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**Minali Masih**
Department of Agriculture Process and Food Engineering, S.H.U.A.T.S, Prayagraj, Uttar Parades, India

**Tushar Desale**
Department of Agriculture Process and Food Engineering, S.H.U.A.T.S, Prayagraj, Uttar Parades, India

**Shivani Saini**
Department of Agriculture Process and Food Engineering, S.H.U.A.T.S, Prayagraj, Uttar Parades, India

**Corresponding Author:**
**Minali Masih**
Department of Agriculture Process and Food Engineering, S.H.U.A.T.S, Prayagraj, Uttar Parades, India

# Development of whole wheat chapati with increased shelf-life and flexibility

**Minali Masih, Tushar Desale and Shivani Saini**

**Abstract**
Chapatti or flat bread is very popular in the world because it constitutes a major source of dietary protein and calories. Several modifications in the formulations have been made in the recent past in order to improve the quality and delicacy of these food products. With increasing urbanization and industrialization, the demand for ready to eat and easy to carry products resembling flat bread in appearance. In this study shelf life of chapatti and its flexibility was tried to improve by adding several ingredient like hot water, choker, spinach, yeast and oil in the wheat flour. Variables such as spinach, choker and oil are added at three different levels as 20%, 30%, 40%; 20%, 30%, 40%; 10%, 15%, 20% respectively. The chapatti was prepared by traditional method and then undergoes the thermal process and then stored at 5°C in refrigerator in LDPE packaging material and then followed the results for shelf life of chapatti in equal interval of 24 h for 4 readings for $0^{th}$ h, for $24^{th}$ h, $48^{th}$ h and $72^{th}$ h and no spoilage were found in any sample and the overall acceptability is good rated to hot water sample and poor was rated for control sample. The sensory analysis was done using 9-point hedonic scale and from mean sensory score it was predicted that the hot water sample had significantly superior acceptability as compared to others and control sample had significantly poor acceptability. At the end of the test it was found that hot water sample was best accepted while control sample was having poor acceptability. Results from the time measurements and microbiological tests showed that the product was in acceptable condition throughout the storage period.

**Keywords:** Wheat chapatti, choker, flat bread, spinach, wheat flour

## Introduction
Chapatti is made from wheat flour for which wheat is grinded to make flour and wheat (*Triticum aestivum*) is a major cereal crop used for the preparation of bakery products such as bread, biscuits and cakes all over the world. However, in India, about 75% of the wheat grown is used for the preparation of chapati, flat bread, which is prepared from whole wheat flour. Chapati is the main traditional wheat based food, consumed by majority of the population in Indian subcontinent and also widely consumed in UK and other countries by Asian ethnic community. Carbohydrate is the major component present in whole wheat flour and among the carbohydrates, starch is the major component.

Whole wheat flour is mixed with water into a dough and the dough is normally given a minimum rest period of 15–30 min before it is sheeted to a thickness of about 1.5–2 mm. The dough thus sheeted is cut into a circular shape of 12–15 cm diameter and baked on a hotplate at 220 °C and finally puffed on a live flame for a few seconds. It is generally consumed hot along with other adjuncts. Complete and full puffing, soft and pliable texture as well as light creamish brown color with dark brown spots is some of the important physical attributes of good quality chapati.

Chapattis are an economical source of protein, and contribute to satiety through abundant dietary fiber, that reduces constipation and diverticular disease, rates of chronic bowel disease and diet-related cancers**.** Chapatti is one of the daily food needs of human being. It provide sufficient amount of energy and calories for a healthy living. Due to increasing work load and lack of time it has become very difficult to make fresh chapatti at every meal. As the chapatti after some time become hard and has rubbery effect in them, so it become the necessity and finds some solution for it; it is necessary to prepare different varieties of chapatti with spinach, yeast, chokar, oil and hot water, study the sensory attributes and microbial analysis of the developed chapattis over time.

In India, wheat is one of the daily staples, consumed in the form of different flat breads such as Chapati, Parotha, Phulka, Puri and Tandoori Roti. Different wheat varieties have been used for the production of flat breads. In recent years, many researchers have tried to improve ingredient level, baking properties, organoleptic characteristics, nutritional value and extension of the shelf life of flat bread.

They are usually produced from a simple recipe consisting of flour, salt and water in varying proportions, however, sometimes the manufactures also use optional ingredients like yeast fat, skim milk powder and certain additives like emulsifiers, hydrocolloids, enzymes and preservatives for quality improvement and shelf life enhancement.
Arabinoxylans were isolated from good and poor chapati making varieties, added them at different levels (0.25 and 0.5 g/100g) to the same flour, interchanged with other varieties and determined the effect of arabinoxylans. Rheological properties were improved upon adding isolated arabinoxylans of good chapati making varieties to flours. Interestingly, addition of isolated arabinoxylans of good chapati making varieties to poor chapati making varieties had significantly improved the chapati quality. Sensory studies showed that chapatis prepared from flour added with arabinoxylans of good chapati varieties had soft texture and high overall quality scores. These changes are attributed to differences in their arabinose/xylose ratio. Thus, results indicated that addition of isolated arabinoxylans of good chapati making flour improved the chapati quality of poor chapati making flour.

## Materials and Methods

### Materials used for chapatti making:

Whole wheat flour was taken of Aashirvaad brand; salt of Tata brand was used. Oil, yeast, choker and spinach are procured from market. The utensils such as plate for dough kneading, rolling pin, rolling board, iron tawa, pair of tongs are used for the food process engineering lab.

### Materials used for microbial analysis

The equipments used for microbial analysis are laminar air flow chamber, colony counter, electronic balance and incubator and the glassware used are test tubes, sterile disposable petri plates, pipettes (1 ml), beakers, sterile disposable micropipette tips, measuring cylinders and spatulas.

### Equipments

Laminar Air Flow Chamber, Incubator, Digital Weighing Balance, Digital Colony Counter, Autoclave

### Chemicals:

Ringer's Solution and Potato Dextrose Agar were used during the study.

### Preparation of Chapati in laboratory:

- **Flour was chosen:** Chapati flour is a finely ground whole wheat flour. It's the traditional choice for making roti.
- **Used water:** Distilled water was taken as it contains no impurities and prevents side reactions and contamination of products.

**Table 1:** Preparation of Chapati in laboratory

| Treatments/Ingredients | | Flour (gm) | Salt (gm) | Distilled Water (ml) | Choker (gm) | Spinach (gm) | Oil (ml) | Yeast (gm) | Hot Water(ml) |
|---|---|---|---|---|---|---|---|---|---|
| Control | $T_0$ | 200 | 1.2 | 158 | 0 | 0 | 0 | 0 | 0 |
| Choker 20% | $T_1$ | 200 | 1.2 | 158 | 40 | 0 | 0 | 0 | 0 |
| Choker 30% | $T_2$ | 200 | 1.2 | 158 | 60 | 0 | 0 | 0 | 0 |
| Choker 40% | $T_3$ | 200 | 1.2 | 158 | 80 | 0 | 0 | 0 | 0 |
| Spinach 20% | $T_4$ | 200 | 1.2 | 40 | 0 | 40 | 0 | 0 | 0 |
| Spinach 30% | $T_5$ | 200 | 1.2 | 40 | 0 | 60 | 0 | 0 | 0 |
| Spinach 40% | $T_6$ | 200 | 1.2 | 40 | 0 | 80 | 0 | 0 | 0 |
| Oil 10% | $T_7$ | 200 | 1.2 | 158 | 0 | 0 | 10 | 0 | 0 |
| Oil 15% | $T_8$ | 200 | 1.2 | 158 | 0 | 0 | 20 | 0 | 0 |
| Oil 20% | $T_9$ | 200 | 1.2 | 158 | 0 | 0 | 30 | 0 | 0 |
| Hot Water | $T_{10}$ | 200 | 1.2 | 0 | 0 | 0 | 0 | 0 | 158 |
| Yeast | $T_{11}$ | 200 | 1.2 | 158 | 0 | 0 | 0 | 2.38 | 0 |

- **Flour and salt were shifted:** The flour was mixed in a large mixing bowl; salt was added and mixed thoroughly.
- **Variable was added:** The different materials were added in the flour separately.
- **Water was added.** Distilled water was slowly added to the flour. The dough will be sandy at first, but as more was added, it started to pull together to form a ball.
- **Dough was kneaded:** Once your ball of dough has formed, knead by hand for about five minutes. This will help gluten proteins form.
- **Dough was kept for rest:** Once dough kneading was finished, the dough was rested for approximately 30 minutes.. The gluten formed during the kneading process was relaxed.
- **Cooking surface was heated:** To cook the chapati, a cast-iron skillet with a diameter of at least 8-9 inches, or a traditional iron tawa was used.
- **Dough is needed and divided:** The rested dough was taken and kneaded again for a minute or two. The dough was divided into even balls of the same weight (approximately 25gm).
- **Balls were rolled out:** One ball was taken and it was flattened between the palms. It was lightly dusted both sides with flour, and began to roll out the ball on the powdered surface with powdered rolling pin. Rolling pin was constantly moved in order to get as circular of a shape as possible.
- **Chapati was cooked:** The flattened dough was placed on the hot pan or tawa for about 15-30 seconds. The roti became ready to be flipped once the bubble form was seen on the top side.
- **Finished cooking the roti:** The chapatti was cooked on the other side for about another 30 seconds. The roti began to puff.

The bunch of roti was packed in LDPE packaging material and was store in the refrigerated temperature at 5 $^{o}$C for 4 days. After four days of storage, the chapatti was taken out and the elasticity and shelf life were being tested at interval of

24 hours. Thus the differently prepared chapatis are tested at 24 hr, 48 hr and 72 hr. Sensory test and microbial test was carried out at that interval.

**Microbiological analysis during storage conditions**

**Table 2:** Microbial analysis

| Packaging material | Product | Type | Levels | Microbial analysis (h) |
|---|---|---|---|---|
| LDPE | Chapati | spinach | 3 | 0, 24, 48, 72 |
| | | choker | 3 | 0, 24, 48, 72 |
| | | hot water | 1 | 0, 24, 48, 72 |
| | | oil | 3 | 0, 24, 48, 72 |
| | | yeast | 1 | 0, 24, 48, 72 |

**Media and sample preparation**

Potato dextrose agar was prepared by adding 9.75 g potato dextrose agar into 250 ml distilled water. The sample weighing 1g of chapatti was taken in 9 ml ringer solution in sterile condition and dissolved completely. From this 1 ml of the sample was transferred into 9 ml ringer solution by seria dilution method. 1 ml of the sample from $10^{-3}$ dilution for Spread plate method from each of the samples individually.

**Enumeration of yeast and molds**

Enumeration of yeast and molds were done by spread plate method where in approximately 15ml of PDA at 45ºC is poured in to sterile petriplates and allowed to solidify. After solidification, 0.1ml of inoculums from $10^{-3}$ diluted chapatti sample is uniformly spread over the agar surface using L-shaped glass rod. These plates were incubated at 37ºC for 3 to 4 days for incubation and colony count was taken on 3rd and 4th day of incubation.

**Sensory evaluation**

Sensory attributes including color, texture, taste, appearance and overall acceptability is determined by hedonic rating tastes as recommended by Ranganna (2007). Hedonic rating taste is used for evolution of sensory characteristics. This test is used for acceptability by consumer for the product. The expert panelist will be asked to rate the acceptability of the product through sense organs on scale of nine (9) points ranging from like extremely to dislike extremely.

**Packaging material used**

The Low-Density Polyethylene (LDPE) packaging material was used during the experiment.

**Pouch standardization**

After many trials these aspects had been standardized for each product. The final product of the chapatti which was weighed 25 gram and of the size diameter 13cm and thickness 0.2 cm and the total diameter of the pouch was 20×14 cm.

**Fig 1:** LDPE Packaging

**Result and Discussion**

Studies based on sensory properties were determined for cooked chapatti like flavor, taste, texture appearance and overall acceptability. The chapatti was packed in LDPE bags and stored at 5 °C. The shelf life studies were conducted at the interval of 24 to 72 hours. The result of the study are being presented and discussed further.

**Result and Discussion**

**Product Development**

The utilization of spinach, yeast, oil, hot water and choker along with wheat flour increases the shelf life and flexibility of chapatti. From all the preparations, it was seen that wheat flour with hot water was accepted by panel judges depending on sensory evaluation and was best according to shelf life. LDPE is the packaging material used for the chapatti. On the basis of above results revealed in the present study it might be concluded that this formulation of chapatti will satisfy consumer and will be widely accepted in the market.

**Sensory attributes of chapatti influenced by storage period and using different variables**

Sensory attributes of chapatti were evaluated for fresh condition and at 24 hour interval up to 72 hours at 5 $^{0}$C temperature. Nine point hedonic rating test method was used for the evaluation of different samples of chapatti. Different attributes such as color, taste, texture, appearance and overall acceptability were evaluated.

**Effect of hot water, oil, spinach, yeast, chokar on flavour analysis of chapatti at different storage time**

The effect of different contents of chapatti is presented in table 3. The highest score for flavor at 0th hour was obtained for $T_{10}$, at 24th hour again it was for $T_{10}$, at 48th hour it was for $T_7$ and at 72th hour it was for $T_{10}$. The lowest score for flavor at 0th hour was obtained for $T_0$, at 24th hour it was for $T_{11}$, at 48th hour it was for $T_{10}$ and at 72th hour it was for $T_0$.

**Table 3:** Flavor analysis of chapatti with hot water, oil, spinach, yeast, choker at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| Control Fresh | | 8.375 | 8.25 | 8.25 |
| $T_0$ | 7.75 | 6.875 | 5.625 | 5.125 |
| $T_{10}$ | 8.5 | 8.25 | 8 | 7.75 |
| $T_7$ | 8 | 8 | 8.25 | 7.5 |
| $T_4$ | 8.125 | 7.375 | 7 | 6.75 |
| $T_{11}$ | 7.375 | 6.5 | 6.5 | 6.25 |
| $T_1$ | 8 | 7.25 | 6.875 | 6.5 |
| F.Test | S | ---------- | | |
| C.D. | 0.003 | ---------- | | |
| S.Ed | 0.42 | | | |

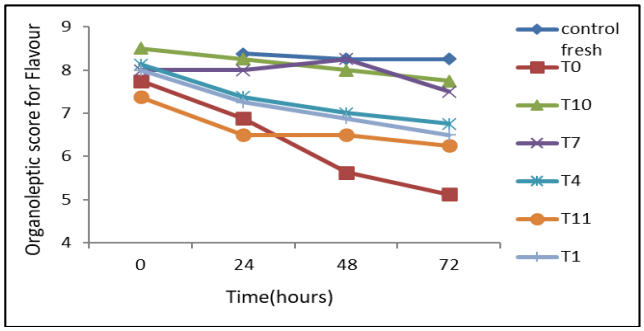


**Fig 1:** Flavor analysis of chapatti with hot water, oil, spinach, yeast, choker at different storage time Effect of hot water, oil, spinach, yeast, choker on texture analysis of chapatti at different storage time

The effect of different contents of chapatti is presented in table 4. The highest score for texture at 0th hour was obtained for $T_4$, at 24th hour it was for $T_{10}$, at 48th hour it was for $T_{10}$ and at 72th hour it was for $T_{10}$. The lowest score for texture at 0th hour was obtained for $T_{11}$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 4:** Texture analysis of with hot water, oil, spinach, yeast, choker at diff. storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| Control Fresh | | 8.75 | 8.25 | 8.25 |
| $T_0$ | 7.875 | 6.125 | 5.75 | 5.25 |
| $T_{10}$ | 8.25 | 8 | 8.125 | 7.375 |
| $T_7$ | 8.25 | 7.5 | 7.5 | 6.625 |
| $T_6$ | 8.5 | 7.125 | 6.25 | 6 |
| $T_{11}$ | 7.75 | 6.75 | 6.5 | 6.25 |
| $T_1$ | 8.125 | 7.5 | 7 | 6.25 |
| F.Test | S | | | |
| C.D. | 0.00003 | ---------- | | |
| S.Ed | 0.306 | | | |

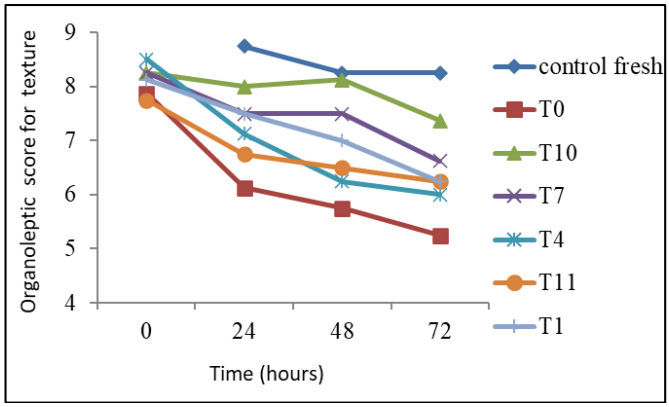


**Fig 2:** Texture analysis of chapatti with hot water, oil, spinach, yeast, chokar at different storage time Effect of hot water, oil, spinach, yeast, choker on appearance analysis of chapatti at different storage time

The effect of different contents of chapatti is presented in table 5. The highest score for appearance at 0th hour was obtained for sample with $T_{10}$ and $T_0$, at 24th hour it was for $T_{10}$ and $T_7$, at 48th hour it was for $T_7$ and at 72th hour it was for $T_{10}$. The lowest score for appearance at 0th hour was obtained for $T_1$, at 24th hour it was for $T_{11}$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 5:** Appearance analysis of chapatti with hot water, oil, spinach, yeast, chokar at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| Control Fresh | | 8.5 | 8.5 | 8 |
| $T_0$ | 8.375 | 7.125 | 5.625 | 5.375 |
| $T_{10}$ | 8.375 | 8 | 7.5 | 7.25 |
| $T_7$ | 8.125 | 8 | 7.875 | 6.5 |
| $T_4$ | 8.375 | 7.5 | 7 | 6.625 |
| $T_{11}$ | 7.75 | 7 | 6.375 | 6.25 |
| $T_1$ | 7.375 | 7.125 | 7 | 7 |
| F.Test | S | | | |
| C.D. | 0.002 | ---------- | | |
| S.Ed | 0.529 | | | |

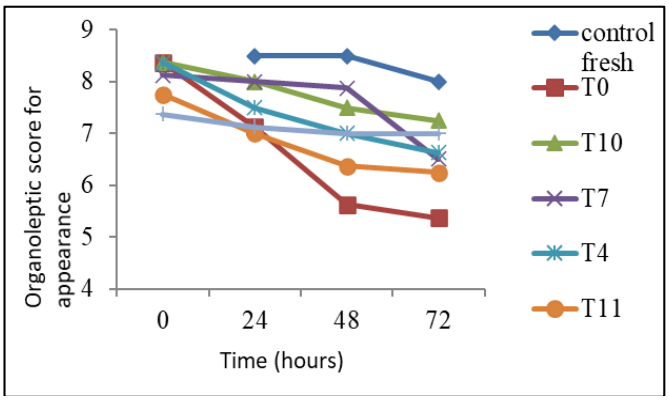


**Fig 3:** Appearance analysis of chapatti with hot water, oil, spinach, yeast, choker at different storage time

**Effect of hot water, oil, spinach, yeast, choker on overall acceptability analysis of chapatti at different storage time**

The effect of different contents of chapatti is presented in table 6. The highest score for overall acceptability at 0th hour was obtained for $T_4$, at 24th hour it was for $T_{10}$, at 48th hour it was for $T_1$ and at 72th hour it was for $T_{10}$. The lowest score for overall acceptability at 0th hour was obtained for $T_{11}$, at 24th hour it was for $T_{11}$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 6:** Overall acceptability analysis of chapatti with hot water, oil, spinach, yeast, choker at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| Control Fresh | | 8.5 | 8.46875 | 8.1875 |
| T0 | 8 | 6.71875 | 5.625 | 5.3125 |
| T10 | 8.25 | 7.84375 | 7.406 | 7.375 |
| T7 | 7.90625 | 7.625 | 7.324 | 6.59375 |
| T4 | 8.375 | 7.28125 | 6.625 | 6.375 |
| T11 | 7.5 | 6.5625 | 6.34375 | 6.25 |
| T1 | 7.71875 | 7.5 | 7.5 | 7.25 |
| F. Test | S | | | |
| C.D. | 0.0007 | ---------- | | |
| S.Ed | 0.37 | | | |

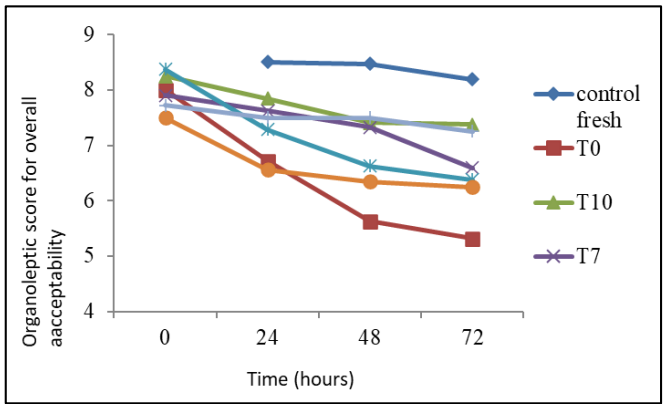


**Fig 5:** Overall acceptability analysis of chapatti with hot water, oil, spinach, yeast, choker at different storage time

Effect of different level of choker on flavor analysis of chapatti at different storage time

The effect of different level (20%, 30%, and 40%) of choker on chapatti is presented in table 7. The highest score for flavor at 0th hour was obtained for sample with $T_2$ and $T_0$, at 24th hour it was for $T_1$ and $T_3$, at 48th hour it was for $T_3$ and at 72th hour it was for $T_1$. The lowest score for flavor at 0th hour was

obtained for $T_1$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 7:** Effect of different level of choker on flavour analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_1$ | 8.375 | 8.125 | 7.625 | 7.5 |
| $T_2$ | 8.625 | 7.875 | 7.5 | 6.75 |
| $T_3$ | 8.5 | 8.125 | 7.75 | 7.2 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.00001 | ---------- | | |
| S.Ed | 0.093 | | | |

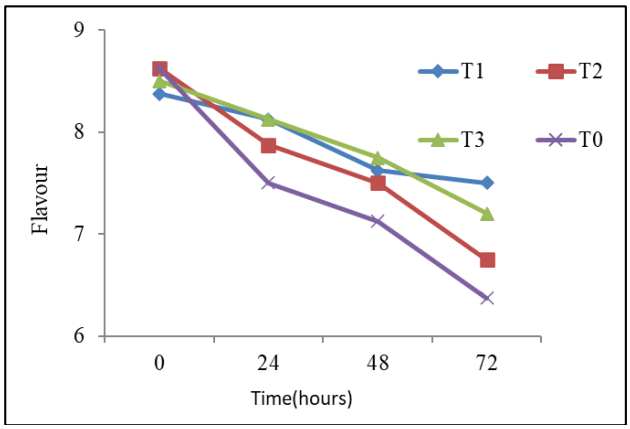


**Fig 6:** Effect of different level of choker on flavor analysis of chapatti at different storage time

**Effect of different level of choker on texture analysis of chapatti at different storage time**

The effect of different level (20%, 30%, and 40%) of choker on chapatti is presented in table 8. The highest score for texture at 0th hour was obtained for $T_0$, at 24th hour it was for $T_2$, at 48th hour it was for $T_2$ and at 72th hour it was for $T_2$. The lowest score for texture at 0th hour was obtained for $T_1$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 8:** Effect of different level of chokar on texture analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_1$ | 8 | 7.75 | 7.25 | 6.75 |
| $T_2$ | 8.375 | 8.25 | 8.125 | 7.375 |
| $T_3$ | 8.125 | 7.75 | 7.375 | 7.25 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.005 | ---------- | | |
| S.Ed | 0.29 | | | |

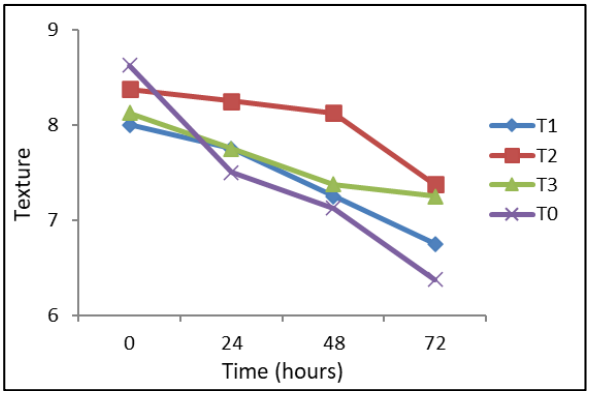


**Fig 7:** Effect of different level of choker on texture analysis of chapatti at different storage time

**Effect of different level of choker on appearance analysis of chapatti at different storage time**

The effect of different level (20%, 30%, and 40%) of choker on chapatti is presented in table 9. The highest score for appearance at 0th hour was obtained for $T_1$, at 24th hour it was for $T_1$, at 48th hour it was for $T_1$ and at 72th hour it was for $T_1$. The lowest score for appearance at 0th hour was obtained for $T_3$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 9:** Effect of different level of choker on appearance analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_1$ | 8.875 | 8.25 | 8 | 7.625 |
| $T_2$ | 8.625 | 8 | 7.625 | 7.125 |
| $T_3$ | 8 | 7.875 | 7.625 | 7 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.0004 | ---------- | | |
| S.Ed | 0.12 | | | |

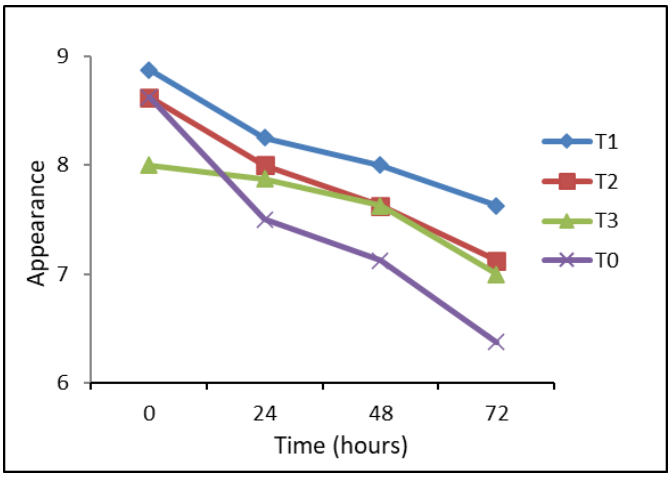


**Fig 8:** Effect of different level of choker on appearance analysis of chapatti at different storage time

**Effect of different level of choker on overall acceptability analysis of chapatti at different storage time**

The effect of different level (20%, 30%, and 40%) of choker on chapatti is presented in table 10. The highest score for overall acceptability at 0th hour was obtained for $T_3$, at 24th hour it was for $T_3$, at 48th hour it was for $T_3$ and at 72th hour it was for $T_3$. The lowest score for overall acceptability at 0th hour was obtained for $T_2$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 10:** Effect of different level of choker on overall acceptability analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_1$ | 8.625 | 8 | 7.87 | 7.325 |
| $T_2$ | 8 | 7.75 | 7.25 | 6.75 |
| $T_3$ | 8.75 | 8.25 | 8.125 | 7.375 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.0001 | ---------- | | |
| S.Ed | 0.155 | | | |

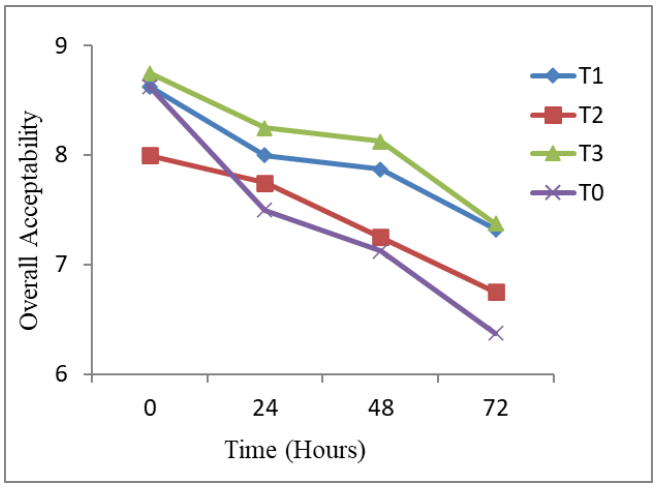


**Fig 9:** Effect of different level of chokar on overall acceptability analysis of chapatti at different storage time

**Effect of different level of oil on flavour analysis of chapatti at different storage time**

The effect of different level (20%, 30%, and 40%) of chokar on chapatti is presented in table 11. The highest score for flavour at 0th hour was obtained for sample with $T_7$, at 24th hour it was for $T_7$, at 48th hour it was for $T_7$ and at 72th hour it was for oil $T_7$. The lowest score for flavour at 0th hour was obtained for oil $Y_9$, at 24th hour it was for $_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 11:** Effect of different level of oil on flavor analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_7$ | 8.875 | 8.5 | 8.375 | 8.125 |
| $T_8$ | 8.625 | 8.375 | 8.125 | 8 |
| $T_9$ | 8.125 | 7.875 | 7.625 | 7.25 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.009 | ---------- | | |
| S.Ed | 0.29 | | | |

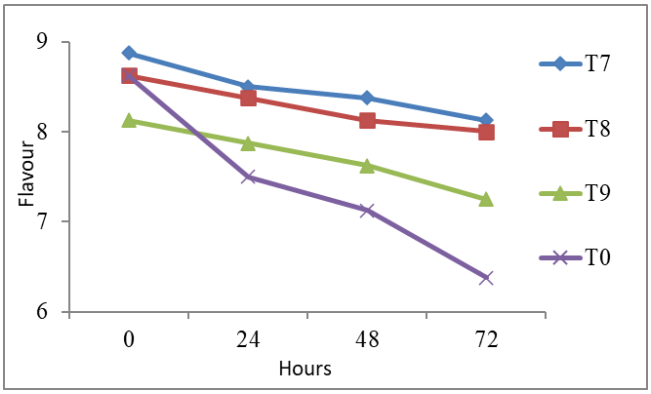


**Fig 10:** Effect of different level of oil on flavor analysis of chapatti at different storage time

**Effect of different level of oil on texture analysis of chapatti at different storage time**

The effect of different level (20%, 30%, and 40%) of chokar on chapatti is presented in table 12. The highest score for texture at 0th hour was obtained for sample with $T_7$, at 24th hour it was for $T_7$, at 48th hour it was for $T_7$ and at 72th hour it was for $T_7$. The lowest score for texture at 0th hour was obtained for $T_9$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 12:** Effect of different level of oil on texture analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_7$ | 8.875 | 8.5 | 8.375 | 8.125 |
| $T_8$ | 8.625 | 8.375 | 8.125 | 8 |
| $T_9$ | 8.125 | 7.875 | 7.625 | 7.25 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.005 | ---------- | | |
| S.Ed | 0.17 | | | |

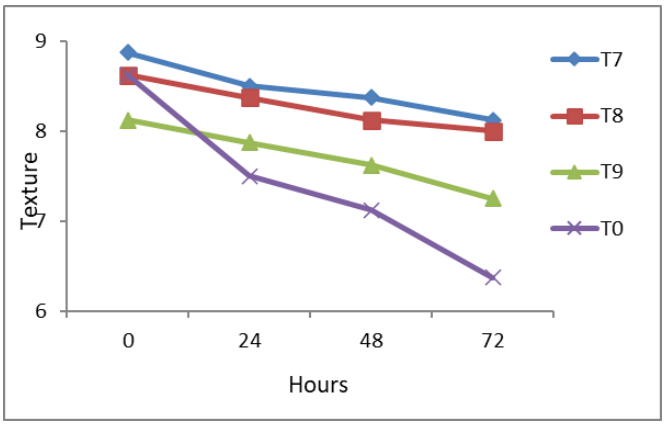


**Fig 11:** Effect of different level of oil on texture analysis of chapatti at different storage time

**Effect of different level of oil on appearance analysis of chapatti at different storage time**

The effect of different level (20%, 30%, and 40%) of chokar on chapatti is presented in table 13. The highest score for appearance at 0th hour was obtained for $T_9$, at 24th hour it was for $T_9$, at 48th hour it was for oil $T_9$ and at 72th hour it was for $T_9$. The lowest score for appearance at 0th hour was obtained for $T_8$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 13:** Effect of different level of oil on appearance analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_7$ | 8.625 | 8 | 7.625 | 7.125 |
| $T_8$ | 8 | 7.875 | 7.625 | 7 |
| $T_9$ | 8.875 | 8.25 | 8 | 7.625 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F. Test | S | | | |
| C.D. | 0.0006 | | | |
| S. Ed | 0.19 | | | |

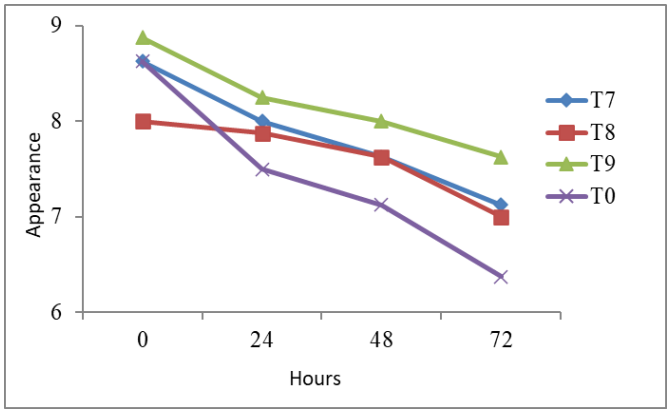


**Fig 12:** Effect of different level of oil on appearance analysis of chapatti at different storage time

**Effect of different level of oil on overall acceptability analysis of chapatti at different storage time**

The effect of different level (20%, 30%, and 40%) of choker on chapatti is presented in table 14. The highest score for overall acceptability at 0th hour was obtained for $T_7$, at 24th hour it was for $T_7$, at 48th hour it was for $T_7$ and at 72th hour it was for oil $T_7$. The lowest score for overall acceptability at 0th hour was obtained for $T_9$, at 24th hour it was for $T_0$, at 48th hour it was for $T_0$ and at 72th hour it was for $T_0$.

**Table 14:** Effect of different level of oil on overall acceptability analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_7$ | 8.75 | 8.625 | 8.5 | 8.25 |
| $T_8$ | 8.625 | 8.375 | 8.25 | 7.75 |
| $T_9$ | 8.375 | 8.125 | 7.825 | 7.25 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.0004 | | | |
| S.Ed | 0.18 | | | |

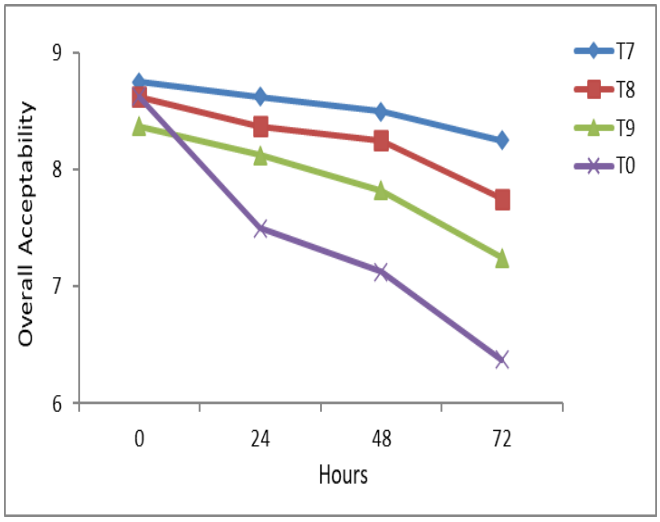


**Fig 13:** Effect of different level of oil on overall acceptability analysis of chapatti at different storage time

**Effect of different level of spinach on flavour analysis of chapatti at different storage time**

The effect of different levels (20%, 30%, and 40%) of spinach on chapatti is presented in table 15. The highest score for flavor at 0th hour was obtained for control sample, at 24th hour it was for spinach (20%) and spinach (30%), at 48th hour it was for spinach (20%) and at 72th hour it was for spinach (20%). The lowest score for flavor at 0th hour was obtained for spinach (40%), at 24th hour it was for control, at 48th hour it was for control sample and at 72th hour it was for control sample.

**Table 15:** Effect of different level of spinach on flavour analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| T4 | 8.5 | 8.25 | 8.125 | 7.875 |
| T5 | 8.375 | 8.25 | 7.625 | 7.25 |
| T6 | 7.875 | 7.625 | 7.25 | 7.125 |
| T0 | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.004 | | | |
| S.Ed | 0.28 | | | |

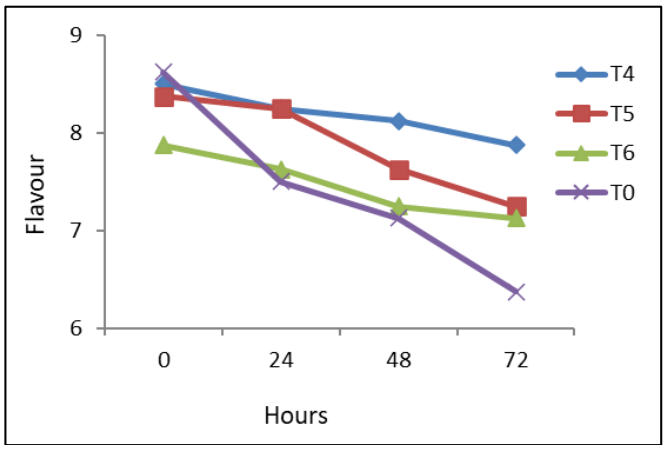


**Fig 14:** Effect of different level of spinach on flavor analysis of chapatti at different storage time

**Effect of different level of spinach on texture analysis of chapatti at different storage time**

The effect of different levels (20%, 30%, and 40%) of spinach on chapatti is presented in table 16. The highest score for texture at 0th hour was obtained for spinach (30%) sample, at 24th hour it was for spinach (20%) and spinach (30%), at 48th hour it was for spinach (30%) and at 72th hour it was for spinach (20%) and spinach (30%). The lowest score for texture at 0th hour was obtained for spinach (20%), at 24th hour it was for control, at 48th hour it was for control sample and at 72th hour it was for control sample.

**Table 16:** Effect of different level of spinach on texture analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_4$ | 8.375 | 8.125 | 7.875 | 7.75 |
| $T_5$ | 8.75 | 8.125 | 8 | 7.75 |
| $T_6$ | 8.625 | 8 | 7.625 | 7.25 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.006 | | | |
| S.Ed | 0.28 | | | |

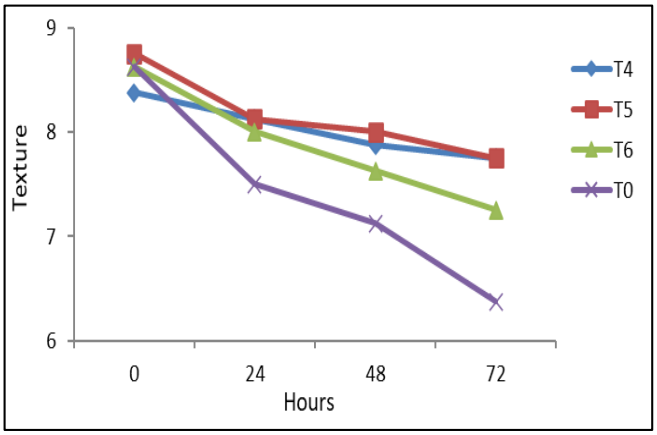


**Fig 15:** Effect of different level of spinach on texture analysis of chapatti at different storage time

**Effect of different level of spinach on appearance analysis of chapatti at different storage time**

The effect of different levels (20%, 30%, and 40%) of spinach on chapatti is presented in table 17. The highest score for texture at 0th hour was obtained for spinach (20%) sample, at 24th hour it was for spinach (20%), at 48th hour it was for spinach (20%) and at 72th hour it was for spinach (20%). The

lowest score for texture at 0th hour was obtained for spinach (40%), at 24th hour it was for control, at 48th hour it was for control sample and at 72th hour it was for control sample.

**Table 17:** Effect of different level of spinach on appearance analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_4$ | 8.875 | 8.625 | 8.25 | 8 |
| $T_5$ | 8.5 | 8.125 | 7.875 | 7.75 |
| $T_6$ | 8.25 | 8.125 | 7.625 | 7.25 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.007 | | | |
| S.Ed | 0.3 | | | |

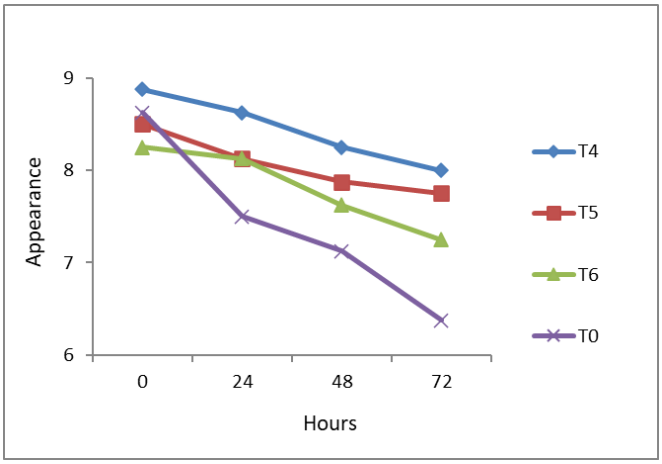


**Fig 16:** Effect of different level of spinach on appearance analysis of chapatti at different storage time

**Effect of different level of spinach on overall acceptability analysis of chapatti at different storage time**

The effect of different levels (20%, 30%, and 40%) of spinach on chapatti is presented in table 18. The highest score for overall acceptability at 0th hour was obtained for spinach (20%) sample, at 24th hour it was for spinach (20%), at 48th hour it was for spinach (20%) and at 72th hour it was for spinach (20%). The lowest score for overall acceptability at 0th hour was obtained for spinach (40%), at 24th hour it was for control, at 48th hour it was for control sample and at 72th hour it was for control sample.

**Table 18:** Effect of different level of spinach on overall acceptability analysis of chapatti at different storage time

| Storage Time/ Samples | 0 | 24 | 48 | 72 |
|---|---|---|---|---|
| $T_4$ | 8.875 | 8.625 | 8.25 | 8 |
| $T_5$ | 8.5 | 8.125 | 7.875 | 7.75 |
| $T_6$ | 8.25 | 8.125 | 7.625 | 7.25 |
| $T_0$ | 8.625 | 7.5 | 7.125 | 6.375 |
| F.Test | S | | | |
| C.D. | 0.007 | | | |
| S.Ed | 0.29 | | | |

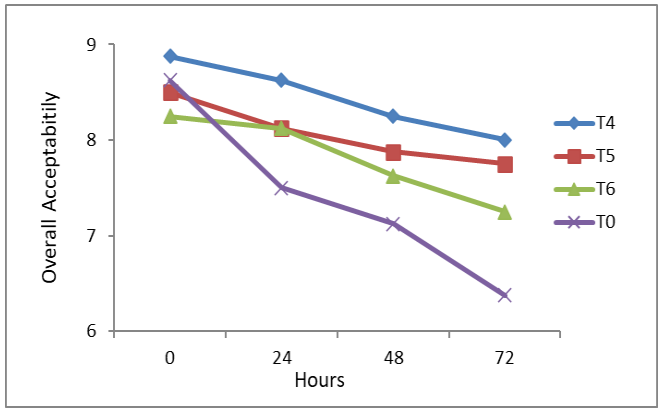


**Fig 17:** Effect of different level of spinach on overall acceptability analysis of chapatti at different storage time Microbiological analysis during storage conditions

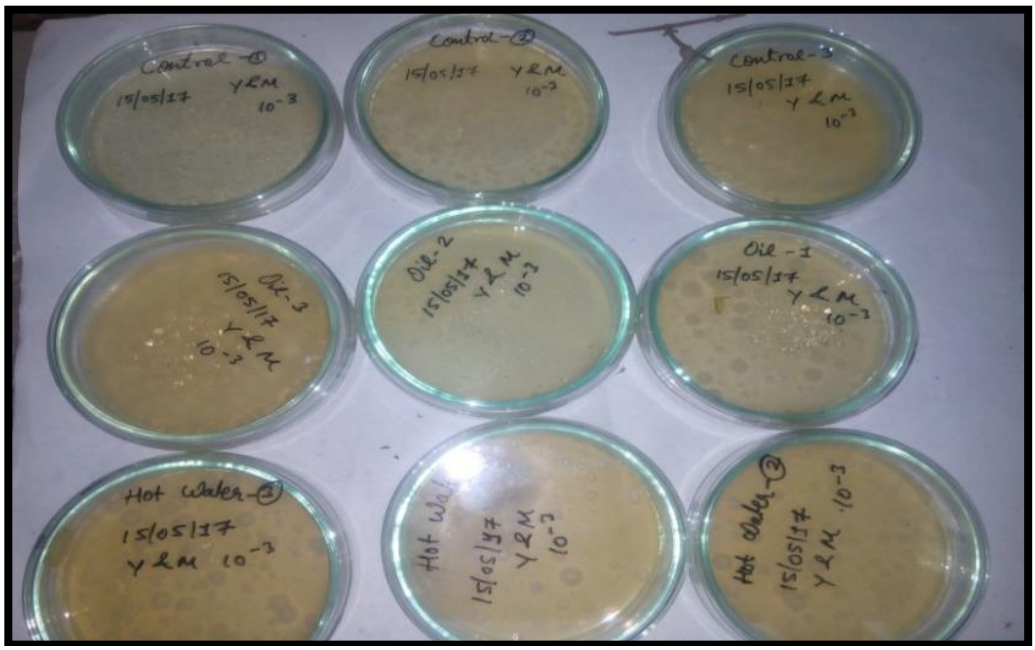


**Fig 18:** Microbial analysis for Control, Oil and Hot water at 0 h

The microbial analysis shown in Fig 17 for control, oil and hot water sample at 0 hour and as per the observation the growth of yeast and mold count was respectively. Since a representative portion of a sample is analyzed, the results indicate that no growth was observed in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

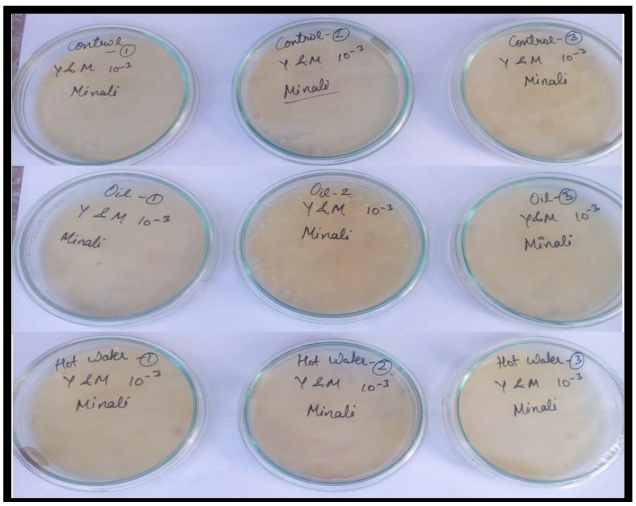


**Fig 19** Microbial analysis for Oil and Hot water at 24 h

The microbial analysis shown in Fig 18 for control, oil and hot water sample after 24 hour the growth was observed for yeast and mold count. Since a representative portion of a sample is analysed, the results indicate that very minimal growth was obtained in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

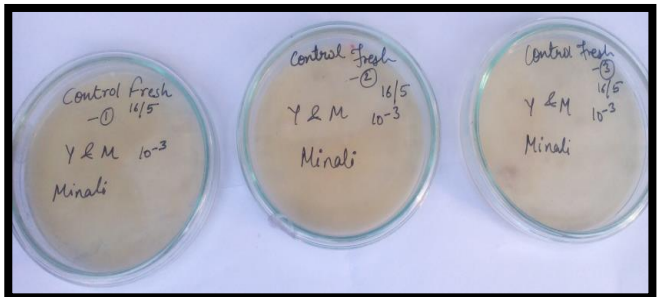


**Fig 20:** Microbial analysis for Control Fresh at 0 h

The microbial analysis shown in Fig 19 for control, oil and hot water sample at 0 hour and as per the observation the growth of yeast and mold is very small. Since a representative portion of a sample is analysed, the results indicate that no growth was obtained in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

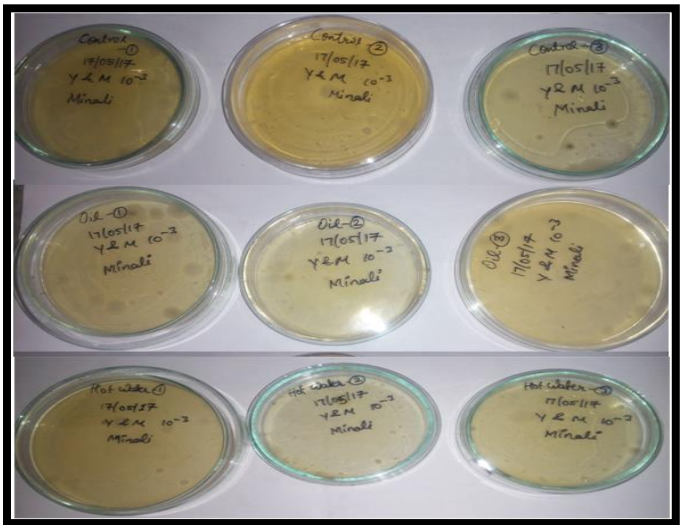

**Fig 21:** Microbial analysis for Control, Oil and Hot water at 48 h

The microbial analysis shown in Fig 20 for control, oil and hot water sample at 48 hour and as per the observation the growth of yeast and mold is very small. Since a representative portion of a sample is analysed, the results indicate that no growth was obtained in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

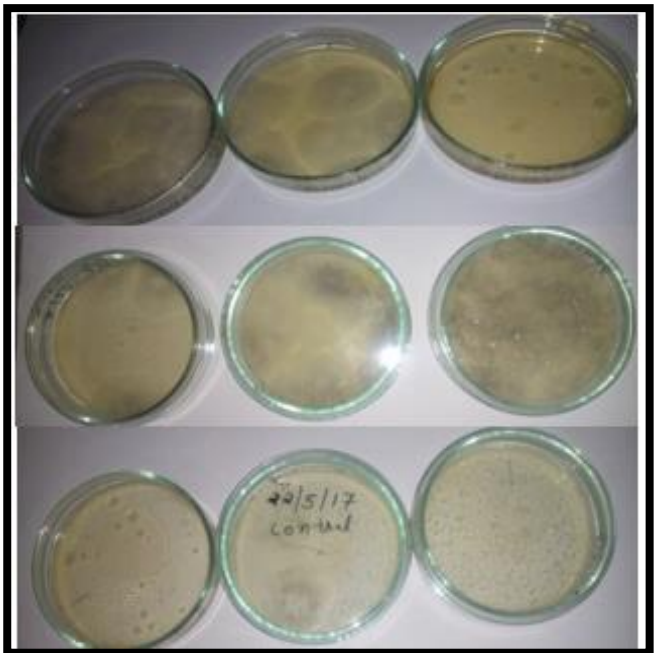


**Fig 22:** Microbial analysis for Spinach, Yeast and Control at 0 h

The microbial analysis shown in Fig 21 for spinach, yeast and control sample at 0 hour and as per the observation the growth of yeast and mold is very small. Since a representative portion of a sample is analysed, the results indicate that no growth was obtained in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

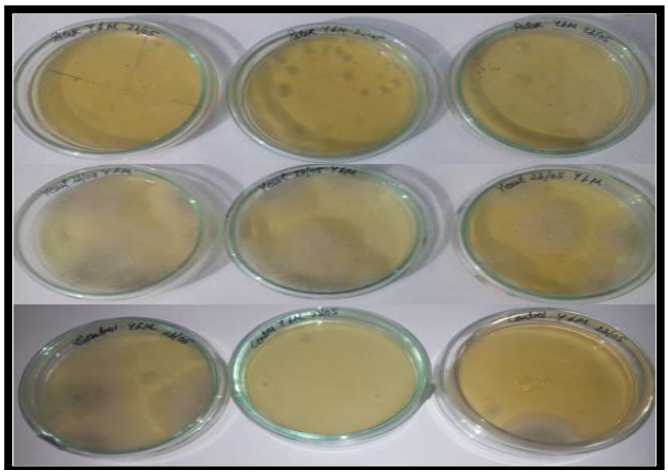

**Fig 23:** Microbial analysis for Spinach, Yeast and Control at 24 h

The microbial analysis shown in Fig 22 for spinach, yeast and control sample at 24 hour and as per the observation the growth of yeast and mold is very small. Since a representative portion of a sample is analysed, the results indicate that no growth was obtained in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

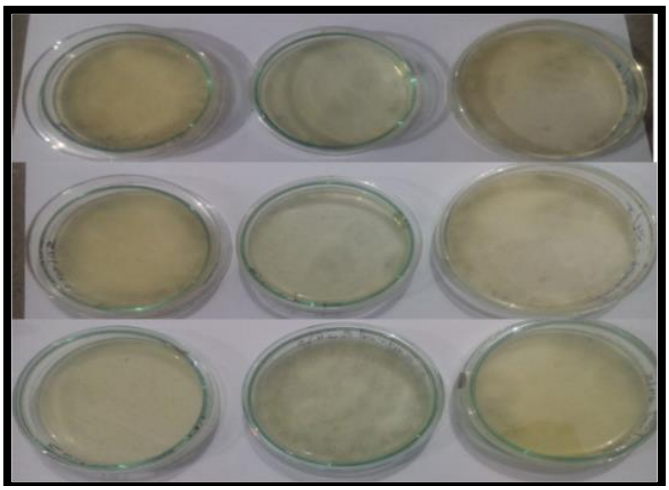

**Fig 24:** Microbial analysis for Spinach, Yeast and Control at 48 h

The microbial analysis shown in Fig 23 for spinach, yeast and control sample at 48 hour and as per the observation the growth of yeast and mold is very small. Since a representative portion of a sample is analyzed, the results indicate that no growth was obtained in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

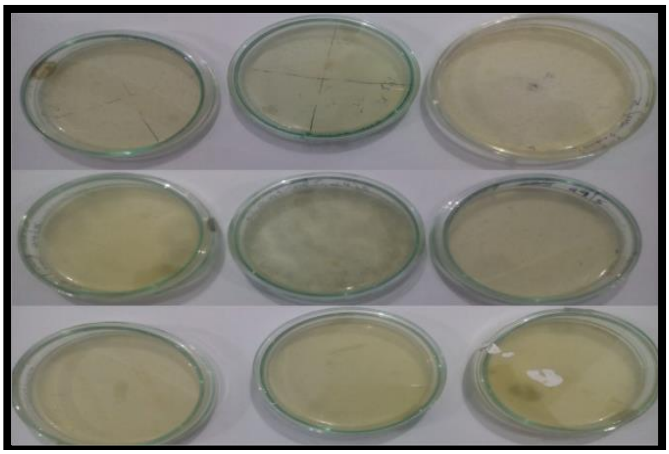

**Fig 25:** Microbial analysis for Spinach, Yeast and Control at 72 h

The microbial analysis shown in Fig 24 for spinach, yeast and control sample at 48 hour and as per the observation the growth of yeast and mold is very small. Since a representative portion of a sample is analyzed, the results indicate that no growth was obtained in the sample portion tested. The unit of measurement for the enumeration of microbes is a colony forming unit (CFU) derived from plate count methods.

**Table 19:** Yeast and Mold count analysis

| Samples | 0 hrs | 24 hrs | 48 hrs | 72 hrs |
|---|---|---|---|---|
| $T_0$ | 2 | 3 | 4 | 5 |
| $T_1$ | 3 | 4 | 3 | 5 |
| $T_2$ | 3 | 4 | 4 | 5 |
| $T_3$ | 2 | 3 | 4 | 5 |
| $T_4$ | 2 | 4 | 3 | 5 |
| $T_5$ | 3 | 3 | 4 | 4 |
| $T_6$ | 2 | 3 | 3 | 4 |
| $T_7$ | 3 | 3 | 3 | 5 |
| $T_8$ | 2 | 3 | 4 | 5 |
| $T_9$ | 3 | 4 | 4 | 4 |
| $T_{10}$ | 3 | 3 | 4 | 4 |
| $T_{11}$ | 3 | 4 | 4 | 5 |

## Conclusion

The present study revealed that due to application of thermal processing at different time combinations, the microbial stability as well as the sensory, and the texture appearance characteristics of the chapatti using different variables were retained. Chapati which was thermally processed had significantly superior acceptability at $0^{th}$ h for all variables and it gone decreasing as per the storage time increases. Processed samples were stored at 5 °C for 72 h and tested at each 24 h interval for sensory and microbial tests. At 72 h it was found that all samples were in good condition and showed the overall acceptability good with no microbial spoilage. At the end of the test it was found that hot water sample was best accepted while control sample was having poor acceptability. Results from the time measurements and microbiological tests showed that the product was in acceptable condition throughout the storage period.

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