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Increasing shelf life of chapati by value addition

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Abstract
Chapatti or flat bread is very popular in the world because it constitutes a major source of dietary protein and calories. There are several forms of flat bread, and the variation is mainly in terms of ingredient, technology, and quality. 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 ingredients like jowar, barley, hot water and oil in the wheat flour. Variables such as jowar, barley and oil are added at three different levels as 20%, 30%, 40%; 20%, 30%, 40%; 10%, 15% and 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 0th h, for 24th h, 48th h and 72th h and no spoilage were found in any sample and the overall acceptability is good rated to jowar 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 jowar 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 jowar 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: increasing shelf life, chapatti, value addition

1. 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, unleavened 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. The desired sensory quality characteristics of chapati are greater pliability, soft texture, light creamish brown color, slight chewiness and baked wheat aroma. Carbohydrate is the major component present in whole wheat flour and among the carbohydrates, starch is the major component and arabinoxylan is the minor component. (Hemalatha, *et. al.*, 2013) [2].
Chapati, a flat and unleavened baked product made from whole wheat flour, is the staple diet of majority of population of India and its subcontinent. 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. Hemalatha, *et al.* (2007) [1].
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 (Maneepun *et al.*, 2005). Ideally the chapatti is creamy in color, cooked with a minimum of small brown spots and fully puffed so that two distinct layers are present. The chapatti should be easily torn and pliable so that it can be folded by the thumb and forefinger to produce a small scoop for holding vegetables or curried preparations. A wheatish aroma and taste is desirable with a non sticky, soft chewing feel in the mouth.

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 find some solution to

i. To prepare different varieties of chapatti with jowar, barley, oil and hot water.
ii. To study the sensory attributes of the developed chapaties over time.
iii. To study the microbial analysis of the developed chapatti over time.
iv. To evaluate the shelf life with the help of ANN.

2. Artificial neural network

ANN imitates the learning process of the human brain and processes problems involving non-linear and complex data even if the data are imprecise and noisy. ANNs can identify and learn correlated patterns between input data sets and corresponding target values, which is called the training process and after the training, ANNs can be used to predict the outcome of new independent data set.

Hardeep Singh Gujral and Ambika Pathak (2002) reported that Chapatis were prepared from composite flours and the tensile properties of the chapatis were determined using an Instron Universal Testing Machine. Parameters like extensibility, peak force to rupture, modulus of deformation and energy to rupture were used to describe texture. The whole wheat flour was replaced with flours from rice, corn, barley, millets and black gram. Effect of additives like skim milk powder, wet gluten, liquid shortening, carboxymethylcellulose, glycerol monosterate, sodium caseinate and diastase on chapati texture was also evaluated. Upon storage up to 24 h, the extensibility and energy to rupture decreased whereas modulus of deformation and peak load to rupture increased. It was observed that chapaties made from some composite flours showed higher extensibility even after 24 h of storage, especially barley. Some of the additives like wet gluten and sodium caseinate also significantly improved the texture of chapatti.

Kamini Sood *et al*. (1992) studied theaddition of hulless barley flour to wheat flour increased protein content, but it had diluting effect on the gluten content. The water absorption capacity of blended samples was higher. Puffing of chapatis in all composite flours was satisfactory. Colour, appearance and texture of chapatis were good upto 30% of hulless barley flours in the blends, but flavour score was slightly decreased. Chewability of chapati was acceptable upto 40% of hulless barley flour in the blend.

Vahini J. and K. Bhaskarachary (2013) concluded that an understanding of the Glycemic Index (GI) values of foods or beverages can help dieticians to plan and direct patients/consumers to choose sensible, low GI foods that are believed to "reduce the risk of developing type-2 diabetes. The data on the GI values of different varieties of foods within India is very limited. Also effect of processing and cooking on GI of these foods is also scanty. Though millets production and consumption in India was decreased to post green revolution period, but recent diabetes prevalence rates (5-16%) have made people to rethink about millets in their diet because of high dietary fiber and other nutritional benefits. In view of this background, the current study was undertaken to determine the assessment of GI in popular varieties of jowar and correlation with in-vitro digestibility of wheat flour. Millets were milled into flour and coarse flour (rava) using Cyclone sample mill (UDYC, MODEL: 3010-019, USA). These flours and Rava were subjected to various cooking procedures like Boiling, Roti making, porridge preparation, sweet preparation and determined the Invitro GI. Results revealed that the GI of the variety, white jowar (flour) was lower (49.85±0.29) than the yellow Jowar (flour) variety (52.56± 0.87). Similar trend was observed in GI values of rava for these jowar varieties. When these flours of jowar varieties were boiled their GI values decreased. Similar observations were made with wheat flour for boiling. The current study clearly indicated that both milling and cooking methods effected the GI of the food significantly (P<0.001). Dietary fiber, Resistant starch, rapidly digestible starch, Alpha amylase inhibitors are the major contributing factors for lower GI values.

3. Materials and Methods

Table 1: Experimental Plan

S. No	Variable	Level	Description
1	Product	1	Chapati
2	Variables	4	Jowar, Barley, Hot Water, Oil
3	Levels	3	Jowar(20%, 30%, 40%) Barley(20%, 30%, 40%) Oil (10%, 15%, 20%)
4	Analysis	3	i. Sensory (9 point hedonic scale) ii. Microbial (Yeast and mold) ii. Calculation and estimation of shelf life (Artificial Neural Network)
5	Packaging Material	1	LDPE
6	Statistical Analysis	1	ANOVA

3.1 Materials

3.1.1 Materials used in chapatti making

Whole wheat flour was taken of Aashirvaad company, salt of Tata brand was used. Oil, Barley flour, Jowar flour are procured from market. The utensils such as plate for dough kneading, rolling pin, rolling board, iron tawa, pair of tongs are used.

3.1.2 Materials used in 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.

3.1.3 Equipments
- Laminar Air Flow Chamber
- Incubator
- Digital Weighing Balance
- Digital Colony Counter
- Autoclave

3.2 Chemicals used
- Ringer's Solution
- Potato Dextrose Agar

3.3 Formulation and preparation of chapatti

Table 2: Formulation and preparation of chapati

Treatments/Ingredients		Flour (gm)	Salt (gm)	Distilled Water (ml)	Jowar (gm)	Barley (gm)	Oil (ml)	Hot Water(ml)
Control	T_0	200	1.2	158	0	0	0	0
Jowar 20%	T_1	200	1.2	158	40	0	0	0
Jowar 30%	T_2	200	1.2	158	60	0	0	0
Jowar 40%	T_3	200	1.2	158	80	0	0	0
Barley 20%	T_4	200	1.2	158	0	40	0	0
Barley 30%	T_5	200	1.2	158	0	60	0	0
Barley 40%	T_6	200	1.2	158	0	80	0	0
Oil 10%	T_7	200	1.2	158	0	0	20	0
Oil 15%	T_8	200	1.2	158	0	0	30	0
Oil 20%	T_9	200	1.2	158	0	0	40	0
Hot Water	T_{10}	200	1.2	0	0	0	0	158

3.4 Preparation of chapati in laboratory
- **Flour was chosen:** Traditional roti recipes call for chapati flour, which is also known as durum wheat atta. 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.
- **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. Letting the dough rest resulted in softer rotis. 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 25gram).
- **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 ºC 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 chapaties are tested at 24 hr, 48 hr and 72 hr. Sensory test and microbial test was carried out at that interval.

3.5 Product standardization
Product standardization is one of the most critical steps in processing because the acceptability and sensory quality of the product mostly depend upon it though the effect of the way of processing may also be there. Here, we made Chapati by using wheat flour, distilled water, salt and variables as jowar, barley, oil and hot water. For making chapatti we have taken 25 gram of dough.

The control chapatti was taken as wheat flour of Aashirvaad whole wheat atta. Distilled water and a little amount of salt were added for the preparation of control sample.

3.6 Microbial analysis
3.6.1 Microbiological analysis during storage conditions:

Table 3: Microbial analysis

Packaging material	Product	Type	Levels	Microbial analysis (h)
LDPE	Chapati	jowar	3	0, 24, 48, 72
		barley	3	0, 24, 48, 72
		hot water	1	0, 24, 48, 72
		oil	3	0, 24, 48, 72

3.6.2 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. One ml of the sample from 10^{-3} dilution for Spread plate method from each of the samples individually.

3.6.3 Enumeration of yeast and molds
Enumeration of yeast and molds were done by spread plate

method where in approximately 15ml of PDA at 45 ºC 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 37 ºC for 3 to 4 days for incubation and colony count was taken on 3rd and 4th day of incubation.

3.7 Sensory evaluation
Sensory attributes including colour, 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 detailed methodology is presented below. A panel of eight expert judges of different age group having different habit will be selected and sample will be serving to them. 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.

3.8 Packaging material used
The Low-Density Polyethylene (LDPE) packaging material was used during the experiment. It's a thermoplastic made from monomer ethylene and the first grade of polyethylene, produced in 1933 by Imperial Chemical Industries (ICI) using a high pressure process via free radical polymerization.

Fig 1: LDPE Packaging

3.9 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.

The experiments were conducted for "Increasing Shelf Life of Chapati by Value Addition". The present investigation was under taken to evaluate the quality as well as acceptability of utilization of different variables such as jowar, barley, hot waterand oil for the preparation of chapatti. The sensory and microbial evaluation had been carried out.

Studies based on sensory properties were determined for cooked chapatti like flavour, 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 in this chapter.

Artificial Neural Network was used for prediction of shelf-life of the product. We have used MLP (Multi-layer Perceptron) for the prediction.

3.10 Multilayer Perceptron (MLP)
Artificial neural network (ANN) is one the most popular data driven model and have many applications in modeling process. The main objective of this study was to simulate continuous and event-based shelf-life model based on MLPNN (Multilayer Perceptron Neural Network).

The ANN technology is an alternate computational approach inspired by studies of the brain and nervous system. It is based on theories of the massive interconnection and parallel processing architecture of biological neural systems. The human brain is a natural neural network which has billions of neurons.

The first technique of neural network modeling is the MLP model, and the architecture of a typical neuron with single hidden layer. Multilayer Perceptron (MLP) is a supervised and feed forward neural network with one or more layers of nodes between input and output nodes (Nawaz *et al*., 2015). It is a most commonly used neural computing technique. The basic structure of network basically consists of three layers which include:

- Input layer, where data is introduced to network
- Hidden layer or layers, where the data is processed
- Output layer, where the results are produced.

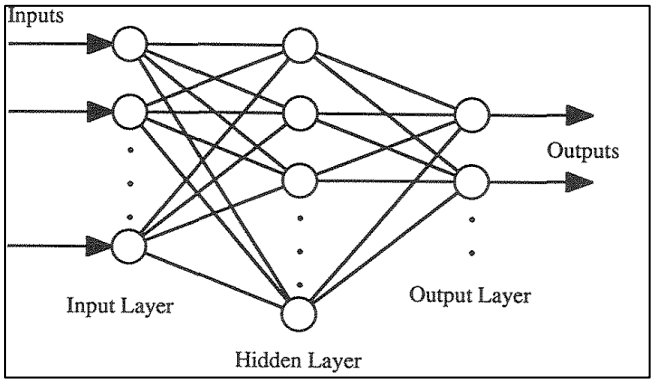

Fig 2: A basic overview of MLP

MLP is a network of simple neurons called perceptrons. The perceptron computes a single output from multiple real-valued inputs by forming a linear combination according to its input weights and then possibly putting the output through some nonlinear activation function.

In NeuroSolution 5.0 software the Neural Builder we have used Delta-Bar-Delta as learning rule, Hyperbolic Tangent (Tanh) as Activation function

4. Results And Discussion
4.1 Product Development
The product development was done bythe utilisation of jowar, barley, hot water and oil along with wheat flour increases the shelf life and flexibility of chapatti. From all the preparations, it was seen that wheat flour with barley flour (40%) 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.

4.2 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 5^0C 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.

4.2.1 Effect of different level of jowar on flavour analysis of chapatti at different storage time

The effect of different level (20%, 30%, and 40%) of jowar on chapatti is presented in table 4. The highest score for flavour at 0^{th} hour was obtained for sample with T_2 and T_0, at 24^{th} hour it was for T_1 and T_3, at 48^{th} hour it was for T_3 and at 72^{th} hour it was for T_3. The lowest score for flavourat 0^{th} hour was obtained for T_1, at 24^{th} hour it was for T_0, at 48^{th} hour it was for T_0 and at 72^{th} hour it was for T_0.

Table 4 Effect of different level of jowar on flavour analysis of chapatti at different storage time

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

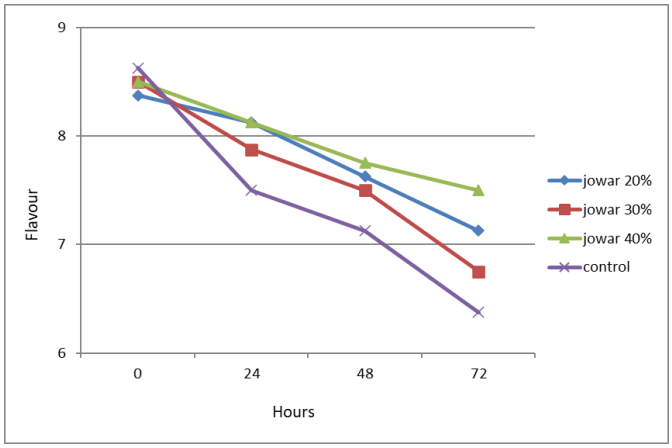

Fig 3: Effect of different level of jowar on flavour analysis of chapatti at different storage time

4.2.2 Effect of different level of jowar on texture analysis of chapatti at different storage time

The effect of different level (20%, 30%, and 40%) of jowar on chapatti is presented in table 5. The highest score for texture at 0^{th} hour was obtained for T_3, at 24^{th} hour it was for T_3, at 48^{th} hour it was for T_3 and at 72^{th} hour it was for T_3. The lowest score for textureat 0^{th} hour was obtained for T_1, at 24^{th} hour it was for T_0, at 48^{th} hour it was for T_0 and at 72^{th} hour it was for T_0.

Table 5: Effect of different level of jowar 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	7.75	7.375	7.25
T_3	8.625	8.25	8.125	7.375
T_0	8.25	7.5	7.125	6.375
F.Test	S			
C.D.	0.005			
S.Ed	0.29			

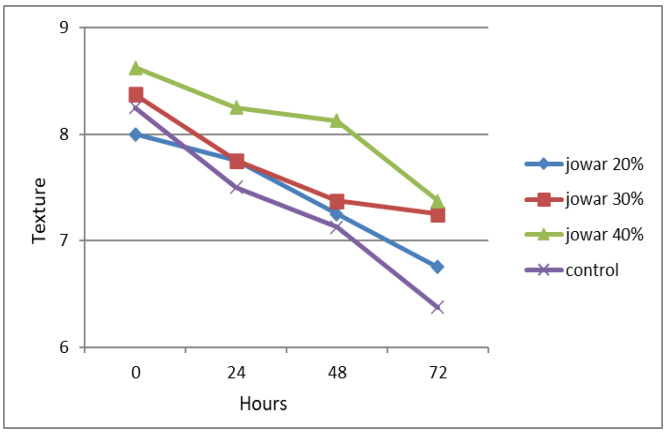

Fig 4: Effect of different level of jowar on texture analysis of chapatti at different storage time

4.2.3 Effect of different level of jowar on appearance analysis of chapatti at different storage time

The effect of different level (20%, 30%, and 40%) of jowar on chapatti is presented in table 6. The highest score for appearance at 0^{th} hour was obtained for T_3, at 24^{th} hour it was for T_3, at 48^{th} hour it was for T_3 and at 72^{th} hour it was for T_3. The lowest score for appearanceat 0^{th} hour was obtained for T_1, at 24^{th} hour it was for T_0, at 48^{th} hour it was for T_0 and at 72^{th} hour it was for T_0.

Table 6: Effect of different level of jowar on appearance analysis of chapatti at different storage time

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

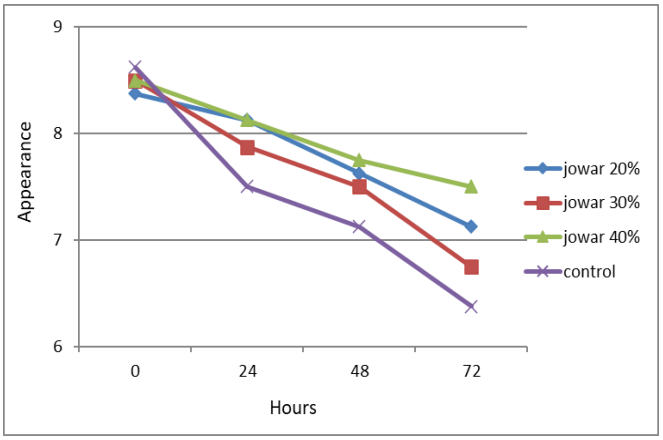

Fig 5: Effect of different level of jowar on appearance analysis of chapatti at different storage time

4.2.4 Effect of different level of jowar on overall acceptability analysis of chapatti at different storage time

The effect of different level (20%, 30%, and 40%) of jowar on chapatti is presented in table 7. The highest score for overall acceptability at 0^{th} hour was obtained for T_3, at 24^{th} hour it was for T_3, at 48^{th} hour it was for T_3 and at 72^{th} hour it was for T_3. The lowest score for overall acceptabilityat 0^{th} hour was obtained for T_2, at 24^{th} hour it was for T_0, at 48^{th} hour it was for T_0 and at 72^{th} hour it was for T_0.

Table 7: Effect of different level of jowar on overall acceptability analysis of chapatti at different storage time

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

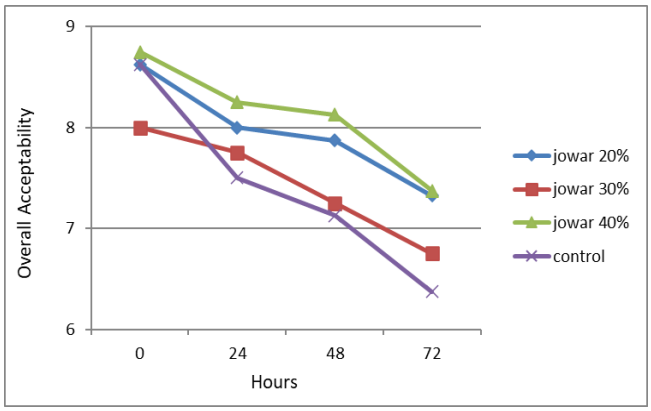

Fig 6: Effect of different level of jowar on overall acceptability analysis of chapatti at different storage time

4.2.5 Effect of different level of barley on flavour analysis of chapatti at different storage time

The effect of different levels (20%, 30%, and 40%) of barley on chapatti is presented in table 8. The highest score for flavour at 0^{th} hour was obtained for control sample, at 24^{th} hour it was for T_5 and T_6, at 48^{th} hour it was for T_6 and at 72^{th} hour it was for T_6. The lowest score for flavour at 0^{th} hour was obtained for T_4, at 24^{th} hour it was for T_4, at 48^{th} hour it was for T_0 and at 72^{th} hour it was for T_0.

Table 8: Effect of different level of barley on flavour analysis of chapatti at different storage time

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

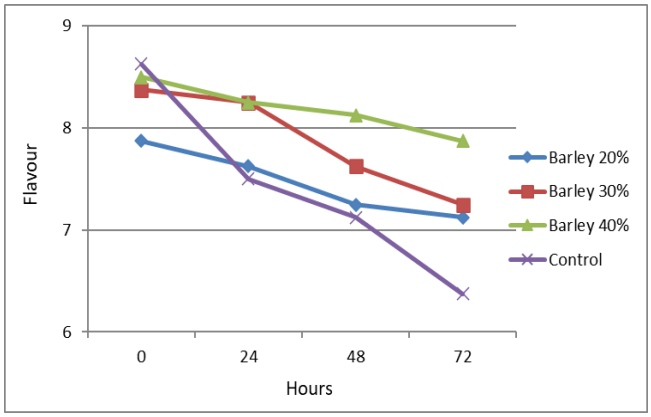

Fig 7: Effect of different level of barley on flavour analysis of chapatti at different storage time

4.2.6 Effect of different level of barley on texture analysis of chapatti at different storage time

The effect of different levels (20%, 30%, and 40%) of barley on chapatti is presented in table 9. The highest score for texture at 0^{th} hour was obtained for sample T_6, at 24^{th} hour it was for T_6 and T_4, at 48^{th} hour it was for T_6 and at 72^{th} hour it was for T_6 and T_4. The lowest score for texture at 0^{th} hour was obtained for T_4, at 24^{th} hour it was for T_0, at 48^{th} hour it was for T_0 sample and at 72^{th} hour it was for T_0.

Table 9: Effect of different level of barley 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	8.625	8	7.625	7.25
T_6	8.75	8.125	8	7.75
T_0	8.625	7.5	7.125	6.375
F.Test	S			
C.D.	0.006			
S.Ed	0.28			

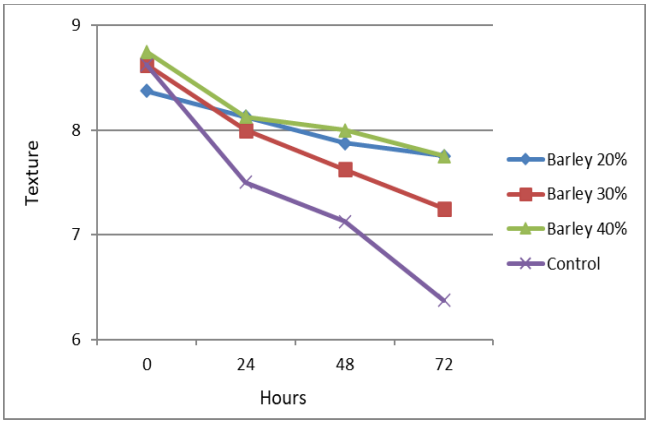

Fig 8: Effect of different level of barley on texture analysis of chapatti at different storage time

4.2.7 Effect of different level of barley on appearance analysis of chapatti at different storage time

The effect of different levels (20%, 30%, and 40%) of barley on chapatti is presented in table 10. The highest score for texture at 0^{th} hour was obtained for T_4 sample, at 24^{th} hour it was for T_6, at 48^{th} hour it was for T_6 and at 72^{th} hour it was for T_6. The lowest score for texture at 0^{th} hour was obtained for T_4, at 24^{th} hour it was for T_0, at 48^{th} hour it was for T_0 and at 72^{th} hour it was for T_0.

Table 10: Effect of different level of barley on appearance analysis of chapatti at different storage time

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

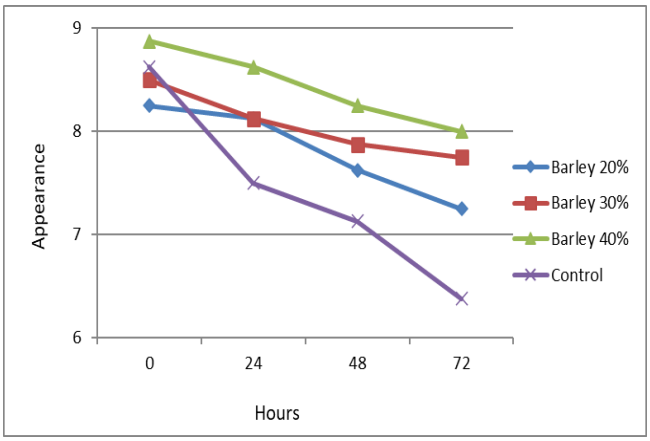

Fig 9: Effect of different level of barley on appearance analysis of chapatti at different storage time

4.2.8 Effect of different level of barley on overall acceptability analysis of chapatti at different storage time

The effect of different levels (20%, 30%, and 40%) of barley on chapatti is presented in table 11. The highest score for overall acceptability at 0th hour was obtained for T_6 sample, at 24th hour it was for T_6, at 48th hour it was for T_6 and at 72th hour it was for T_6. The lowest score for overall acceptability at 0th hour was obtained for T_4, at 24th hour it was for T_0, at 48th hour it was for T_0 and at 72th hour it was for T_6.

Table 11: Effect of different level of barley on overall acceptability analysis of chapatti at different storage time

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

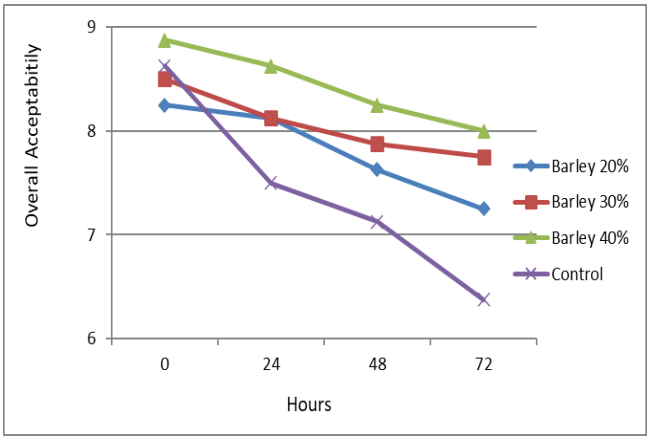

Fig 10: Effect of different level of barley on overall acceptability analysis of chapatti at different storage time

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

The effect of different level (10%, 15%, and 20%) of oil on chapatti is presented in table 12. 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 12: Effect of different level of oil on flavour 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			

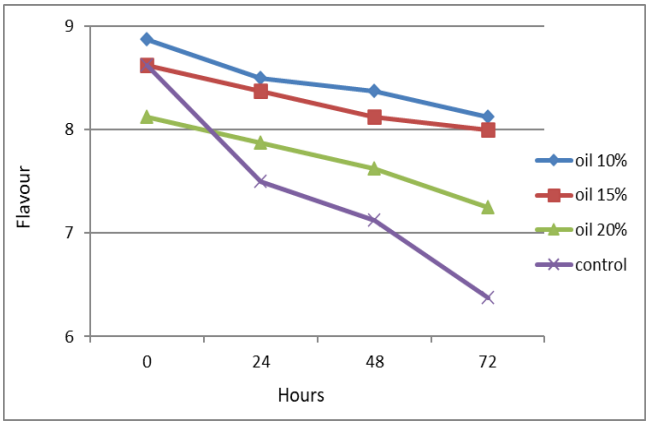

Fig 11: Effect of different level of oil on flavour analysis of chapatti at different storage time

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

The effect of different level (10%, 15%, and 20%) of oil on chapatti is presented in table 13. 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 13: 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			

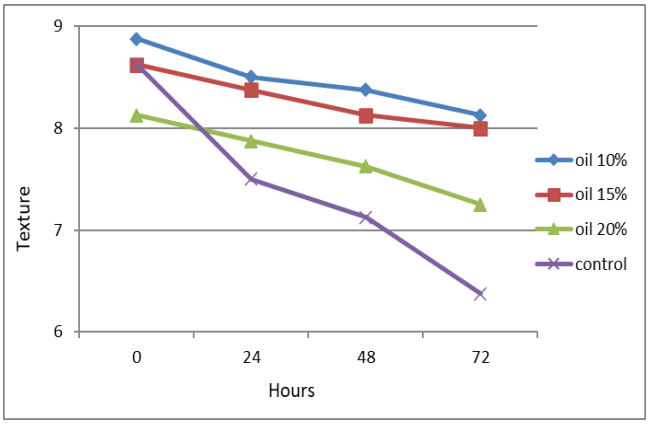

Fig 12: Effect of different level of oil on texture analysis of chapatti at different storage time

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

The effect of different level (10%, 15%, and 20%) of oil on chapatti is presented in table 14. 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 72_{th} 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 14: 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			

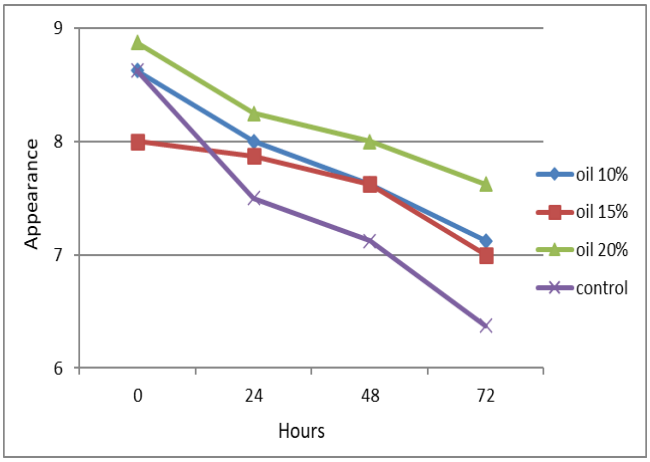

Fig 13: Effect of different level of oil on appearance analysis of chapatti at different storage time

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

The effect of different level (10%, 15%, and 20%) of oil on chapatti is presented in table 15. 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 15: 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			

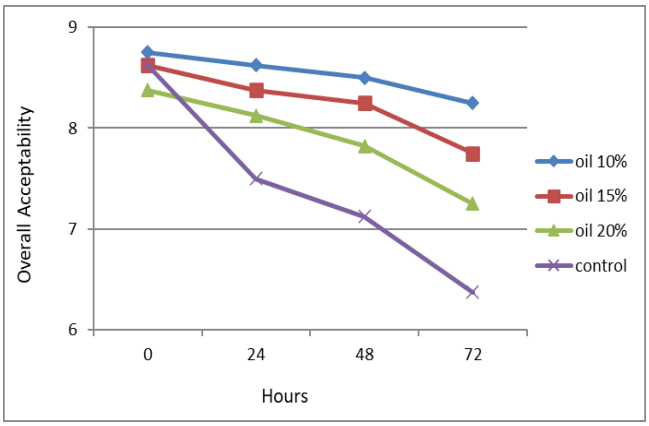

Fig 14: Effect of different level of oil on overall acceptability analysis of chapatti at different storage time

Out of three levels of jowar, barley and oil the best considered are Jowar 40% (T_3), Barley 40% (T_6) and Oil 10% (T_7), thus further analysis was done by taking these three (T_3, T_6 and T_7) and hot water (T_{10}) along with Control (T_0).

4.2.13 Effect of jowar, barley, hot water and oilon flavour analysis of chapatti at different storage time

The effect of different contents of chapatti is presented in table 16. The highest score for flavour at 0th hour was obtained for T_0, at 24th hour it was for T_6, at 48th hour it was for T_3 and at 72th hour it was for T_6. The lowest score for flavour at 0th hour was obtained for T_{10} andT_7, 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. Control fresh is the sample prepared at the particular time interval for better comparison of different variables to the freshly prepared chapatti.

Table 16: Flavour analysis of chapatti with jowar, barley, hot water and oil at different storage time

Storage Time/ Samples	0	24	48	72
Control Fresh		8.25	8.25	8.125
T_0	8.625	7.5	7.125	6.375
T_{10}	8.125	7.75	7.5	7.375
T_7	8.125	8	7.5	7.125
T_6	8.5	8.25	8.125	7.875
T_3	8.5	8.125	7.75	7.5
F.Test	S			
C.D.	0.003			
S.Ed	0.42			

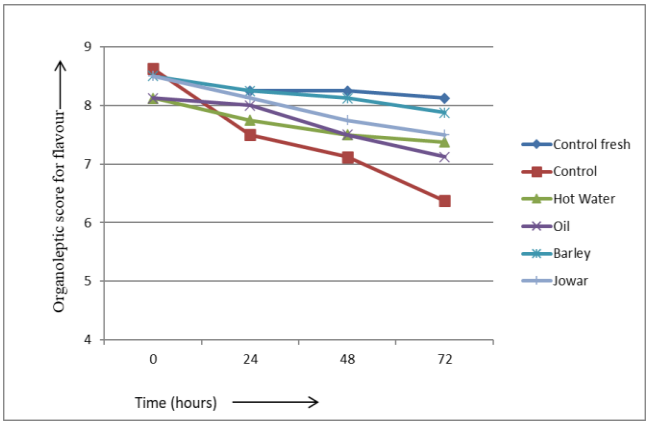

Fig 15: Flavour analysis of chapatti with jowar, barley, hot water and oil at different storage time

4.2.14 Effect of jowar, barley, hot water and oil on texture analysis of chapatti at different storage time

The effect of different contents of chapatti is presented in table 17. The highest score for texture at 0th hour was obtained for T_6, at 24th hour it was for T_{11}, at 48th hour it was for T_{11} and at 72th hour it was for T_6. The lowest score for texture at 0th hour was obtained for T_0, 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 17: Texture analysis of chapatti with jowar, barley, hot water and oil at different 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	7.5	7.5	7
T_7	8.5	8	7.75	7
T_6	8.75	8.125	8	7.75
T_3	8.625	8.25	8.125	7.375
F.Test	S			
C.D.	0.00003			
S.Ed	0.306			

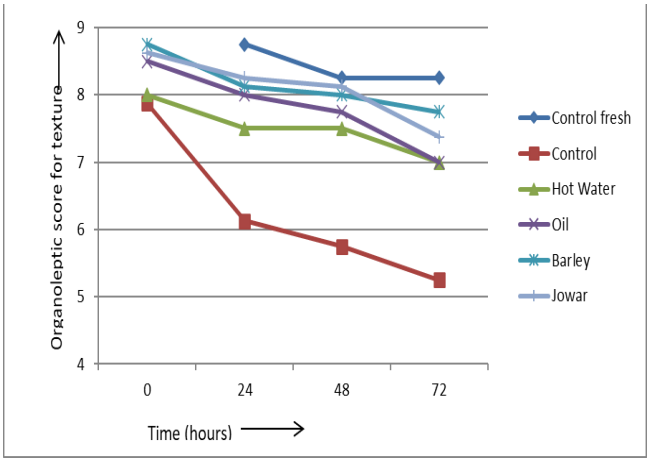

Fig 16: Texture analysis of chapatti with jowar, barley, hot water and oil at different storage time

4.2.15 Effect of jowar, barley, hot water and oil on appearance analysis of chapatti at different storage time

The effect of different contents of chapatti is presented in table 18. The highest score for appearance at 0th hour was obtained for sample with T_6 and T_3, at 24th hour it was for T_6, at 48th hour it was for T_6 and at 72th hour it was for T_6. The lowest score for appearance at 0th hour was obtained for T_0 and T_{10}, 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 18: Appearance analysis of chapatti with jowar, barley, hot water and oil 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	8.625	8	7.625	7.125
T_6	8.875	8.625	8.25	8
T_3	8.875	8.25	8	7.625
F.Test	S			
C.D.	0.002			
S.Ed	0.529			

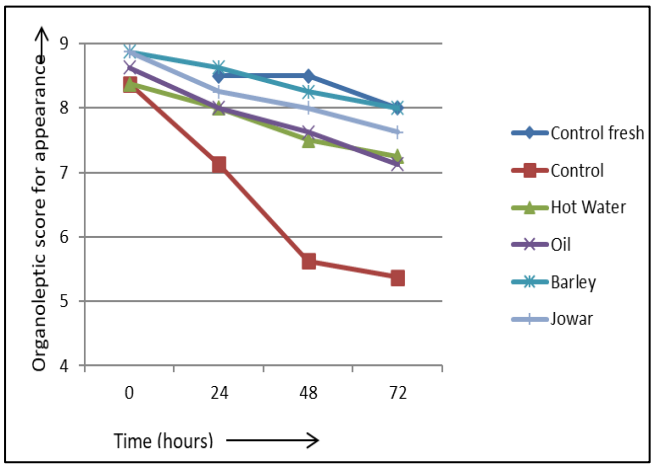

Fig 17: Appearance analysis of chapatti with jowar, barley, hot water and oil at different storage time

4.2.16 Effect of jowar, barley, hot water and oil on overall acceptability analysis of chapatti at different storage time

The effect of different contents of chapatti is presented in table 19. The highest score for overall acceptability at 0th hour was obtained for T_6, at 24th hour it was for T_6, at 48th hour it was for T_6 and at 72th hour it was for T_6. The lowest score for overall acceptabilityat 0th hour was obtained for T_0, 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 19: Overall acceptability analysis of chapatti with jowar, barley, hot water and oil at different storage time

Storage Time/ Samples	0	24	48	72
Control Fresh		8.5	8.46875	8.1875
T_0	8	6.71875	5.625	5.3125
T_{10}	8.25	7.84375	7.406	7.375
T_7	8.5	8.25	8	7.75
T_6	8.875	8.625	8.25	8
T_3	8.625	8	7.87	7.325
F.Test	S			
C.D.	0.0007			
S.Ed	0.37			

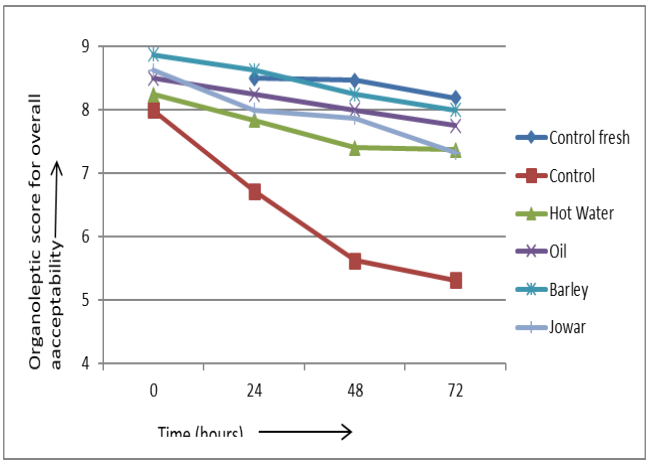

Fig 18: Overall acceptability analysis of chapatti with jowar, barley, hot water and oil at different storage time

4.3 Microbiological analysis during storage conditions

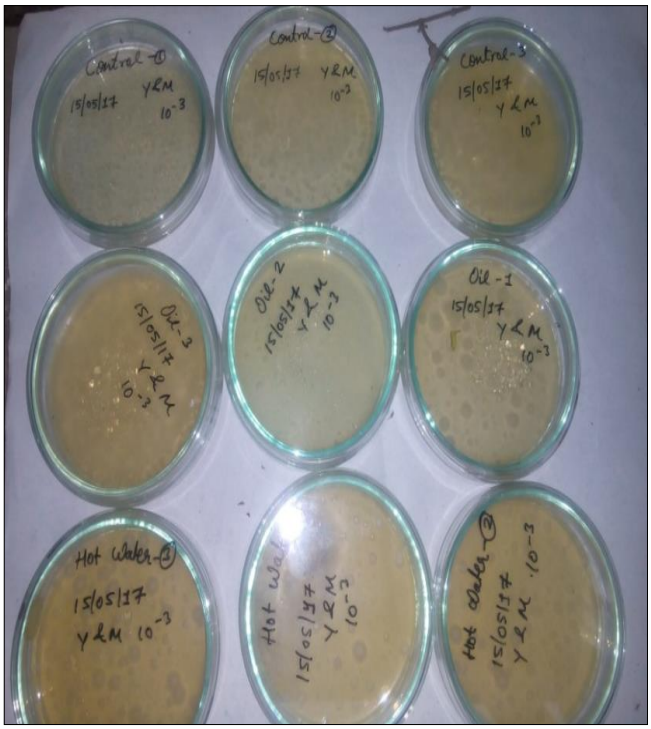

Fig 19: Microbial analysis for Control, Oil and Hot water at 0 h

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 count was respectively. Since a representative portion of a sample is analysed, 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.

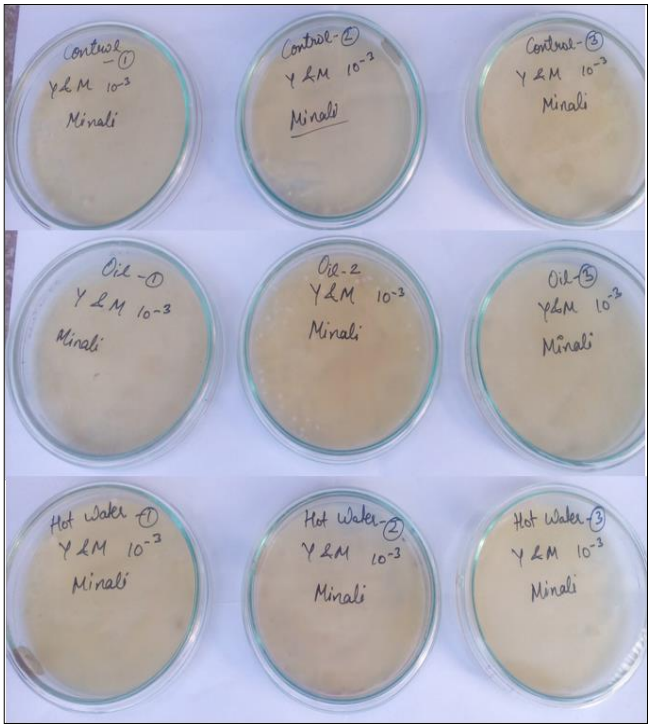

Fig 20: Microbial analysis for Oil and Hot water at 24 h

The microbial analysis shown in Fig 20 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.

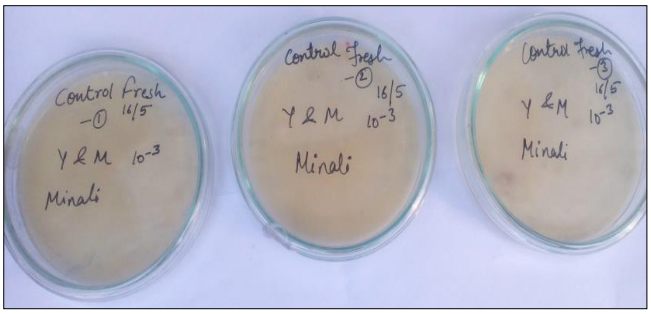

Fig 21: Microbial analysis for Control Fresh at 0 h

The microbial analysis shown in Fig 21 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.

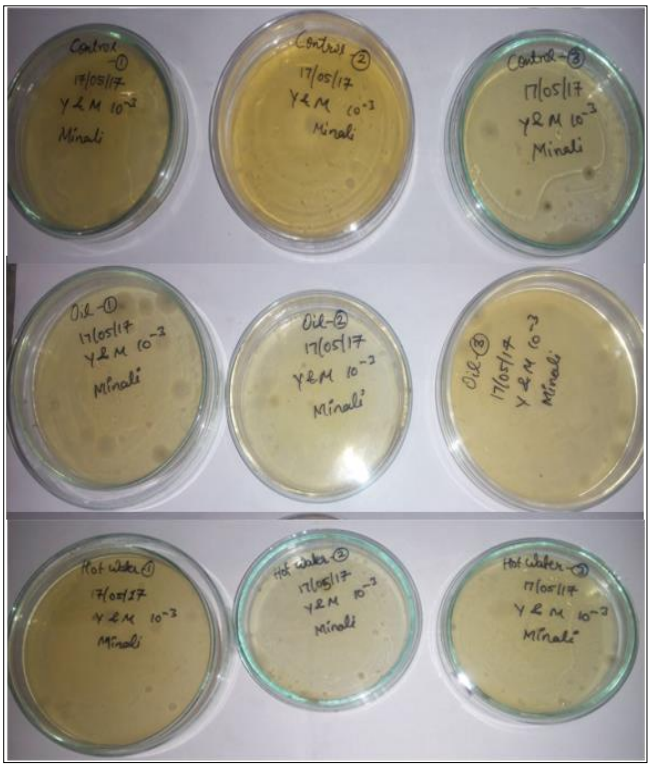

Fig 22: Microbial analysis for Control, Oil and Hot water at 48 h

The microbial analysis shown in Fig 22 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.

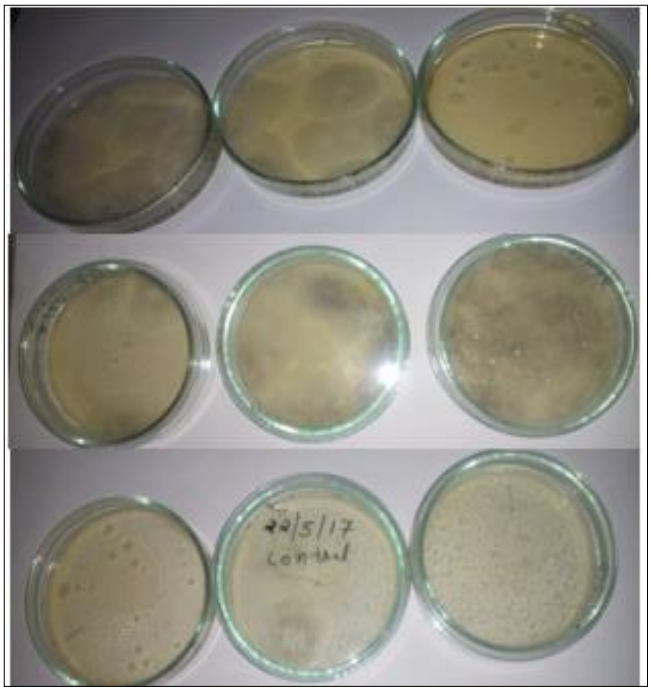

Fig 23: Microbial analysis for barley, jowar and control at 0 h

The microbial analysis shown in Fig 23 for barley, jowarand 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.

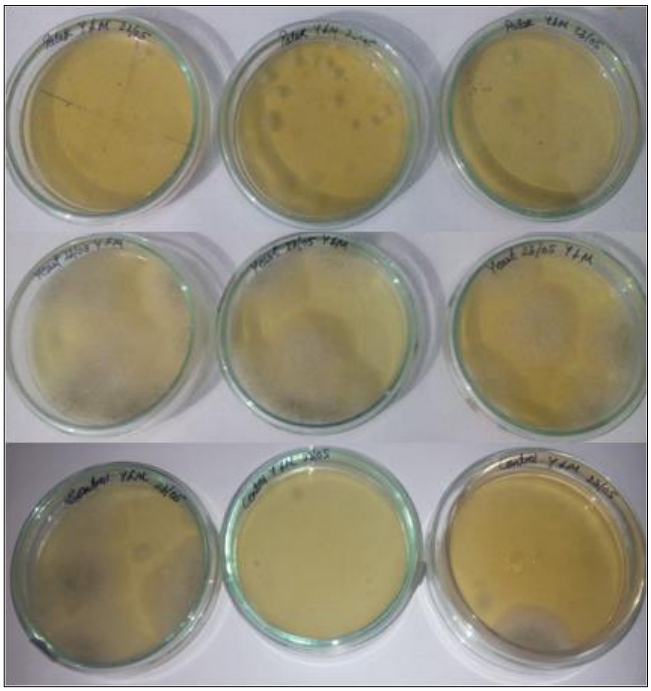

Fig 24: Microbial analysis for barley, jowar and control at 24 h

The microbial analysis shown in Fig 24 for barley, jowar 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.

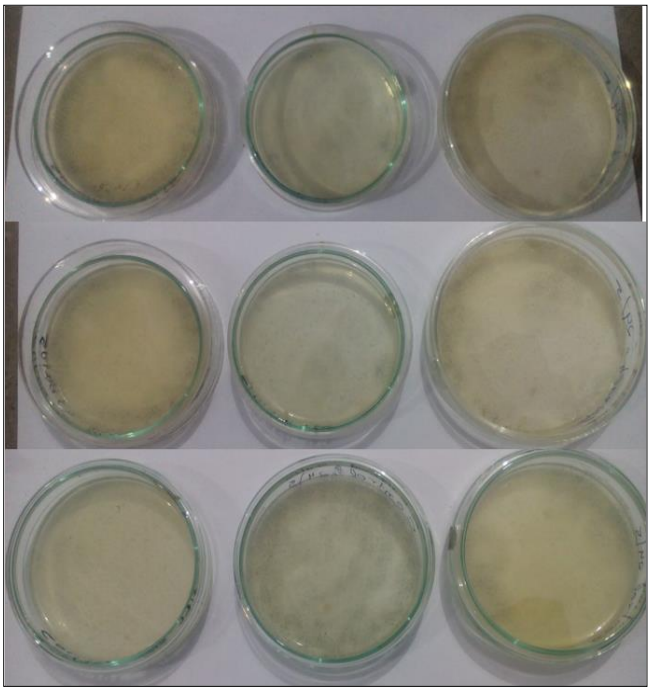

Fig 25: Microbial analysis for barley, jowar and control at 48 h

The microbial analysis shown in Fig 25 for barley, jowar and controlsample 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.

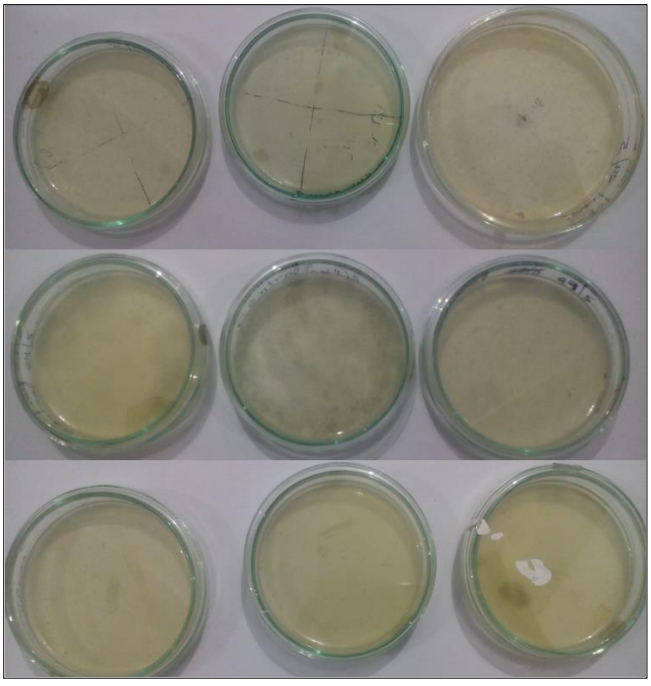

Fig 26: Microbial analysis for barley, jowar and control at 72 h

The microbial analysis shown in Fig 26 for barley, jowar and controlsample 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.

Table 20: 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

4.4 Shelf-life modeling using MLP

Using Neurosolutions 5.0 and statistical analysissuch as MSE, R^2 and r was carried out. By selecting the model with lowest MSE and higher values of r and R^2. We get the best model predicting the shelf-life for the product. With the MSE value as 0.711 and value of r as 0.953, we get the model with the inputs as Hot Water and Barley. Thus, predicting that hot water and barley affect the shelf-life of product.

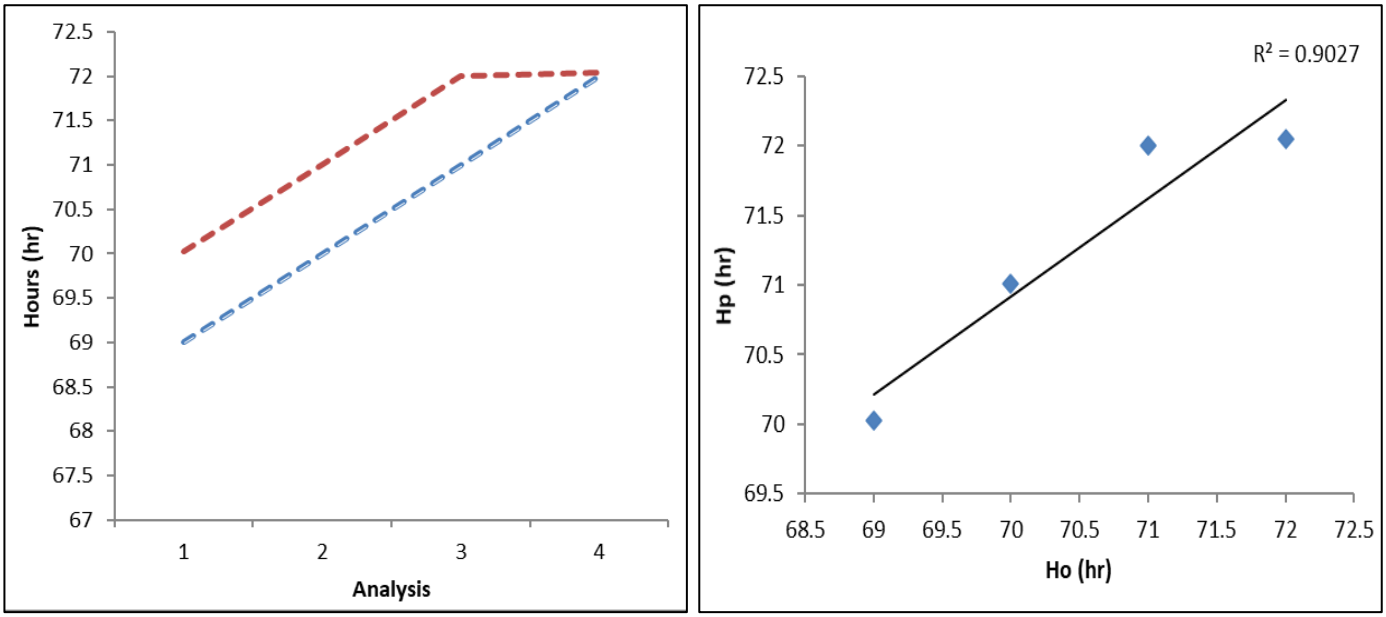

Fig 27: Comparison of observed (H_o) and predicted (H_p) shelf lifeand corresponding scatter plot in testing MLP-11 (2-2-1) model

5. Summary and Conclusions

5.1 Summary

The results summarized were drawn after the present study entitled "Increasing the shelf life of Chapati by value addition" are discussed as follows:

- Using different variable and balls dough was prepared each weighing 25gm.
- The variable such as barley 20%, 30%, 40%, jowar 20%, 30%, 40%; and oil 10%, 15%, 20% were added at three different levels.
- The chapatis were prepared by traditional method and then undergo the thermal process for chapati.
- The prepared chapatti was stored at 5°C in refrigerator and then shelf life of chapatti was studied in equal intervals of 24 h for 4 readings.
- For the 0^{th} h test, no spoilage were found in any sample and the overall acceptability is good rated to barley sample and poor was rated for control sample.
- For the 24^{th} h test, no spoilage were found in any sample and the overall acceptability is good rated to barley sample and poor was rated for control sample.
- For the 48^{th} h test, no spoilage were found in any sample and the overall acceptability is good rated to barley sample and poor was rated for control sample.
- For the 72^{th} h test, no spoilage were found in any sample and the overall acceptability is good rated to barley 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.

5.2 Conclusions

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 barley 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.

6. References

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