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Pooja Giri
Department of Food Process Engineering, SHUATS, Allahabad, Uttar Pradesh, India

Chitra Sonkar
Department of Food Process Engineering, SHUATS, Allahabad, Uttar Pradesh, India

Dorcus Masih
Department of Food Process Engineering, SHUATS, Allahabad, Uttar Pradesh, India

Corresponding Author:
Pooja Giri
Department of Food Process Engineering, SHUATS, Allahabad, Uttar Pradesh, India

Effect of food additives on the quality and storage of whole wheat flat bread (chapatti)

Pooja Giri, Chitra Sonkar and Dorcus Masih

Abstract
Supplementation of additives (hydrocolloids) on quality, physicochemical, microbiological and sensory characteristics of wheat flat breads was investigated in the present work. In order to delay staling by using additives in chapati making, additives (Vital Gluten, Oxidised Corn Starch and K-carrageenan) were incorporated at different concentrations (0.15, 0.50 and 0.10%) with wheat flour. Physical Characteristics (moisture loss and baking time), chemical (Protein content, Fat content, Starch content and Ash content), microbiological (Yeasts and Moulds count) and sensory properties of developed wheat chapaties were investigated by applying different experiments and results were compared with those of control chapati prepared with whole wheat flour. With respect to the control wheat chapati, almost in terms of all attributes wheat chapati developed by incorporating K-carrageenan as an additive, showed the highest anti-staling rate and was also greatly acceptable when compared with all the other chapati samples.

Keywords: Hydrocolloids, wheat chapatti and staling

1. Introduction
Wheat is a major cereal in India and consumed mainly in the form of unleavened flat bread known as chapati (Prabhasankar *et al*., 2002) [10]. Chapati is usually prepared from whole wheat flour and the desired quality parameter in chapati are greater pliability, soft texture, light creamish brown colour, slight chewiness and baked wheat aroma (Rao *et al*., 1986) [11]. The quality of wheat greatly influences the quality of chapati. Normally, the quality of wheat is assessed by chemical, rheological and baking tests. Since the quality of wheat is governed by the interaction of many constituents, it is difficult to judge quality by any single test. It has been reported that the rheological and baking properties of dough depend on the quality of protein and proportion of different type of protein (Gujral and Pathak, 2002) [8]. Wheat proteins are classified into gluten proteins and non-gluten proteins. The non -gluten proteins are albumins and globulins and molecular weights of majority of these proteins were reported to be less 25000 Da (Balestra *et al*., 2011) [2].
The main problem encountered during storage of chapati is staling caused by retrogradation of starch. To prevent this problem of staling such ingredients should be added in chapati that retards staling process. Staling also damages the texture and flavor of bread and chapati. Some food additives must be added in chapati to delay or retard staling. The content of damaged starch directly influences bread staling through the increase of amylopectin recrystallization (Guarda *et al*., 2004) [7]. Staling results in loss of important sensory parameters of bread, like flavour and texture, and it is a consequence of a group of several physical–chemical changes occurring during bread storage that lead mainly to an increase of crumb firmness and loss of freshness (Gray and Bemiller 2003) [6]. The freshness of flat bread is the holistic attribute and is prized for its taste, aroma and texture. Because of the lean formula flat bread stale quickly during storage and shelf life is limited to few hours (Sandhu *et al*., 2007) [13], resulting from the physiochemical changes that lead to a loss of freshness with an increased firmness and an alteration of its organoleptic quality, and becomes difficult to chew which is considered objectionable in acceptance by consumers (Gujral and Pathak., 2002) [8].
Flat breads are consumed fresh as they stale rapidly on storage. With rapidly changing lifestyles, increasing urbanization and industrialization and changing socio-economic trends, there is an increase in the demand for convenience foods, which require less preparation time. Large-scale production of flat breads calls for mechanization and marketing of this flat bread in suitable unit packs. When it reaches the consumer, the packed flatbreads should retain all the sensory characteristics of fresh bread (Cheng and Bhat, 2015) [4].

In recent years, there has been increasing interest in hydrocolloids due to their natural origin, effects on dough rheology and bread quality. Hydrocolloids have also been satisfactorily used as antistaling agents. In addition, improvement in wheat dough stability during proofing can be obtained by the addition of hydrocolloids, namely sodium alignate, k-carrageenan, xanthan gum and HPMC (Rosell *et al*., 2001a) [12]. Modified starches could be used as alternatives to natural hydrocolloids. The use of modified starches to retard the staling of bread has been suggested since the 1990s (Barcenas and Rosell, 2005) [3], and chemically modified starches have been widely used in the baking industry to improve bread quality. Addition of modified starches may change the texture of bread crust and crumb, allowing the development of unique breads that differ from conventional bread (Davidou *et al*., 1996) [5]. The same authors found that oxidized starch (OX) can lower the degree of retrogradation compared to native starch because of the bulky carboxyl or carbonyl groups that are substituted on starch. Vital wheat gluten is marketed as an ingredient for the bakery industry and is usually added as a food additive to weak wheat flour of poor bread-making quality (Villaudy and Tilly, 1989) [15] to improve its visco elastic properties, or it is incorporated in bread formulations where the gluten from wheat flour is diluted, as flour including bran.

The objective of this present study was to enhance the shelflife of wheat chapatties, delay staling and to develop a food product which takes less time in preparation.

2. Materials and Methods

2.1 Procurement of raw materials

Ingredients

The materials such as commercial wheat flour, hydrocolloids, water, tawa or hot plate, gas stove, rolling pin (belan), flat circular rolling board (chakla), mixer, Tongs (chimta), bowl and kneader were procured from the local market of Prayagraj.

2.2 Equipment used

The list of various equipment used during entire research work are sieve (40 meshes), Electric Weighing Balance (model no.LCB4A), Heat Sealer (Brand: Sevanas), Soxhlet Apparatus (Brand: DIMART), Muffle Furnace (Brand: Alpine), Hot Air Oven (Brand: Grits), Desiccator (Brand: Dainsons), Protein Distillation Unit (Brand: Vikas), Mixer (Brand: Usha), Laminar Air Flow Chamber (Tanco), Incubator (Brand: Tanco), Digital Colony Counter (Brand: Insif Electronics).

2.3 Chemicals Used

Boric Acid, Sulfuric Acid, Petroleum Ether, Hydrochloric Acid, Sodium Hydroxide, Bromocresol Green, Selenium Dioxide, Potassium Sulphate, Methyl Red, Copper Sulphate, Potato Dextrose Agar, Citric acid, Iodine Solution.

2.4 Raw material preparation

2.4.1 Wheat Chapatti formulations

Four chapati samples were prepared to investigate the effect of food additives on physicochemical properties. Chapati ingredients based on flour basis are wheat flour 100g, optimum amount of water and different hydrocolloids added 0.50g. To prepare different chapati samples, firstly control sample were prepared by using wheat flour 100g only. Then different hydrocolloids were added such as Oxidized corn starch 0.5% and wheat flour 100% (0.5g of oxidized corn starch and 100 g of wheat flour), Vital gluten 0.15% and wheat flour 100% (0.15 g of Vital Gluten and 100 g of wheat flour) and K- carrageenan 0.1% and wheat flour 100% (0.1 g of K-carrageenan and 100% of wheat flour).

2.4.2 Preparation of wheat chapatties

Chapattis were prepared by using wheat flour (100g) and mixing it with optimum amount of water for 3 mins in laboratory mixer. The dough was allowed to rest for half an hour. Dough (25g) will be rounded, placed on a rolling board and then sheeted to a diameter of 155 mm and thickness of 2 mm using a rolling pin. The raw chapatti was immediately placed on tawa or hot plate and were baked from one side and then baked from other side. It will be again turned and baked. The chapatis were allowed to cool for 10 minutes and then packed in polythene pouches and were stored at refrigerated temperature (4 ^{0}C). Each formulation was baked one time and each experiment was performed with 3 replications.

2.5 Qualitative Testing

2.5.1 Determination of Crude Protein (AOAC, 2000)

Protein estimation was done by Micro kjeldahl method using 2g of moisture and fat free sample by digestion with 25 ml concentrated sulfuric acid and 2g catalyst mixture (2.5g of selenium dioxide, 100g of potassium sulfate and 220g of copper sulfate) and after that it was heated continuously until color changed to pale blue. The digest was then cooled and distilled water was added in three portions to volume makeup of 100 ml.

$$\text{Nitrogen percentage by weight} = \frac{(\text{Sample titre} - \text{Blank titre}) \times \text{Normality of HCl} \times 14 \times \text{volume makeup of digest} \times 100}{\text{Aliquot of the digest taken} \times \text{weight of sample} \times 1000}$$

$$\text{Protien percentage by weight} = \frac{(TV\text{-}V_3)\ T \times V_2 \times F \times 100}{V_1 \times W} \quad \text{.....Eq. 3.1}$$

Protein by weight = Nitrogen by weight × 6.25

Where,
V1 = Volume of hydrochloric acid used in distillation
V2 = Volume of water required for volume makeup.
V3 = Volume of hydrochloric acid used in blank test.
T = Titrable value of ammonia sulphate.
W = Weight of sample taken for analysis.
F = Molecular weight of nitrogen present in sample.

2.5.2 Determination of Crude Fat (AOAC, 2000)

A sample of 5g was taken in a thimble made of filter paper and was placed in butt type tube of Soxhlet apparatus. The flask of the apparatus was weighed on a weighing machine and extraction was carried out using petroleum ether. Extraction continued for 6 hours initially at low temperature and then at high temperature.

Fat by weight = (W2 – W1) / (W × 100) ……..Eq. 3.2

Where,
W1 = Weight of flask
W2 = Weight of flask along with contents after oven drying.
W = Weight of sample taken for analysis

2.5.2 Determination of Total Ash content (AOAC, 2005)
Sample weight of 5 g was taken in a clean and dry porcelain or silica dish. Ignition of the material with the flame of a suitable burner for about 1 hour was done. The ignition was carried by keeping in a muffle furnace at 550+ 10 ˚ C until it resulted in grey ash. The ignited sample was cooled down in a desicator and weighed. The process of igniting, cooling and weighing was done at every half an hour intervals until the difference between two successive weights was less than 1 mg. The lowest value was noted.

2.5.3 Determination of Carbohydrate content (AOAC, 2000)
Carbohydrate content was calculated by difference (AOAC, 2000).
Total carbohydrate (%) = 100 -% (moisture + protein + fat + fibre + ash)

2.6 Microbiological Analysis
2.6.1 Yeast and Mould Count
1ml of sample was taken and transferred into 9 ml blank water test tube and shaken vigorously (label as 1:10). Using a sterile 1ml pipette aseptically, 1ml of sample from that test tube was taken and transferred in another 9ml blank water test tube (label as 1:100) and same was repeated up to 1:1000. From each test tube 1ml sample was transferred into petri plates on which 4-5ml of PDA (Potato Dextrose Agar) media was poured and after that the plates were incubated at 37˚C for 24 hours.

2.7 Sensory analysis
2.7.1 Nine-point hedonic scale test
The sensory analysis of the prepared wheat chapatties was done by using 9 point hedonic scale for colour, appearance, flavour and texture and overall acceptability.

Evaluation of organoleptic attributes of the additive supplemented wheat Chapaties for colour, flavour, texture, appearance, mouth feel and overall acceptability was done by a semi-trained panel of judges. The panel of judges scored on a 9 point scale or Hedonic scale. The sensory laboratory was well equipped such as good lighting, airflow and was odourless. The samples were given to the panelists in 3-digit coded sealed pouches. The panelists were instructed to rinse their mouth thoroughly with potable water in between sample evaluations and they were asked to taste the chapati samples one by one (Cheng and Bhat, 2015) [3].

2.8 Statistical analysis
Results generated in this study were expressed as mean ± standard deviation of three independent replications. The statistical esignificance of the results was obtained by subjecting the results to two-way analysis of variance (ANOVA).

3. Results and Discussions
3.1. Qualitative Analysis
3.1.1 Effect of storage period on the Protien content of LDPE packed wheat chapatties
On evaluation of results it was found that protein content of wheat chapaties was considerably decreased as with increase in storage of chapatties. Maximum protein content was found in sample 3 (K-carrageenan- 0.1%) and minimum protein content was found in control sample. The decrease in protein content during storage was due to the reaction between sugars and amino acids which leads to the breakdown of protein molecules, reported by (Balestra *et al*., 2011). On comparison it was found that the protein content as reported by in the current study was found ranging from 9.37-7.26 g/100g which was in close similarity with the work of Gujral and Pathak, (2002) whose work was based on the effect of composite flours and additives on the texture of chapati.

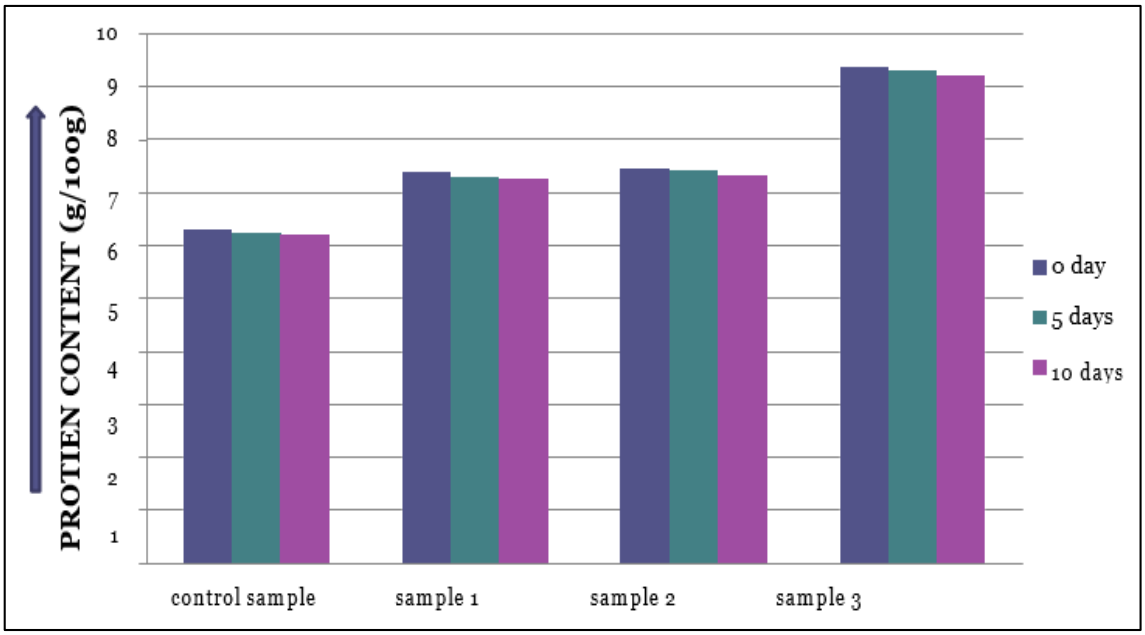

Fig 1: Effect of storage period on the protien content of LDPE packed wheat chapatties

3.1.2 Effect of storage period on the Fat content of LDPE packed wheat chapatties
On critical evaluation of results it was found that fat content of wheat chapatties containing additives decreased considerably. Maximum fat content was found in control sample which was prepared from wheat flour and minimum fat content was found in sample 3 (K-carrageenan-0.1%). The fat content decreases during storage due to the incorporation of moisture and air in prepared chapatties. The lipids present in chapatties may undergo quality deterioration during

prolonged storage (Ashwini *et al*., 2009) [1].
On comparison it was found that the fat content as reported in the current study was found ranging from 0.41-0.25 (g/100g) which was in close similarity to work of Maleki *et al*., (2012) [9] whose work was based on Effect of different hydrocolloids on staling of Barbari bread.

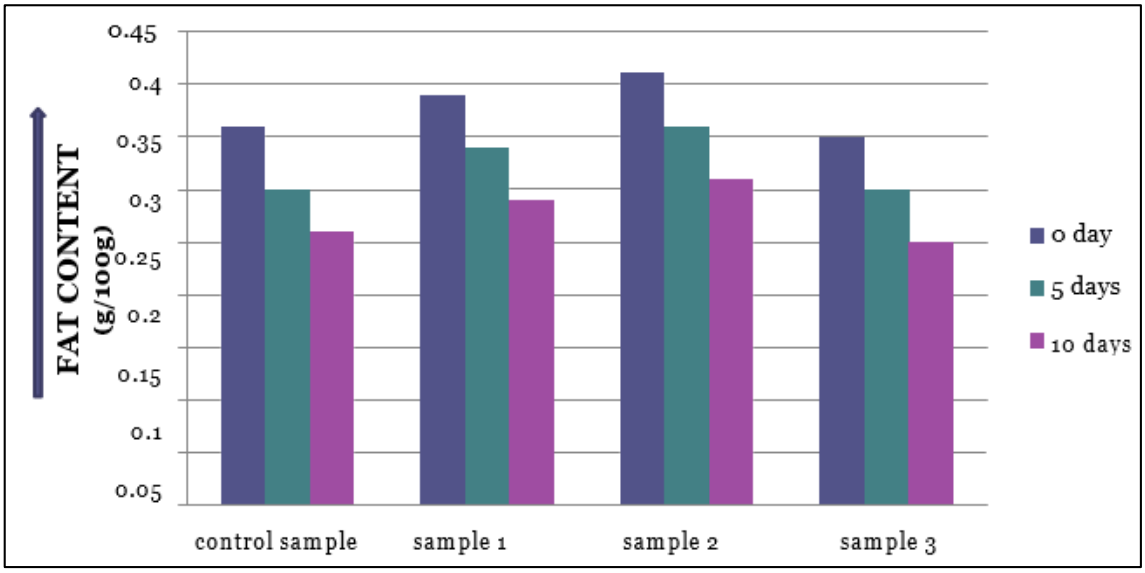

Fig 2: Effect of storage period on the fat content of LDPE packed wheat chapatties

3.1.3 Effect of storage period on the ash content of LDPE packed wheat chapatties

On evaluation of result it was found that the increased ash content was due to ability of additives especially hydrocolloids which have mineral binding and mineral absorption properties (Shittu *et al*., 2009) [14], the average maximum ash content for 10 days was found in control sample and then in sample 3 and average minimum ash content for 10 days was found in sample 1. On the first ash content analysis of the developed chapatties i.e. on 0 day, ash content of control sample, sample1, and 2 and 3 was found to 1.20, 0.95, 1.05 and 1.07.
On comparison it was found that the ash content as reported in this study was found ranging from 0.80-1.20 (g/100g) while the total average ash content was found to be 1.11 g/100g which was in close similarity to the findings of Guarda *et al*., (2004) [7] whose work was based on Different hydrocolloids as bread improving and antistaling agents.

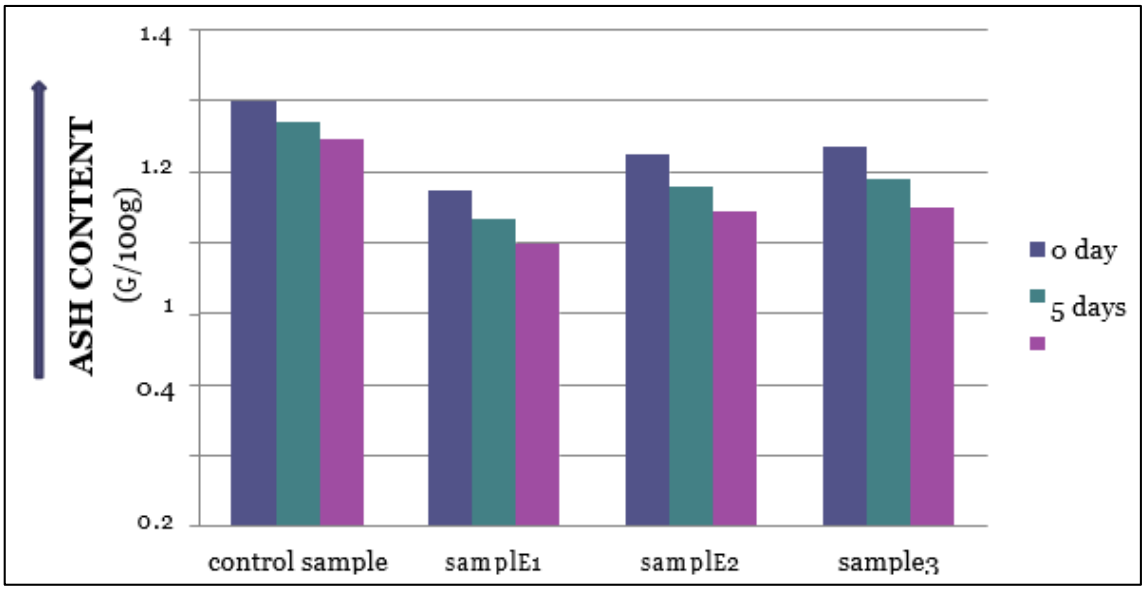

Fig 3: Effect of storage period on the ash content of LDPE packed wheat chapatties.

3.1.4 Effect of storage period on the carbohydrate content of LDPE packed wheat chapatties

On evaluation of results it was found that carbohydrate content of wheat chapatties was considerably decreased as with increase in storage of chapatties. Maximum carbohydrate content was found in sample 3 and minimum carbohydrate content was found in sample 1. The decrease in starch content during storage of chapatti was due to the gelatinisation of starch. The overall results clearly revealed that starch content of chapatties packed in LDPE decreases considerably with the increase in storage period. On comparison it was found that the carbohydrate content as reported by in the current study was found ranging from 62.05-54.87g/100g which was in close similarity with the work of Gujral and Pathak, (2002) [8] whose work was based on the effect of composite flours and additives on the texture of chapatti.

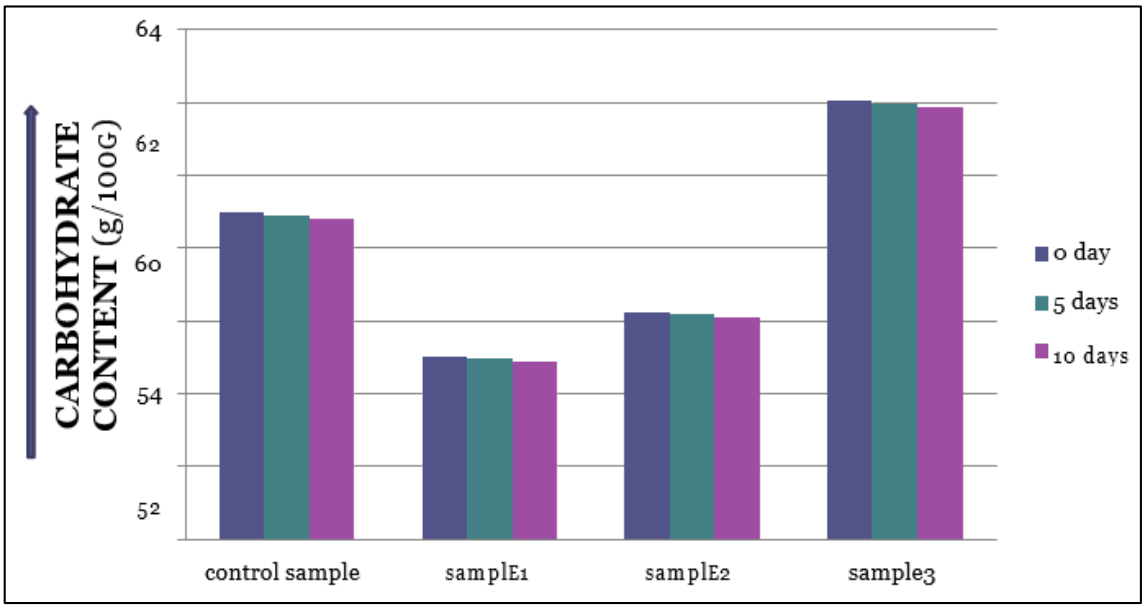

Fig 4: Effect of storage period on the carbohydrate content of LDPE packed wheat chapatties.

3.2 Microbiological Analysis

3.2.1 Effect of Storage Period on Yeast and Mold count of LDPE Packed Wheat Chapatties.

Fig 5 shows the values of yeast and mold count as observed on the storage time period which gives an idea of level of spoilage that may be observed during storage and the ultimate life span of the prepared wheat chapatties. The chapaties produced lasted for 9 days before obvious spoilage was noticed. Control Sample lasted for 9 days while sample 1 and sample 2 lasted for 10 days before spoilage occurred. It was also observed that sample 3 lasted for 11 days before spoilage. The chapatties may be considered best for consumption within 9 days as per the safety point of view. Due to the addition of hydrocolloids there was a decrease in number of colonies.

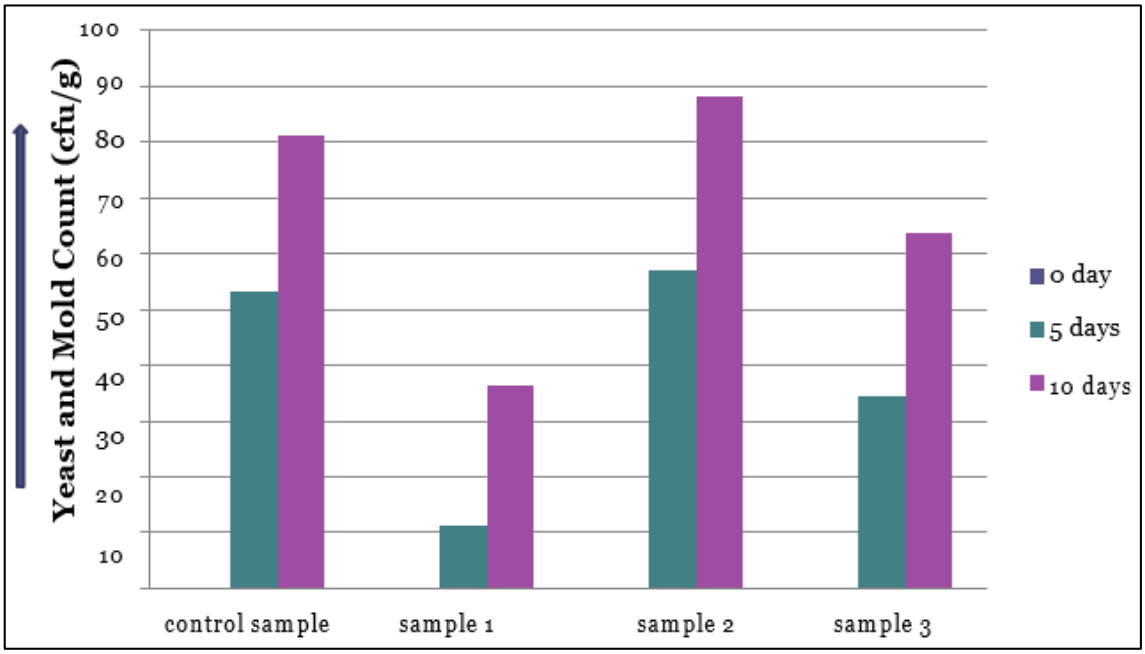

Fig 5: Effect of storage period on the yeast and mould count of LDPE packed wheat chapatties

3.3 Sensory Analysis

From the results, it was found that sample 3 (k- carrageenan as an additive) obtained the highest sensory scores from the panelists as compared to control sample (Balestra *et al.*,2011) [1]. The samples containing hydrocolloids showed better results than the control sample.

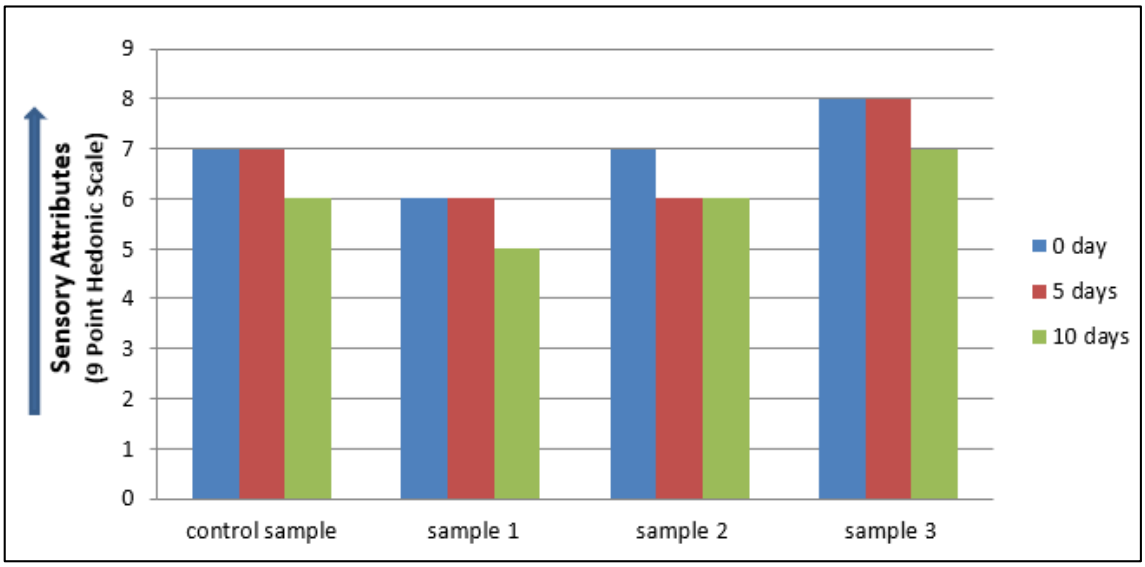

Fig 6: Effect of storage period on the Sensory Attributes of LDPE packed wheat chapatties.

3.4 Statistical Analysis

Statistical analysis was conducted as per the data obtained from three levels of temperatures for three levels of time periods i.e. from 9 treatments and 3 replications during trial and was analyzed statistically by Analysis of Variance technique, 3 way classification to study the effect of temperature, time and days on the various chemical, microbiological and sensory qualities of the developed wheat Chapatti samples. This technique was developed by Dr. R.A. Fisher in 1923. It gives an appropriate method capable of analyzing the variation of population variance. The significant effect of treatment was judged with the help of F'(variance ratio).

Table 1: ANOVA for protein content of Additives supplemented Wheat Chapatties.

Source	D.F.	SS	MSS	Cal. F	Results	F table 5%
Treatment	3	0.789	0.260	18870.000	**S**	4.757
Replication	2	0.058	0.028	1922.600	**S**	9.780
Error	6	0.000	0.000			
TOTAL	11	0.839				
S.EM=	0.002	CD(5%)=	0.007			
SE.d=	0.003	CD(1%)=	0.011			

Table 2: ANOVA for fat content of Additives supplemented Wheat Chapatties.

Source	D.F.	SS	MSS	Cal. F	Results	F tabl 5%
Treatment	3	0.006	0.002	85.667	**S**	4.757
Replication	2	0.047	0.023	930.333	**S**	9.780
Error	6	0.000	0.000			
TOTAL	11	0.053				
S.EM=	0.002	CD (5%) =	0.011			
SE.d=	0.004	CD (1%) =	0.015			

Table 3: ANOVA for ash content of Additives supplemented Wheat Chapatties.

Source	D.F.	SS	MSS	Cal. F	Results	F tabl 5%
Treatment	3	0.035	0.012	29.587	**S**	4.757
Replication	2	0.056	0.028	71.678	**S**	9.780
Error	6	0.002	0.000			
TOTAL	11	0.093				
S.EM=	0.013	CD (5%) =	0.030			
SE.d=	0.016	CD (1%) =	0.050			

Table 4: ANOVA for carbohydrate content of Additives supplemented Wheat Chapatties.

Source	D.F.	SS	MSS	Cal. F	Results	F tabl 5%
Treatment	3	981.308	283.769	8823081.742	**S**	4.757
Replication	2	0.050	0.027	759.000	**S**	9.780
Error	6	0.000	0.000			
Total	11	981.360				
S.EM=	0.003	CD (5%) =	0.012			
SE.d=	0.005	CD (1%) =	0.017			

Table 5: ANOVA for yeast and mould of Additives supplemented Wheat Chapatties.

Source	D.F.	SS	MSS	Cal. F	Results	F tabl 5%
Treatment	3	20.389	5.463	3.858	**NS**	4.757
Replication	2	92.725	44.863	26.085	**S**	9.780
Error	6	0.000	0.000			
TOTAL	11	112.912				
S.EM=	0.002	CD (5%) =	0.011			
SE.d=	0.004	CD (1%) =	0.014			

Table 6: ANOVA for Sensory Attributes of Additives supplemented Wheat Chapatties.

Source	D.F.	SS	MSS	Cal. F	Results	F tabl 5%
Treatment	3	1.263	0.444	62.379	**S**	4.757
Replication	2	0.286	0.158	20.982	**S**	9.780
Error	6	0.000	0.000			
TOTAL	11	1.729				
S.EM=	0.006	CD (5%) =	0.015			
SE.d=	0.007	CD (1%) =	0.018			

4. Conclusion

Chapatti could be made by adding hydrocolloids suitable to improve sensory characteristics of dough suitable for chapatti making. The chapatti quality was improved by all hydrocolloids tested. However the highest improvement in overall quality of chapatti was brought about by wheat vital gluten, corn starch and K-carrageenan. When added at 0.15gm, 0.5gm and 0.1gm on flour weight basis, respectively. The chapatti made with these hydrocolloids possessed attractive surface characteristics excellent pliability and softness for a much longer time period.

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