall good quality should have an appealing colour with high brown spots spread evenly over the surface, a smooth soft and pliable hand feel, the desired soft chewing quality, sweetish taste, should be optimally baked and puffed to impart pleasant wheat-like aroma. The quality characteristics of chapatti have been affected by the thickness of the dough sheet and this effect was evaluated at different thicknesses of dough sheet (1.5, 2, 2.5 and 3mm). The thickness of the dough sheet was controlled manually by adjusting the height of the mechanical press at a specific point. The effect of thickness was evaluated at optimum conditions (baking at 200^{0}C for 120Sec and puffing at 310^{0}C for 25Sec) which were obtained at 2mm thickness of dough sheet. The results indicated that the optimum baking time increases with the increase in thickness of chapatti. Whereas, a thin chapatti (1.5mm) shows a puffing height of around 7-9 cm and a thick chapatti (3mm) results in a poor puffing height of around 3-5cm. The chapatti less than 2mm in thickness had a rough hand feel and it was also tough to chew resulting in overall low-quality scores. Although the chapatti had more than 2.5mm thickness and appeared to be optimally baked from the surface it had a slight underbaked taste and higher amount of moisture content which possibly contributed to its softer texture. The thickness of chapatti shows an increase in pliability and a decrease in shear value (Mir et al., 2014).

The overall acceptability of chapatti was calculated from the total score given to one treatment of chapatti by the 15 panellists. The thickness of the dough sheet significantly ($p \leq 0.5$) affects the overall acceptability of chapatti from 30.97±1.58 to 40.20±1.66. The low sheet thickness (1.5mm) gives good puffing height, pliability and aroma but the appearance of chapatti was more like a burnt one which also reduces the scores for its taste. However, the overall acceptability of the chapatti with 1.5mm thickness was 32.29±1.66, which was slightly higher than the chapatti of 3 mm thickness (30.97±1.58) which was the lowest score obtained in this study. The main reason for the low acceptability of this chapatti was that this thickness could not be baked from the optimized conditions of the chapatti maker. The raw or unbaked taste and appearance of the chapatti resulted in low scores given by the panellists, hence overall acceptability was the lowest. The dough sheet thickness of 2.5mm was considered the optimum dough sheet thickness for making chapattis using these optimized

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Vol 10, Issue 2, February 2023

conditions (baking at 200^{0}C for 120Sec and puffing at 310^{0}C for 25Sec) on a chapatti maker. The overall acceptability scores were highest (40.20±1.66) for this thickness due to the good appearance of chapatti, proper cooking, good taste and puffing height.

Table 4

Effect of dough sheet thickness on the overall quality of chapatti

Source	Sum of Squares	df	Mean Square	F	Sig.
Model	328.396^a	3	109.465	138.272	.000
Thickness	328.396	3	109.465	138.272	.000
Error	6.333	8	.792		
Corrected Total	334.729	11			

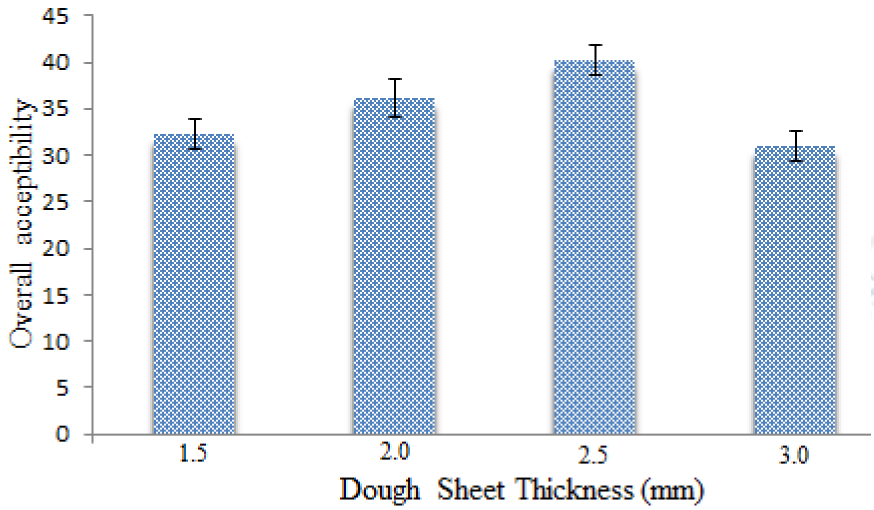

Fig.4. Effect of dough sheet thickness on the overall quality of chapatti

Table 5

Sensory evaluation of dough sheet thickness effect on the quality of chapatti

Dough sheet thickness (mm)	Puffing Height (10)	Pliability(10)	Appearance (10)	Aroma (10)	Taste (10)	Total Score(50)
1.5	$7.41\pm0.21_a$	$6.53\pm0.51_a$	$5.72\pm0.31_a$	$6.21\pm0.42_a$	$6.42\pm0.21_a$	$32.29\pm1.66_a$
2.0	$7.67\pm0.51_a$	$7.43\pm0.43_b$	$6.98\pm0.22_b$	$7.21\pm0.33_b$	$6.87\pm0.44_b$	$36.16\pm1.99_b$
2.5	$8.12\pm0.13_b$	$7.89\pm0.32_c$	$7.64\pm0.51_c$	$8.34\pm0.23_c$	$8.21\pm0.47_c$	$40.20\pm1.66_d$
3.0	$6.41\pm0.41_c$	$6.57\pm0.11_d$	$5.65\pm0.31_a$	$6.45\pm0.42_a$	$5.89\pm0.33_d$	$30.97\pm1.58_c$

Baked at 200 ^{0}C for 120 Sec (Side 1 for 40 sec and side 2 for 80 sec) and puffed at 310 ^{0}C for 25 seconds (Mean± SD of 15 values was taken, different subscripts in the same column show significant difference)

IV. Conclusion

Due to more awareness in public about their health and also due to the development of the food production industry, it was required to design a machine that can produce the chapatti hygienically. The fully automated indigenous chapatti maker was designed and fabricated. Furthermore, it was optimized for its baking conditions to produce around 600 chapattis per hour. In old days chapattis were produced in an oven or kiln made of mud or clay where coal was burnt as a fuel source which causes many problems. The developed machine is environment and labour friendly in its operation and can be fully controlled through its main control panel. This machine can be utilised at hotels, restaurants, mess, ceremonies and langars in Asian countries where large scale production of chapatti is required at a very short interval of time such as dinner or lunch.

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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