Rheological Properties of Barbari Bread Containing Apple Pomace and Carboxy Methyl Cellulose

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Abstract: Fast staling of traditional bread is one of the reasons for bread wastes. This study was designed to investigate the effect of applied apple fiber and carboxy methyl cellulose on improve the rheological properties and staling of traditional barbari bread. The rheological properties of dough were evaluated using farinograph and extensograph. Bread staling test was applied by sensory evaluation during 1, 2, and 3 days. For this purpose, three different amounts of apple fiber (5%, 8%, and 11%) were dried in a cabinet dryer at 58°C as a powder as well as carboxymethyl cellulose (CMC) at 0.1%, and 0.5% (w/w) were added to the flour. A full factorial design used to arrange treatments. The results of farinograph showed that, the sample containing 11% apple fiber and 0.5% CMC showed higher water absorption capacity, lower degree of softening, and higher quality properties compared to control and also the other samples. The results of extensograph in the sample containing 11% apple fiber and 0.5% CMC indicated lower ratio and high energy for all three time ranges (45, 90, 135 min) as compared with other experimental samples. The results of the panelists indicated that the enriched breads containing 11% apple fiber and 0.5% CMC obtained highest bread score for overall acceptability. The results of this study demonstrated that the combination of high level of apple fiber and CMC in the barbari flat bread significantly retard staling on it and improved its rheological properties.

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1. Introduction

Considering the importance of bread, its quality control and shelf life have been the concern of experts in bread industry. Fast staling of traditional bread (not more than 12-18h) is one of the reasons for bread wastes (Arasteh,1994). In Iran, bread wastes caused by staling are much significant as estimated by 20-25% (Payan,2001) . Based on literature breads contained high fiber has longer shelf life than the control sample because fiber may bond to water preventing from moisture loss or may react with starch retarding starch retrogradation. Fibers are cell walls of plants which are not broken down by digestive enzymes. They include cellulose, hemicelluloses, lignin, pectin, gums, and mucilage which may be used to reduce calories and also disease such as high cholesterol, diabetes, and constipation (Mandala et al., 2007). Apple fiber is a byproduct of apples squeeze (sudha et al., 2007). Apples may be used as a good source of dietary fiber (Mckee and Lather., 2000). Fibers derived from fruits and vegetables contain high amount of soluble fiber while fibers originated from grains consisted of in soluble cellulose and hemicellulose. Vegetable fibers show practical properties including water holding capacity, swell capacity, increased viscosity or gelation, ability to bond to biliary acids and cationic exchange capacity which all have significant role in physiological functions (Gallaher and Schneeman., 2001). These are due to their porous network structure formed by polysaccharide chains which may hold high amount of water through hydrogen bond (Kethireddipalli et al., 2002), or water may be hold in capillary structures of fibers through surface absorbption (Lopez et al., 1996). Fibers usually are divided into soluble dietary fibers and insoluble dietary fibers (Gorinstein et al., 2001). Insoluble fibers including: cellulose, lignin and hemicelluloses accelerate digestive contents passing through digestive system so prevent from constipation. Also they may reduce the risk of colon cancer because of increased beneficial bacteria of intestine flora and prevented growth of pathogenic bacteria (Latner and Mckee, 2007). Soluble fibers such as pectin, gums, and some hemicelluloses undergo intestinal bacterial fermentation, affecting metabolism of carbohydrates and lipids (Nawirska and Uklanska., 2008). Practical properties of vegetable fibers depend on the ratio of insoluble dietary fibre (IDF) to soluble dietary fibre (SDF) content, particle size, extraction conditions, and the vegetable source of the fiber. In general, fiber sources with 2:1 IDF/SDF are suitable for nutritional purposes (Jaime et al., 2002). Apples fiber has a balanced IDF/SDF (Gorinstein et al., 2001). One of the most successful methods to keep high quality and long shelf life of bread is the addion of additives such as hydrocolloids (Barcenas and Rosell, 2005). Hydrocolloids may be used as modifiers for bread dough. All characteristics of hydrocolloids depend on their sources and chemical structures. Viscosity properties of wheat starch are modified to a large extent through addition of hydrocolloids, although chemical structures (Guarda and Rosell., 2004).

CMC often is used to hold moisture, improve texture or mouthfeel, control crystallization of sugar and ice, and control rheological properties of dough, improve volume and consistency of baked products or increase their shelf life (Gimens et al., 2004). Moreover, CMC may absorb more water compared to the other additives such as sugar. This gum is compatible with other additives and modifiers (collar, 1999).

Previous researchers Masoodi and Chauhan (1998) were added apple fiber as a source of dietary fiber at 2, 5, 8 and 11% to wheat flour and they observed that the apple fiber significantly increased water binding capacity. They reported that when the fiber concentrations increased, the volume of dough decreased. In another study Masoodi et al (2002) investigated the application of apple fiber as a dietary fiber on cakes. Dried powdered apple fiber at 5, 10, and 15% with different sizes mixed with wheat flour of the cakes. They observed that increased apple fiber and reduced particle size resulted in increased viscosity. Also specific gravity and pH value of bread dough reduced as a result of increased apple fiber. They also noticed that fiber particle size had significant effect on cake volume as fine particles of fiber made more voluminous cakes compared to coarse particles.

Chen et al (1988) were added apple fiber and cellulose to wheat flour and investigated water holding capacity of different mixtures. They observed that apple fiber is a suitable water binder and increased water holding capacity of bread. Asghar et al (2005) studied the effect of carboxymethyl cellulose and Arabic gums on the frozen dough stability. The results indicated that the qualitative properties of the resulting breads have improved compared to the control bread (Asghar et al., 2005). Mettler and Seibel studied the effect of the addition of carboxymethyl cellulose and guar gums to the bread made of rye and the research results indicated that the qualitative properties of the breads had improvement compared to the control bread (Mettler & Seibel 1995). The aim of this study was to investigate the effect of CMC and apple fiber on rheological properties of Barbari bread dough and staling of bread.

2. Materials and Methods

2.1. Materials

Red variety apple was purchased from a farms located in Damavand. At first, the apples were squeezed, then dried at 58-60$^{o C}$ in a cabinet dryer for 2 days. Dried apple fiber was grinded by Tecator mill and then analyzed. Carboxy methyl cellulose (CMC) was purchased from Danisco (Denmark) and dry active yeast obtained from Fariman (Iran, Mashhad).

2.2. Physicochemical analysis

Flour and apple fiber physicochemical characterizations were: The Moisture content by the AACC method No. 16-44, the ashes content according to AACC No: 01-08, the fat content by AACC No. 10-30, the pH value by AACC No. 02-52, and protein content was determined according to AACC No. 12-46.

The particle size and sugar content were determined by national standard methods No. 103 and No. 4781 respectively.

Soluble and insoluble fiber were measured with fibertech, Acid Detergent Fibre (ADF) and Neutral Detergent Fiber (NDF) were measured using Van Soest method.

The wet gluten and precipitation of flour were determined according to AACC methods No. 11-33 and No. 116 respectively.

The Farinograph test, was conducted using Brabender (Germany) according to the standard method AACC No. 21-54, and dough elasticity was determined as ICC standard methods No. 114.

2.3. Sensory evaluation

The sensory and organoleptic assessment of the traditional Iranian bread was carried out by using 15 trained panelists on overall acceptability and staling of bread by using a hedonic scale. The coded samples in plastic bags were examined by the panel and scored. The highest scores were 6 for the desirable bread with lowest staling and 0 for unacceptable bread with highest staling.

The panelists evaluated and scored overall acceptability of bread samples after 72 hour (h) storage by considering characteristics including: aroma, taste and flavor, upper and lower surfaces properties, form and shape, chew ability.

The sensory evaluations of bread staling of all experimental breads were performed at 24, 48 and 72 h storage in proper packages at room temperature.

2.4. Barbari Bread manufacture

Dough of barbari bread was prepared using direct method. The basic formula for control sample included 100 g of flour, 65 g of water, 2 g of yeast, 1.5 g of sugar, 0.5 g salt and different amounts of apple fiber and CMC as powder on a flour replacement basis. The ingredients of each samples were mixed by mixer (Ziafat, Iran) to make a desirable firmness (15 min), then loaves of dough then loaves of dough were prepared (500g) followed by primary fermentation for

15 min at 30°C and 75-85% relative humidity, the loaves of dough (500g) left for 10-15 min, followed by secondary fermentation in ancubator at 30-45°C for 45 min, finally bread was baked at 260°C for 13 min in a industrial oven of tray type.

2.5. Experimental design and statistical analysis

In this study a completely randomized design (CRD) was used to arrange treatments and in order to investigate the effect of different amounts of apple fiber (5%, 8%, and 11%) and carboxymethyl cellulose (0.1% and 0.5% w/w) on rheological properties of Barbari bread dough and staling of bread and compare them with control sample (prepared by basic formula and without apple fiber and CMC).

Therefore as shown in Table 1, ten treatments were designed in triplicates using mechanical methods and five replicates using sensory methods. The data obtained from the measurements were subjected to one-way analysis of variance (ANOVA) to determine the significant differences among the treatments.

All statistical analysis was performed using the Minitab v. 14 statistical package (Minitab Inc., State College, PA, USA).

Table 1. Levels of the independent variable established according to the completely randomized design.

Symbol	**Apple fiber (%w/w)**	**CMC (%w/w)**
A (control)	0	0
B1	5	0
B2	8	0
B3	11	0
C1	11	0.5
C2	8	0.5
C3	5	0.5
C4	5	0.1
C5	8	0.1
C6	11	0.1

3. Results and discussion

3.1. Physicochemical analysis

Results of Physicochemical test of apple fiber and wheat flour, chemical properties of wheat flour and apple fiber are shown in Table 2. The results indicated that the wheat flour used was suitable for the production of Barbari bread in terms of the measured parameters including: moisture, ash, protein, wet, gluten, sedimentation unit and pH.

3.2. Farinograph test

The results of farinograph test of different samples are shown in Table 3. Sample C1 which enriched with high level of apple fiber and CMC showed the highest water absorption capacity as compare with all samples. The control sample showed the lowest water absorption (A).

The result of Table 3 demonstrated that the apple fiber and carboxy methyl cellulose played a significant role to increase of water absorption capacity of bread samples as compare with the control sample.

The average comparison results of dough development factor of samples (Table 3) indicated that there was a significant difference between control sample and the other treatments ($P<0.05$) as treatment C1 had the highest dough development time and the control had the lowest.

Table 2. Chemical properties of apple pomace and wheat flour

Physicochemical analysis	**wheat flour**	**Apple pomace**
Wet (%)	13.7	4.5
Ash (%)	0.7	1.1
Protein (%)	12.4	1.8
Wet Gluten (%)	3.6	---
Falling Number (sec)	612	---
ADF [a] (%)	0.3	13.6
Reducing Sugars (%)	---	41.9
NDF [b] (%)	2.2	19.0
Crude Fiber (%)	0.6	10.5
Sucrose (%)	---	6.2
Sedimentation unit (ml)	28-30	---
Fat (%)	2.6	2.5
pH (%)	6.1	4.6

[a]ADF: Acid Detergent Fiber
[b]NDF: Neutral Detergent Fiber

The result of this research revealed that the increase of the percentages of apple fiber resulted in increased development time of dough.

According the results of Table 3 dough stability time reduced significantly with the addition of apple fiber and CMC to the flour. Thus the control sample exhibited the longest dough stability time and sample C1 showed the shortest stability time.

As shown in Table 3, following the addition of different percentages of apple fiber, softening degree of dough increased significantly at 10 and 12 minutes. Treatment B3 showed the highest softening degree for 10 min and treatments B3, C3 for 12 min.

As shown in Table 3, treatment C1 showed the highest farinograph quality value at 113 and treatment B3 showed the lowest one at 87.

Based on the results of this study dough containing CMC is presented higher farinograph quality than the treatments containing apple pomce alone.

Table 3. Comparison of results Farinography test on Barbari dough containing Apple pomace and Carboxy Methyl Cellulose.Significant difference within column at confidence level of $p < 0.05$.

Treatment	Water absorption%	Dough development time (min)	Dough stability time (min)	Doug softening after 10 minutes (B.U)	Doug softening after 12 minutes (B.U)	Farinograph quality
A	55.20±1.5[a]	5.50±0.15[a]	9.00±0.0[a]	30.50±0.0[b]	65.0±0.0[b]	100.0±0.0 [g]
B1	57.55±1.6[ab]	5.77±0.15[b]	7.55±0.7[b]	38.50±0.0[e]	86.0 ±0.0[e]	89.0±0.0[b]
B2	58.52±1.6[ab]	6.77±0.18[e]	7.07±0.3[c]	43.0±0.0[f]	107.0±0.0[f]	89.0±0.0[b]
B3	59.60±1.6[ab]	6.60±0.18[d]	7.10±0.0[c]	50.0±0.0[g]	121.50±0.0[h]	87.0±0.0[a]
C1	69.35±1.9[c]	7.22±0.31[h]	6.80±0.0[c]	19.0±0.0[a]	93.50 ± 0.0[c]	113.0 ±0.7[h]
C2	62.35±1.7[b]	6.75±0.17[e]	6.50±0.0[cd]	31.0±0.0[b]	103.50±0.0 [e]	99.0±0.0[f]
C3	62.50±1.7[b]	7.10±0.19[g]	6.05±0.0[d]	30.0±0.0[c]	121.50±0.0 [h]	100.50± 0.0[g]
C4	59.85±1.6[ab]	6.85±0.17[f]	7.50±0.0[bc]	33.50±0.0[d]	86.50±0.0 [b]	95.0±0.0[d]
C5	61.20±1.7[ab]	6.60±0.18[d]	7.70±0.0[b]	33.50±0.0[d]	95.50± 0.0[d]	96.0±0.0[e]
C6	61.15±1.7[ab]	6.40±0.17[c]	7.38±0.4[bc]	38.0±0.0[e]	110.0±0.0[g]	94.0±0.0[c]

The values reported are mean ± SD.

The results of extensograph tests in Barbari bread dough samples during fermentation at 45, 90 and 135 min were presented in Tables 4, 5, 6.

The results showed that the control samples in the fermentation time of 45, 90 and 135 had the lowest amounts of energy.

As shown in Tables 4, 5, 6 the amount of energy increased following the addition of CMC in experimental samples. Bread samples of C1, C2 and C3 with 0.5% of CMC showed the highest amounts of energy during fermentation times (45, 90 and 135 min).

The average comparison the results of resistance to stretch during all three fermentation times in Barbari bread dough samples demonstrated that treatments were contained apple fiber and CMC exhibited higher amounts of resistance to stretch as compare to control sample.

Therefore treatments B3, C1 and C6 which enriched with 11% apple fiber had the highest levels and control sample showed the lowest amount of resistance to stretch at all fermentation times.

The results of ability to stretch are shown in Tables 4, 5, 6. According to results, the ability to stretch of sample C1 after control sample was highest during at the fermentation time of 45 min (Table 4). The ability to stretch of sample C1 significantly decreased with increase of fermentation time.

The effect of factors of resistance to stretching and the ability to stretch the dough on the coefficient numerical value is defined as the ratio of resistance to stretching to the ability to stretch.

According to Tables 4, 5, 6 Addition of apple fiber and CMC increased the ratio of Resistance stretch to Ability to stretch, but the results showed that the effect of apple fiber were more effective than CMC as the highest level of this factor during all three fermentation time were belonged to the treatments of B3, C6. As can be seen from the results of Table 7, the highest bread score for overall acceptability was belonged

Table 4. Comparison of results Extansography test on dough containing Apple pomace and Carboxy Methyl Cellulose during fermentation time of 45 min treatment C1 and the lowest was belonged to the control.

Treatment	Energy (cm2)	Resistance to stretch (B.U)	Ability to stretch (mm)	(Resistance stretch / Ability to stretch)
A	84.0±0.07[ab]	330.25±2.1[a]	162.50±11.46[d]	2.05±0.14[a]
B1	103.50±14.85[bcd]	515.50±36.4[bc]	128.0±9.05[abcd]	4.05 ±0.28[cd]
B2	91.0±9.90[ab]	511.50±36.2[bc]	117.50±8.20[ab]	4.35±0.29[d]
B3	84.50±7.70[ab]	602.00±42.6[de]	96.50±6.82[a]	6.25±0.43[e]
C1	106.50±0.71[ed]	590.50±41.7[de]	157.0± 11.10[d]	2.50±0.17[ab]

C2	110.5±16.26[ed]	498.00±35.2[bc]	137.00± 9.69[bcd]	3.60±0.25 [bcd]
C3	112.0±18.38[e]	394.50±27.9[ab]	157.50±11.06[d]	2.90±0.19[abc]
C4	107.0±12.73 [a]	414.50±29.3[ab]	145.50±10.28 [cd]	3.20±0.22[abcd]
C5	106.0±11.31[abc]	467.50±33.1[abc]	128.00±9.05[abcd]	4.25±0.29[d]
C6	101.50±7.78[e]	664.50±47.0[e]	106.50±7.52 [ab]	6.25±0.43[e]

The values reported are mean ± SD

Table 5. Comparison of results Extansography test on dough containing Apple pomace and Carboxy Methyl Cellulose during fermentation time of 90 min

Treatment	Energy (cm2)	Resistance to stretch (B.U)	Ability to stretch (mm)	(Resistance stretch / Ability to stretch)
A	64.7±4.57 [a]	283.50±20.0[a]	139.2±12.85[a]	2.25±0.15[a]
B1	104.5±6.68 [bcd]	662.0± 46.8[bcd]	108.0±7.64[ab]	5.95±0.41[b]
B2	99.5±7.03[ab]	764.5±54.1[de]	114.0±8.06[a]	6.8±0.48[b]
B3	91.5±6.46 [ab]	982.0±69.5[e]	108.5±7.67[c]	9.1±0.63[c]
C1	128.5±9.08[de]	394.5±27.9[ab]	154.5±10.92[bc]	2.55±0.17[a]
C2	129.0±2.05[cde]	565.0±40.0[bc]	147.5±10.42[abc]	3.50±0.24 [a]
C3	144.0±10.18[d]	606.0±42.90[bcd]	125.5±17.68[abc]	4.90±0.33[b]
C4	111.0±7.99[bcd]	494.0±34.90[bc]	120.5±14.85 [abc]	4.10±0.28[def]
C5	113.0 ±7.85[bcd]	600.50±42.50[bcd]	122.0±14.14[abc]	5. 0±0.35[b]
C6	108.0±7.64[bcd]	891.10±63.00[e]	105.5±7.54 [a]	8.45± 0.66[c]

The values reported are mean ± SD.

Table 6. Comparison of results Extansography test on dough containing Apple pomace and Carboxy Methyl Cellulose during fermentation time of 135 min

Different letters in each column are indicate statistical difference at 5% leve.

Treatment	Energy (cm2)	Resistance to stretch (B.U)	Ability to stretch (mm)	(Resistance stretch / Ability to stretch)
A	65.5±4.62[a]	274.0± 19.40[ab]	150.0±10.61[ab]	1.85±0.12[a]
B1	115.0± 8.13 [bc]	687.0± 48.60 [b]	120.5±8.50[ab]	5.7±0.39[b]
B2	114.0±8.06[bc]	858.5±60.70[c]	108.0±7.64[ab]	8.35±0.58[b]
B3	94.0±6.65[b]	995.5±70.40[c]	93.0±8. 0[ab]	10.7±0.75[b]
C1	121.5±8.58[bc]	453.5±31.90[a]	133.5±9.08[ab]	3.4±0.21[c]
C2	125.5±9.22[c]	565.0±40.10[b]	136.0±9.62[ab]	4.20±0.29[bc]
C3	129.5±9.15[c]	610.5±43.10[b]	142.0±10.04[ab]	4.6± 0.32[bc]
C4	97.5±6.89[b]	478.5±33.80[a]	130.0±9.48[ab]	3.75±0.25[c]
C5	110.0±7.78[bc]	641.5±45.30[b]	117.5±8.66[ab]	5.5±0.38[bc]
C6	118.0±8.34[bc]	937.5±66.30[c]	95.0±6.72[ab]	9.85±0.69[bc]

The values reported are mean ± SD.

Different letters in each column are indicate statistical difference at 5% leve.

Table7. Mean scores of sensory evaluation treatments when coefficients applied and Sensory evaluation (Bread staling)

Treatment		Overall acceptability of Bread after 72 h storage^{a}		Bread staling score^{a}		
				24 hours	48 hours	72 hours
A		3.20±0.22^{a}		5.40±0.38^{a}	3.60±0.25 ^{a}	2.0±0.14 ^{a}
B1		4.0±0.28^{ab}		5.60±0.39^{a}	5. 0±0.35 ^{ab}	4.15±0.28 ^{b}
B2		4.21±0.29^{ab}		5.80±0.41 ^{a}	5.20±0.36^{b}	4.50±0.34^{b}
B3		4.60±0.32^{b}		5.80±0.41^{a}	5.40±0.38 ^{b}	4.80±0.33^{b}
C1		4.95±0.33^{b}		6.00.42 ^{a}	5.80± 0.41^{b}	5.20±0.36^{b}
C2		4.40±0.45^{ab}		5.60±0.39^{a}	5.40±0.38^{b}	4.20±0.29^{b}
C3		4.20±0 .29^{ab}		5.60±0.39 ^{a}	5.20±0.36^{b}	4.0±0.28^{b}
C4		4.15±0.28^{ab}		5.60±0.39^{a}	5.20±0.33^{ab}	4.20±0.29^{b}
C5		4.55 ±0.31 ^{b}		5.80±0.41^{a}	5.40±0.38 ^{b}	4.0±0.28^{a}
C6		4.75±0.32^{b}		6.0±0.42 ^{a}	5.60±.0.39^{b}	4.80±0.33^{b}

The values reported are mean ± SD.
Different letters in each column are indicate statistical difference at 5% leve
^{a}:The highest scores were 6 for the acceptable bread with lowest staling and 0 for unacceptable bread with highest staling

4. Discussions

Increased apple fiber content increases water absorption as a result of network structure of fibers consisted of polysaccharide chains holding high amount of water by hydrogen bonds (kethireddipalli et al., 2002) or water may be held in capillary structures of fibers through surface absorption (lopez et al., 1996). Since apple fiber contains high amount of fibers, these results are predictable. Masoodi and chauhan. (1998) obtained similar results. In addition, water absorption of all samples containing apple fiber with gums is higher than the control sample without fiber. This increase in water absorption may be due to hydrophilic structure of gums and higher content of fiber. Hydroxyl groups of hydrocolloids are bound to water molecules through hydrogen bond and increasing water absorption (Tavakol pour & Ashtari, 2006). There is a direct relationship between apple fiber percentage and dough development time so that addition of fiber to the mixture may reduce water absorption rate and gluten development type and amount of fiber have significant effect on water absorption and expansion of dough. A fiber with potential to absorb high amount of water may prolong dough development time. Interactions between fibers and gluten of wheat flour may explain different effects of various fibers on dough development time. The obtained results are consistent

with the results obtained by sudha et al. (2007). It may be noted that all samples contained gums showed increased dough development time compared to control sample. In general, it may say that applying higher percentages of apple fiber and CMC to Barbari dough may increase dough development time compared to control sample. Arabameri et al. (2004) also found that inclusion of carboxy methyl cellulose in Lavash bread dough prolonged dough development time. The results of dough resistance time of samples are consistent with results obtained by sudha et al. (2007). They reported that, increase the level of apple fiber resulted in reduced dough resistance time.

Addition of CMC to flour containing apple fiber reduced softening degree significantly. Chen et al. (1988) suggested that dough softening was due to gluten dilution because of increased fiber content or interaction between fiber and gluten.

The extensographic result showed that the type and amount of additives had significant effect on amount of energy. The results showed that the amount of energy significantly increased following the addition of CMC for all three times (45, 90, and 135) of fermentation. This finding was consistent with the result obtained by Rosell et al. (2005) who reported that addition of different amounts of gums may firm dough and increases the amount of energy of the treatments. A strong complex seems formed between flour starch and gluten network strengthened by gums resulting in increased dough stability and energy for dough elasticity. The energy values and ratios of all the extensograms were in line with the baked volume achieved with these flours. The low energy values in conjunction with low ratios (0.6) that indicated soft and weak doughs and the high ratios (7 and above) in conjunction with low energy values that stand for short doughs were confirmed by low baked volumes.high energy values and ratios in the optimum range (about 1.5 to 3.0) in the extensograms indicated a flour of good quality and high baked volumes (weipert, 2006).

The result of resistance to stretch of this study were consistent with the results obtained by sudha et al. (2007) who showed that addition of different amounts of apple fiber to cakes may increase resistance to stretch and reduce elasticity of dough.

The results of sensory evaluation proved that sample inoculated with highest level of apple fiber and CMC exhibited the highest overall acceptability and lowest staling after 72 h storage. A possible explanation for this could be related to effective role of apple fiber and CMC to improve the quality of traditional barbari bread.

The result of this research revealed that by applying 11% apple fiber and 5% CMC to traditional barbari bread formulation we successfully achieved a proper formulation for producing barbari bread with higher quality and ability to storage.

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