

RESEARCH ARTICLE

Quality evaluation of microwaved and non-microwaved *chakki atta* flour under storage

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ABSTRACT

Chakki atta is ground wheat which is a neutral form available without any addition or subtraction and thus, it is mostly used in rural areas. This research was conducted to evaluate the quality changes of *chakki atta* flour during the storage and to study the effect of microwave on the quality of *chakki atta* flour. *Chakki atta* flour was packed in polyethylene bags separately and subjected to microwave (700 W for 60 s) and the quality changes were assessed within 12 weeks at storage temperature 27 °C. The quality characteristics such as smell test, sieve test, long moisture (hot air oven method), moisture using NIR (Near Infrared Ray), protein using NIR, ash using NIR, wet-gluten, fat acidity, colour and weevil count were evaluated at two weeks interval. Crude fat and crude fibre content were evaluated at four weeks interval. Chapatti was prepared from microwaved and non-microwaved flour and the sensory characteristics were evaluated at four weeks interval. Physio-chemical properties of *chakki atta* such as colour, protein, crude fat and fat acidity changed with the storage period and microwaving treatment prominently influenced on moisture, wet gluten, colour, protein, ash, and fat acidity. There was no any weevil infestation found in both flour. Sensory characteristics of the chapatti were not affected by storage in both microwaved and non-microwaved flour. It can be concluded that *chakki atta* flour can be stored at 27 °C for three months from the date of manufactured.

Keywords: *Chakki atta*, chapatti, microwave, physico-chemical properties, sensory evaluation

INTRODUCTION

Wheat is a cereal which is a staple food in many countries. It is the dominant crop in temperate countries and thus used as a human food as well as a livestock feed. The nutritional value of wheat is extremely important as it takes an important place among the few crop species being extensively grown as staple food sources. The importance of wheat is mainly due to the fact that its seed can be ground into flour which forms the basic ingredients of bread and other bakery products. Hence, it presents the main source of nutrients to the most of the world population (Zuzana *et al.*, 2009).

The chemical composition of wheat grain is characterised by the high content of carbohydrates. Mainly starch, which is deposited in the endosperm, amounts to 56 – 74% and fibre, mainly located in the bran, is to 2 – 13%. The second important constituents are proteins, about 8 – 11%. Lipids belong to the minor constituents (2 – 4%) along with minerals (1 – 3%). Relatively high content of β -vitamins is also found (Koehler and Wieser, 2013).

Wheat is unique among cereals to form cohesive and viscoelastic dough when flour is mixed with water. Wheat dough retains gas which is produced during fermentation and this results in a leavened loaf of bread after baking. Bread making potential of flour is mainly based on the protein quantity and quality (Hruskova and Famera, 2003). Gluten plays a key role in determining the unique baking quality of wheat by conferring water absorption capacity, cohesiveness, viscosity and elasticity of dough (Wieser, 2007). The higher the protein content the harder and stronger the flour, and the more it will produce crusty or chewy breads (Stone and Morell, 2009).

Wheat is mainly milled to whole wheat flour for the production of unleavened flat bread locally known *chapatti* while rest is used for other bakery products like bread, biscuits, cakes, pastries and pizzas. *Chapatti* is unleavened flat breads and a staple food made in Indian homes, shops and restaurants. *Atta* flour is widely used to make *chapattis* and is obtained by grinding wheat in stone *chakkis*. Supplementing *atta* with flours made from various legumes increases protein and mineral content and therefore increases the nutritional content of *chapattis* (Chakrabarti-Bell et al., 2013). Indian wheat flour is mostly ground in stone mills popularly called as *chakkis*. Chakki is nothing but a pair of stones of which one is stationary and other is rotating. Stone mills generate considerable heat due to friction. The *chakki atta* is preferred more than the roller milled *atta* for the texture and taste of the *chapatti*.

One of the issues with whole wheat flour utilisation is the shelf life. Whole wheat flour is highly susceptible to rancidity due to presence of lipolytic enzymes (Every et al., 2006). This affects the end use and storage properties (Wang et al., 2004) as it causes loss in flour functionality, nutritional quality and sensory acceptability during whole wheat flour storage. Storage temperature control has been found to be the most important factor in maintaining product quality. Thus, it is necessary to know the effect of water on storage life before suitable conditions selected.

Dry goods like flour should be stored in a well-ventilated and cool place with the relative humidity of 60 – 65% (Smith and Hui, 2004). Flour is a very hygroscopic material and its moisture changes with the change in temperature and humidity of the store environments. Flour moisture changes can support the acidity alterations caused by the enzymatic breaking, lipolytic and proteolysis (Hansen and Rose, 1996). Changes in the protein-protease complex of wheat flour as reflected in elasticity and extensibility of gluten can exert a positive or a negative influence on the dough bread making characteristics. During the longer storage time, flour properties are changed by the effect of non-saturated fatty acids which

can reduce gluten swelling and water absorption in addition to increasing the starch resistance against gelatinisation (Chen and Schofield, 1996).

Heat treatments can inactivate enzymes to inhibit rancidity caused by lipase and lipoxygenase and reduce moisture content to extend the shelf life of grain (Bucsella *et al.*, 2016). It can also modify starch granules, denature proteins, reduce microbial load and even modify taste and aroma (Gómez and Martínez, 2016). Heat treatment of wheat flour (120 – 130 °C for 30 min) is used as an improver; it increases cake height, bulk density, and fine texture (Chesterton *et al.*, 2015). Heat treatment of cereal grains cause changes in the protein and starch, so rheological characteristics and pasting properties have been investigated. Studies have shown that heating enhanced the water-holding, oil-binding, emulsifying and foaming capacities of the flour (Seema *et al.*, 2012). Moreover, heat could alter the rheological properties of the flour. Heat-treated flour showed higher resistance, viscosity, and rigidity during the mixing process, which contribute to the increase in dough elasticity (Marston *et al.*, 2016). Rheological changes can be caused by protein aggregation together with changes in starch-protein and starch–starch interactions (Bucsella *et al.*, 2016). Therefore, this research study was conducted to evaluate the quality changes of microwaved and non-microwaved *chakki atta* during the maturity period under storage condition of 27 °C.

MATERIALS AND METHODS

Location and time period of study

The study was carried out in the Department of Research and Development, Prima Ceylon (Pvt.) Ltd., Chinabay, Trincomalee. Shelf life study on *chakki atta* flour was undertaken for 12 weeks to check change in nutritional and physiochemical qualities of flour.

Materials and storage conditions

Freshly milled and microwaved (700 W for 60 s) *chakki atta* flour samples (five replicates) were packed separately in polythene bags and stored at the temperature 27 °C for three months.

Determination of physio-chemical and biological properties of *chakki atta*

Smell test was carried out for the two samples at two weeks interval to determine the odour using semi-trained panelists. Sieve test was conducted using 350 µm sieve to measure the over tail percentage in the flour (Sonaye and Baxi, 2012). Long moisture, moisture NIR (Near Infrared Ray), ash NIR, protein NIR, wet gluten (Chen *et al.*, 2006), colour and fat acidity were evaluated at two weeks interval. Mechanical determination of the wet gluten content of the wheat flour (ICC standard 137/1) is carried out with glutomatic machine (Chen *et al.*, 2006). Determination of fat and fibre were conducted in every four weeks during storage while product development was undertaken at the same time of storage. Colour test was practiced using spectrophotometer (Model: MOV-102). The

spectrophotometer works by passing a light beam through a sample to measure the light intensity of a sample. These instruments are used in the process of measuring color and used for monitoring color accuracy throughout production (Cao *et al.*, 2003).

Sieving test was carried out to check the presence of storage pest contamination in the flour. Whole packed flour was sieved using 350 μm sieve and presence of weevils were noted.

Preparation of *chapatti* from *chakki atta*

Chapatti was produced from *chakki atta* (microwaved and non-microwaved) for product development and sensory evaluation. 250 g of *chakki atta* flour, a pinch of salt and a table spoon of coconut oil, were mixed well for two minutes in electrical dough maker. The dough was prepared by adding 65 – 70% water in 250 g flour and mixing was carried out for 3 min in a mixer and kept for 1 h at room temperature. A dough piece weighing 50 g was rounded and turned into *chapatti* (15 cm in diameter, 2 mm in thickness) by using specially designed platform with the help of rolling pin for uniform thickness. Baking of chapatti was practiced on a hot plate at a temperature of 205 – 250 °C for 45 s on one side and 10 s on other side. Puffing was practiced for 15 s at 340 °C. *Chapatti* was cooled into room temperature, covered and labelled for the purpose of sensory evaluation. *Chapatti* was prepared from microwaved and non-microwaved flour at 4 weeks of interval and different fresh samples were used to check the sensory parameters.

Sensory evaluation

Sensory evaluation of *chapatti* was performed by a panel consisting 30 semi-trained panelists to assess general appearance, aroma, colour, taste, texture, mouth feel and overall acceptability sensory attributes using 7-point hedonic scale. The scores for these parameter were summed up by averaging these scores, score of chapatti was calculated.

Statistical analysis

Data of the sensory evaluation and storage studies were subjected to analysis of variance (ANOVA) ($\alpha = 0.05$). Mean separation was undertaken with Duncan's Multiple Range Test (DMRT) for storage studies. Data related to sensory evaluation was analysed using the Tukey's studentised test. Both analyses were undertaken using Statistical Analysis System (SAS) software statistical package.

RESULTS AND DISCUSSION

Physio-chemical properties

Smell Test

According to the results of 12 weeks study period, smell of the all flours remained unchanged. There was no significant ($P > 0.05$) deterioration in the shelf life of

chakki atta flour during the storage period and no significant ($P>0.05$) difference was observed up to 12th week for microwaved and non-microwaved flour.

Sieve Test

Table 1 shows the impact of storage period and microwaving and non-microwaving on the shelf life of *chakki atta* flour in terms of over tail. There was a slight difference between microwaved and non-microwaved *chakki atta* flour. For the microwaved *chakki atta* flour over tail fell between 2.45 – 2.91 g kg⁻¹ whilst non-microwaved flour fell between 2.54 – 3.46 g kg⁻¹ during the study period. At the beginning, for both microwaved and non-microwaved flour, fluctuations in over tail were observed and later on from the 8th week onwards it remained approximately constant.

Table 1: Impact of storage and microwaving on particle size distribution (over tail analysis), moisture % (NIR), Ash % (NIR) and Protein % (NIR) of *chakki atta* flour. The values are means of triplicates. The means with the same letters are not significantly different at 5% level.

Storage time (weeks)	Particle size (g kg ⁻¹)		Moisture % (NIR)		Ash % (NIR)		Protein % (NIR)	
	MW	Non-MW	MW	Non-MW	MW	Non-MW	MW	Non-MW
2	2.45 ^c	2.54 ^d	9.12 ^c	10.10 ^d	1.34 ^a	1.41 ^a	12.37 ^{bc}	12.39 ^b
4	2.81 ^{ab}	3.56 ^c	8.85 ^{ab}	9.90 ^{bc}	1.34 ^a	1.42 ^a	12.25 ^c	12.35 ^{ab}
6	2.60 ^b	3.96 ^{ab}	8.91 ^a	10.08 ^c	1.32 ^a	1.42 ^a	12.48 ^c	12.60 ^b
8	2.98 ^a	3.38 ^b	8.92 ^a	9.96 ^b	1.33 ^a	1.41 ^a	12.21 ^{ab}	12.48 ^a
10	2.88 ^a	3.46 ^a	9.42 ^a	9.87 ^a	1.32 ^a	1.42 ^a	12.17 ^b	12.29 ^a
12	2.91 ^a	3.46 ^a	9.56 ^a	9.90 ^a	1.33 ^a	1.41 ^a	12.14 ^a	12.31 ^a

MW – Microwaved flour

Non-MW – Non-microwaved flour

Long Moisture

The changing pattern of long moisture content of *chakki atta* flour for 12 weeks of storage period is shown in Figure 1. It shows that heating removes a considerable amount of moisture. Moisture content of the microwaved *chakki atta* was significantly ($P<0.05$) lower than that of the non-microwaved *chakki atta* flour throughout the storage period. Moisture was absorbed by both flour due to the high level of relative humidity under storage condition. Moisture content of the microwaved flour increased gradually over the moisture content under the non-microwaved flour. These changes in moisture content during storage were due to the hygroscopic properties of flour. The results are supported by earlier findings of Rehman and Shah (1999) and Kirk and Sawyer (1991). Fungi do not grow at lower moisture content, however; at about 14% or slightly above moisture level, fungal growth takes place (Hoseney, 1994).

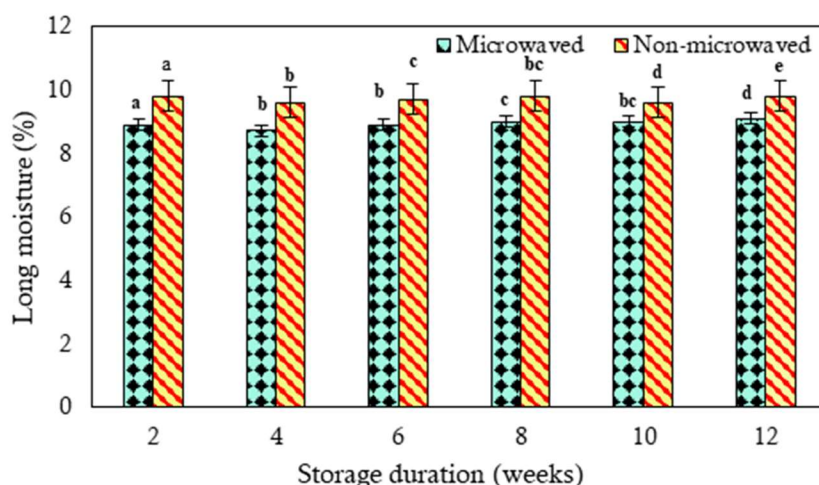


Figure 1: Impact of storage and microwaving on long moisture content of *chakki atta* flour. The values are means of triplicates. The vertical bars indicate the standard errors.

Moisture NIR

According to Table 1, the moisture content of microwaved and non-microwaved *chakki atta* for 12 weeks of storage period is presented. Moisture content of microwaved *chakki atta* flour fluctuated at early stages of storage up to 8th week; then, the moisture content increased gradually ($P>0.05$). But, moisture content of the non-microwaved flour fell between 10.01 – 9.90% and no any typical changes were observed. According to the statistical analysis, there was no significant ($P>0.05$) difference between the mean values during storage but there was a significant ($P<0.05$) effect due to microwaving on the moisture content of the flour.

Ash NIR

Ash content of non-microwaved flour was significantly ($P>0.05$) higher than the microwaved *chakki atta* flour as shown in Table 1. Ash content of *chakki atta* was considerably affected by the microwaving heat treatment, however; the ash content of both flour was not significantly different ($P>0.05$) during the storage period. It is so clear from the statistical analysis that microwaving significantly ($P<0.05$) affected the ash content of the *chakki atta* flour but the ash content was not significantly ($P>0.05$) affected by the storage. During microwaving loss of minerals occurred; that was the reason for reduced level of ash content for microwaved flour than non-microwaved flour. When comparing the results of ash content and colour of flour, microwaved flour had a significantly ($P<0.05$) lower ash content. This is the reason for greater colour in the microwaved flour

than the non-microwaved flour. Ash content is closely related to the colour of flour which is directly linked to the bran contamination of the flour.

Protein NIR

The protein content of non-microwaved flour was changed from 12.39 to 12.31% (Table 1). On the other hand, protein content of the microwaved *chakki atta* changed from 12.37 to 12.14%. This trend agrees with the influence of moisture content on the protein content of soybean flour where increase in moisture content led to increase in protein concentration (Agrahar-Murugker and Jha, 2011). In addition, the decline in protein could be attributed to the decrease in the activities of the microorganism as moisture reduced (Butt *et al.*, 2004). Protein content of non-microwaved *chakki atta* was noticed slightly higher than that of the microwaved flour under study period. Protein content change of both microwaving and non-microwaving flour showed a similar pattern during the study period. According to the statistical analysis there was a significant ($P<0.05$) difference in the protein content due the storage and microwaving of *chakki atta* flour.

Wet gluten

Figure 2 shows the wet-gluten content of microwaved and non-microwaved *chakki atta* flour for the 12 weeks of storage period and also, it compares the difference in wet-gluten content between the microwaved and non-microwaved *chakki atta* flour. Wet-gluten content of non-microwaved *atta* flour was significantly ($P<0.05$) higher than the microwaved *atta* flour throughout the study period. Therefore, microwaving of flour affects the gluten content of *chakki atta*.

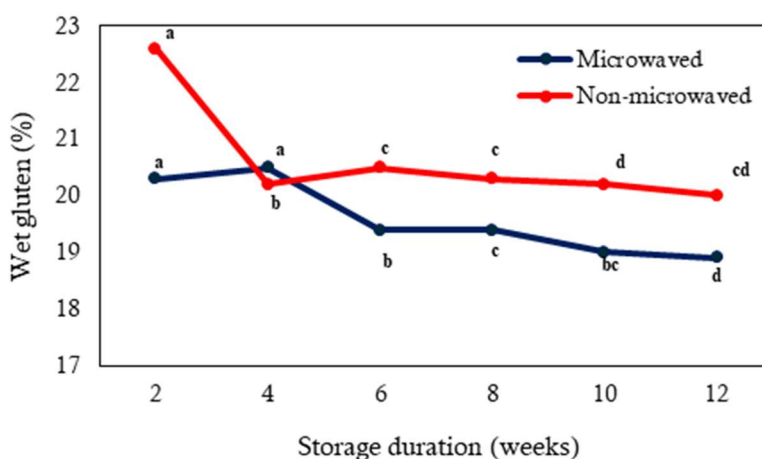


Figure 2: Impact of storage and microwaving on wet-gluten content of *chakki atta* flour.

Fat

Table 2 shows the information related to fat and fiber contents of *chakki atta* flour during 12 weeks study period. Fat content of the flour was not significantly ($P>0.05$) different in both microwaved and non-microwaved flour at the 4th, 8th and 12th weeks.

Table 2: Impact of storage and microwaving on the fat and fibre content of *chakki atta* flour. The values are means of triplicates. The means with the same letters are not significantly different at 5% level.

Storage duration (weeks)	Fat content (%)		Fibre content (%)	
	MW	Non-MW	MW	Non-MW
4	3.12 ^a	3.26 ^a	1.59 ^a	1.42 ^{ab}
8	3.45 ^a	3.47 ^a	1.33 ^a	1.63 ^a
12	2.64 ^a	2.86 ^{ab}	2.05 ^a	2.05 ^a

MW – Microwaved flour; Non-MW – Non-microwaved flour

Fat content of flour increased up to the 8th week and thereafter reduced slightly at the end of the storage period. Thus, it is clear that fat content was not affected by microwaving. According to the statistical analysis fat content was significantly ($P<0.05$) affected by the storage but not by microwaving ($P>0.05$). The decrease in fat could be attributed to the lipolytic activities of the enzyme lipase and lipoxidase (Agrahar-Murugkar and Jha, 2011).

Fibre

According to Table 2, it is clearly shown that fibre content of *chakki atta* significantly ($P<0.05$) increased during the 12 weeks of study period for both microwaved and non-microwaved flour. There was no significant ($P>0.05$) difference for the fibre content between the microwaved and non-microwaved flour. During the storage, fibre content was not significantly ($P>0.05$) affected by the storage period and microwaving. Fibre content of microwaved *chakki atta* fell between 1.59 – 2.0% and for non-microwaved *chakki atta*, it ranged between 1.42 – 2.0%.

Fat acidity

It is evident from the findings in Figure 3 that the storage had a great impact on the fat acidity of both microwaved and non-microwaved flour because fat acidity was increased steadily throughout the study period. Fat acidity of non-microwaved flour was slightly higher ($P>0.05$) than the microwaved flour throughout the study period. According to the statistical analysis, there was a significant effect ($P>0.05$) of storage period and microwaving on the fat acidity.

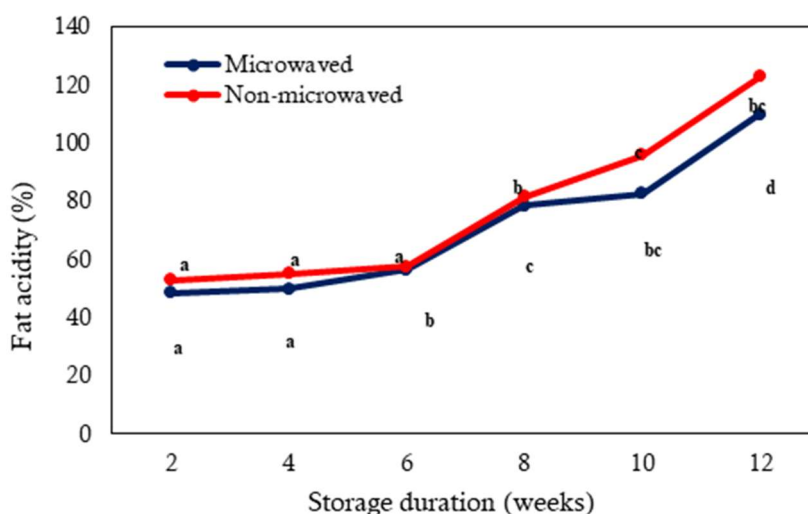


Figure 3: Impact of storage and microwaving on the fat acidity of *chakki atta* flour.

Colour

Figure 4 elaborates the colour change of *chakki atta* flour occurred during 12 weeks of storage period and it compares the effect of microwaving on the flour colour. Microwaved flour had a significantly higher colour percentage ($P < 0.05$) over the non-microwaved flour, as the pigments damaged by heat treatment. Therefore, microwaved flour was slightly lighter than non-microwaved flour. The β -carotene is a thermo-labile pigment and microwave heating induces a decrease in their content, causing higher damages in carotenoids content. These observations are more dependent on the heat exposure time or the temperature within the process (Soussene *et al.*, 2017). In the present study, the statistical analysis reveals that storage and microwaving had a significant ($P < 0.05$) effect on the colour components of the flour.

Biological parameter-weevil count

According to results obtained from the sieve test, there was no any weevil found in both microwaved and non-microwaved flour. All flours were free from weevil throughout the study period.

Sensory Evaluation

Figure 5 shows the quality attributes of *chapatti* prepared from microwaved and non-microwaved flour. According to the web diagram the *chapatti* prepared from non-microwaved flour had higher preference than the *chapatti* prepared from microwaved flour. This may be due to a negative effect of microwaving on the quality of the product. All other attributes did not show a significant ($P < 0.05$) difference between microwaved and non-microwaved *chapatti*, except the texture. There might be a possibility of imposing a negative effect from microwaving of flour which may be observed from by the texture of the *chapatti*.

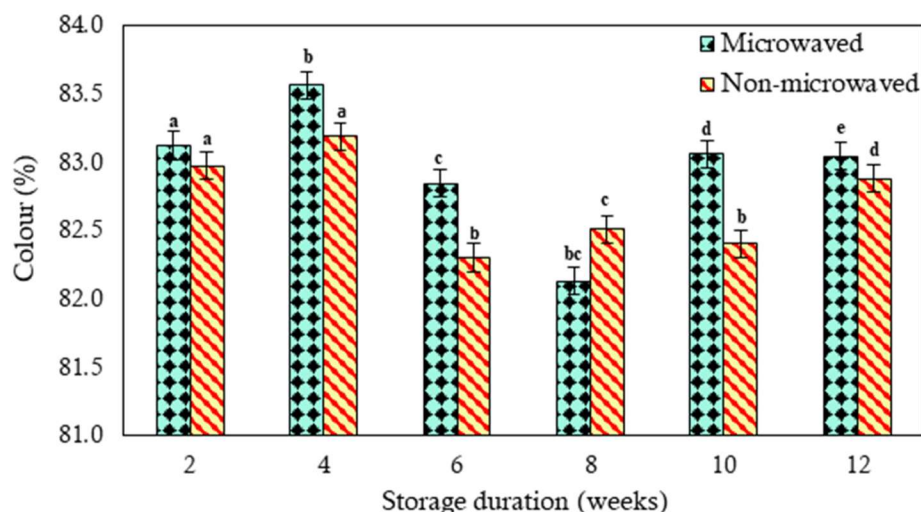


Figure 4: Impact of storage and microwaving on colour of *chakki atta* flour. The values are means of triplicates. The vertical bars indicate the standard errors.

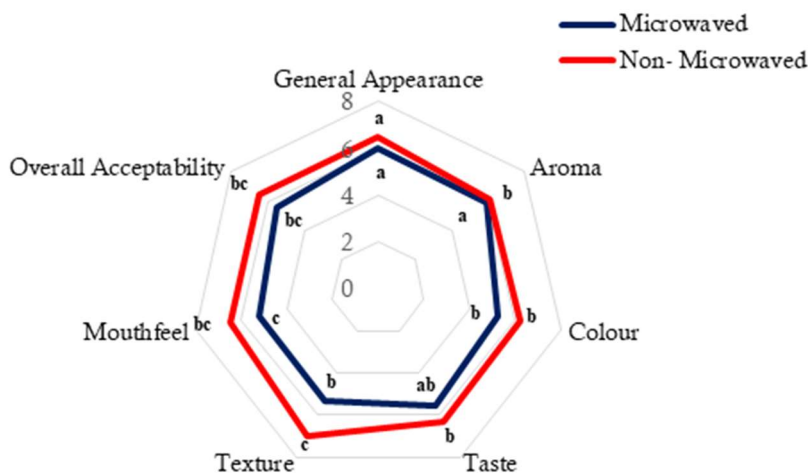


Figure 5: Sensory evaluation of *chapatti* from *chakki atta* flour following 12 weeks storage.

Quality of the product was not affected due to the storage. Texture and puffiness are influenced by the protein and gluten content of the *atta* flour. Protein and gluten content of the *atta* flour reduce over storage time leading to textural changes of *chapatti*. As Dendy and Dobraszczyk (2009) found, the puffed height and the overall quality score of *chapatti* were positively correlated with protein

content, gluten content, sodium dodecyl sulphate (SDS) sedimentation value, and Gluten-1 quality scores of high-molecular weight subunits.

CONCLUSIONS

Microwaving treatment of *chakki atta* has an impact on flour physio-chemical characteristics which were observed to make effects on overall acceptability of *chapatti*. Storage has a significant impact on colour, protein, fat and fat acidity of *chakki atta*. At the same time moisture, wet-gluten, ash and fibre were not significantly affected by the storage. Sensory attributes have proven the above mentioned statement.

It is also clear from the study that even though microwaving has impacts on some physio-chemical characteristics of both flour (microwaved and non-microwaved) mean values of all parameters were within the recommended values. However, all the parameters of the both flours remained within specification throughout the three months of storage period at 27 °C.

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