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Effects of Microcrystalline Cellulose and Hydroxypropylmethyl Cellulose on the Properties of Dough and Flat Bread (Iranian Barbari Bread)

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ABSTRACT-There are many reports on the application of different hydrocolloids in the production of leavened breads; most of which show positive effects on bread quality. However, there is little information to prove such effect on flat breads. The main aim of this study was to improve the quality of Barbari dough and bread (Iranian flat bread) in terms of texture, taste and general acceptability of fresh bread. This was achieved by using two types of hydrocolloids; microcrystalline cellulose and hydroxypropylmethyl cellulose at 0.5% wheat flour basis. The results indicated that addition of either of the two cited hydrocolloids could improve dough and bread quality. However the latter had more positive effects on dough and bread properties mainly due to its more hydrophilic molecular property. Higher water absorption, improved dough stability time, softer bread texture and higher volume, as well as greater acceptability were all observed when hydroxypropylmethyl cellulose was added in bread recipe.

Keywords*:* Flat bread, Hydrocolloids, Bread quality, Hyroxypropylmethyl cellulose, Microcrystalline cellulose

INTRODUCTION

Bread is the most consumed food in the world. It is generally made in two major shapes; flat and leavened. Flat bread is more common in Asian countries and is prepared either fermented (using bakery yeast or sourdough in formulation) or non-fermented (18).

Bread is also the main source of calories, minerals and vitamins for the human body. The importance of the nutrition value of bread in the human diet is more significant in developing countries which are not able to provide other sources of nutrients (2, 7 and18).

Despite the importance of bread in the human diet, a large amount of the product is wasted causing a large damage to the economic of baking industry. Many factors contribute to bread wasting including the application of inappropriate ingredients and baking methods, undesirable texture, color, taste and flavor of fresh bread and rapid staling (12). Different components have been used to improve bread quality (e.g. sugars, emulsifiers, enzymes, milk and its derivatives, etc.) (2, 6, 7, 10 and 14), amongst them, hydrocolloids have shown promise. Hydrocolloids are generally natural polysaccharides, which can provide a range of functional properties (even at very low concentration) that make them very useful in bakery as well as many other food products (4, 14, 17 and 21). Different hydrocolloids have been tried

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in bread formula including pectin, sodium alginate, κ-carrageenan, xanthan gum, guar gum (13, 20, 22 and 23), cellulose and its derivatives (9, 13, 17 and 23) and modified starches (e.g. cross-linked and substituted starches) (16).

As the previous results in the literature indicate, different hydrocolloids can cause different effects on the properties of dough and bread (22 and 25). For instance addition of κ-carrageenan could increase the water absorption of the dough when added at 0.5 % (flour basis), while at higher levels the water absorption reduced. At the same level, addition of hydroxypropylmethyl cellulose (HPMC) caused significantly higher water absorption of the dough compared to guar gum and κ-carrageenan (22). Therefore, it can be concluded that the effects of hydrocolloids on dough and bread properties depend on many factors including different molecular structure, particle size and amount of hydrocolloids, bread recipe, dough and bread preparation methods as well as bread types (e.g. leavened, chemically leavened flat bread and yeast leavened flat bread) (22). An important effect of hydrocolloids on leavened bread is to increase its volume which is not a desirable characteristic for flat breads. Therefore, understating the effects of hydrocolloids on flat breads is of great importance. Although there are many reports on the effects of hydrocolloids on the quality of leavened breads, there is little information on such effects on the characteristics of flat breads.

The main aim of this study was to determine the effects of two common hydrocolloids; microcrystalline cellulose (MCC) and HPMC on the properties of dough and flat bread in order to improve the quality of the bread. Amongst the different types of flat breads, Barbari bread was selected since it is one of the most consumed breads in Iran as well as many other Middle Eastern countries and unfortunately it has a high rate of waste (nearly 30 % in Iran) (25).

MATERIALS AND METHODS

Wheat flour was purchased from Khoosheh milling factory in Shiraz, Iran, with an average extraction rate of 78% according to the manufacturer. The chemical composition of the flour was determined based on AACC approved methods of the American Association of Cereal Chemists (1) as follow; 10.5 % moisture content, 11.37 % protein content, 32.02% wet gluten and 0.23% ash content (all dry weight basis). MCC and HPMC were obtained from Merck, Germany. Other chemicals used in this study were of analytical grade (Merck, Germany).

Dough preparation

A basic formula for making Barbari bread per 100g flour includes: 2 g yeast (activated before using according to the instruction given by the manufacturer) and 2 g salt (NaCl). Each hydrocolloid (MCC or HPMC) was also added separately at 0.5% w/w to the flour. The appropriate amount of water to make the dough was determined using a Brabender Farinograph (Model FE022N, Germany). Water was added gradually to the dough ingredients while mixing in the Farinograph mixer until the dough consistency reached 500 Brabender Units (BU) (1).

Rheological properties of the dough

The rheological properties of the dough including dough development time, dough stability time and degree of dough softening after 5 and 12 min were determined from the Farinograms according to the AACC (1995) (1).

Bread making

To prepare bread dough, all ingredients were put in a laboratory dough mixer (EB124101, Germany) and were mixed at medium speed (75 rpm) for 15 min. Each time 3500g of dough was produced. Then the dough was placed in a proofing cabinet with a relative humidity of 85%, at 40 °C for 1 hr. During this time, the volume of the dough increased due to the yeast activity. The dough was then divided into dough pieces of 400g and then rounded by hand and placed in the proofing cabinet once again for 45 min. Then the dough was shaped in round metallic moulds with a thickness of 1 cm and radius of 15 cm. The surface of the dough was brushed with a thin layer of a gelatinized wheat starch to improve the color and glaze of the crust after baking.

The dough was then baked in an electrical baking oven (Karl Welkerkg, Germany.) at 210 °C for 30 min. The breads were then cooled down at room temperature (22 ºC) for one hour and were kept in polyethylene bags used for further experiments.

Hardness of bread crumb

To study the hardness of bread crumbs, the crumb of bread was tested using a texture analyzer (Stevens-LFRA) using a metallic probe with circular die of 10 mm. The probe punched the bread crumb at the speed of 1 mm/s. Experiments were performed at five different points (selected randomly) on the bread crust and the averages were reported (7).

Crust color

The color of bread crust was evaluated using a modified method of Yam *et al*. (24). High resolution pictures of whole crust were taken separately by a digital camera. Resolution, contrast and lightness of all images were set to 200 (dpi), 62 (%) and 62 (%), respectively. The pictures were saved in JPEG format and analyzed quantitatively using the Adobe Photoshop 8 software and the color parameters of L (lightness) and a (redness-greenness) were determined in the “Lab” mode of the software (3).

Bread volume

The volume of the breads was measured using the rapeseeds displacement method. A container with a known volume and weight was used. Each bread was placed in the container and the empty void was filled with rapeseeds. Knowing the volume of the container and the volume of rapeseed, the volume of bread was then calculated (11).

Sensory analysis

Sensory attributes of the samples, including aroma, taste, texture and appearance were studied using a taste panel of 12 semi-trained panelists (6 male and 6 female) with a five points hedonic scale. The higher score (5) was given to the most favorite and the lowest (1) was given to the least favorite samples (7 and 13).

Statistical analysis

The experiments were performed in a completely randomized design. All experiments were conducted in triplicates and the mean values and standard deviations were calculated. Analysis of variance (ANOVA) was performed and results were separated using the Multiple Ranges Duncan's test ($\alpha < 0.05$) using statistical software of SPSS 13 (SPSS, Inc. New Jersey, USA).

RESULTS AND DISCUSSION

Effects of hydrocolloids on the water absorption of dough

Figure 1 shows the comparison of the effects of the addition of MCC, HPMC (0.5 % w/w) and the control sample (flour with no hydrocolloids) on the water absorption of the dough as determined by Brabender Farinograph. The results indicated that the water absorption of the control sample and the dough made with MCC were not significantly different ($\alpha < 0.05$), while it increased significantly when HPMC was added.

Rosell et al (20), Guarada et al. (2004), Barcenas and Rosell (2005) and Shalini and Laxmi (2007) reported that the water absorption of the dough contaning HPMC increased (20, 13, 4 and 22). The latter report was on the dough of flat bread (Indian Chapatti bread).

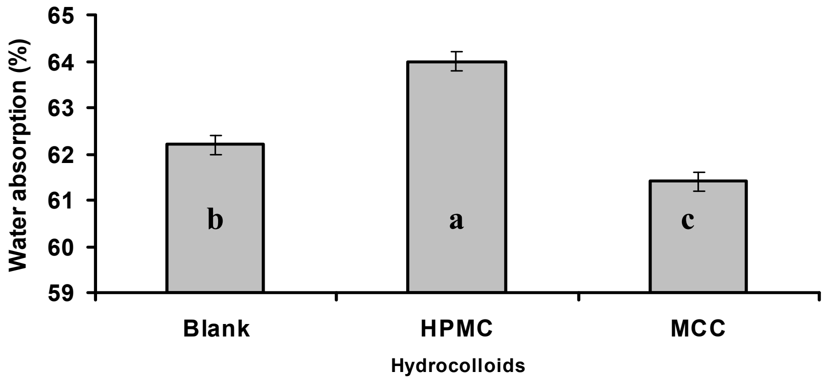

Fig 1. Effect of HPMC and MCC on the water absorption of dough. Different letters on the figure show significant difference between the samples (α <0.05)

Differences in the ability of water absorption of the two hydrocolloids during dough formation can be attributed to their different molecular structures. MCC is basically highly crystalline with low reactivity, while HPMC is highly hydrophilic due to the presence of methyl and hydroxylpropyl groups (8 and 17). Therefore HPMC readily absorbs more water during the initial stage of dough formation, whereas MCC remains inactive at this stage.

Effects of hydrocolloids on dough development time

The results (Figure 2) show that the development time of the control and the dough made with HPMC were similar, however it was higher for the dough made with

MCC. It could be explained that the dough made with MCC require longer time to properly form a dough. Shalini and Laxmi (2007) reported that the addition of 0.5% HPMC did not show any significant increased in dough development time compared to the control, while it was significantly higher than the control when 0.5% guar gum, κ-carrageenan or carboxymethyl cellulose (CMC) were added (22). Therefore, the molecular structure of the used hydrocolloids in terms of molecular size and shape, interaction with water molecules and the presence of hydrophilic or hydrophobic groups on the hydrocolloids are also of great importance.

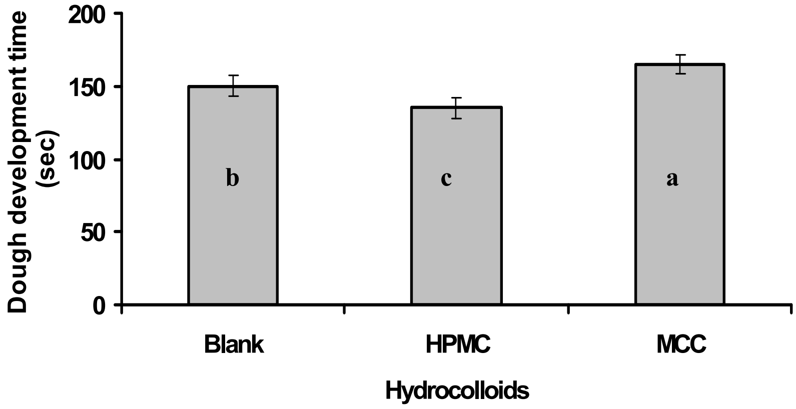

Fig 2. Effect of HPMC and MCC on dough development time. Different letters on the figure show significant difference between the samples (α<0.05)

Effects of hydrocolloids on dough stability time

Dough stability time is an indication of the dough ability to resist mixing without losing its consistency. It is determined from the time that the dough remains with a consistency of 500 BU during mixing. The results (Figure 3) show that the control and the dough made with MCC had similar dough stability time, while the dough made with HPMC had significantly (α < 0.05) longer dough stability time (210 s). It means that the latter dough had higher tolerance for mixing. Similarly, Rosell et al. (20) and Shalini and Laxmi (22) reported improvement in dough stability time by addition of 0.5% HPMC, despite reduction in dough stability time as observed using 0.5% CMC in dough.

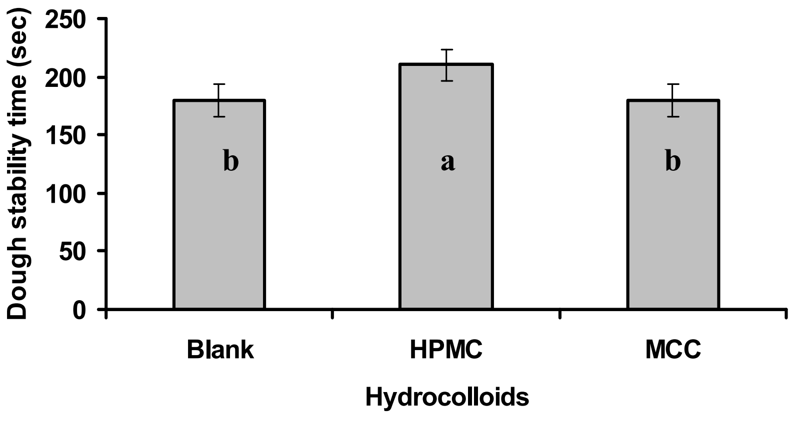

Fig 3. Effect of HPMC and MCC on dough stabilty time. Different letters on the figure show significant difference between the samples (α<0.05)

Effects of hydrocolloids on dough softening after 5 and 12 minutes

The dough consistency reduces when mixing is continued (over-mixed). It has been reported that the alignment of the macromolecules in the dough during mixing may explain the reduction in the dough consistency when dough is over-mixed. However in the complex system of the dough, the role of other components should not be ignored. The results (Figure 4) show that the dough made with hydrocolloids had greater degree of softening after 5 min compared to the control. These two samples also had similar degrees of softening at this stage. However after 12 min, the softness of the dough made with MCC and the control were comparable, while the dough made with HPMC was softened to a greater degree. This implies the presence of more water in the dough containing HPMC, as shown previously. Thus, more unbound water may be released into the dough matrix as a result of over mixing causing greater reduction in dough consistency. It seems that the release of water in the dough occurred at later stages of mixing.

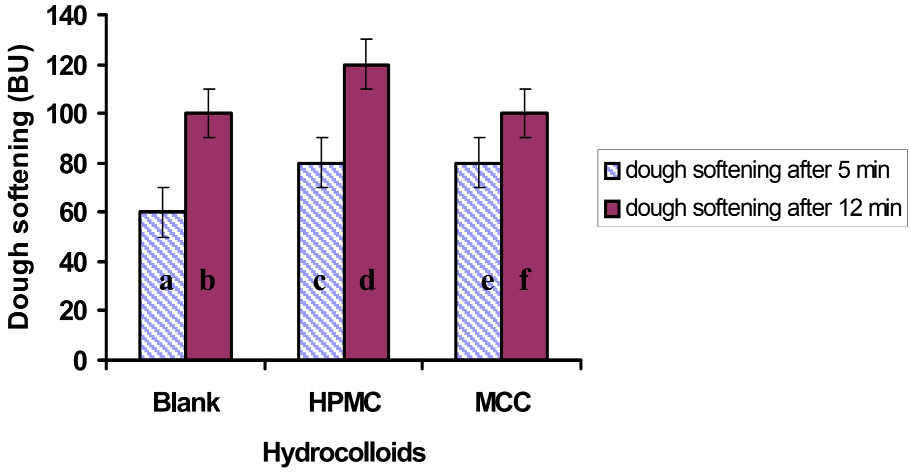

Fig 4. Effect of HPMC and MCC on dough softning after 5 and 15 min. Different letters on the figure show significant difference with in the samples (α <0.05)

Effects of hydrocolloids on bread properties

Bread volume

Bread made with HPMC had the greatest volume amongst all other samples, while the breads made with MCC had slightly higher volume than the control (Figure 5). Rosell et al. (20), Guarada et al. (13) and Barcenas and Rosell (4) also reported higher bread volume when cellulose and it derivatives were added. It is generally accepted that the ability of the hydrocolloids to increase bread volume might be attributed to the fact that at high temperatures the hydrated chains of this polymer release the water molecules associated to them allowing stronger interaction among HPMC chains. Consequently a temporary network is created that will disintegrate during cooling (5). This network will give strength to the air bubbles cell walls in the initial stage of baking. Further during baking the air bubbles expand without being ruptured and in turn bread volume will improve (5 and 15).

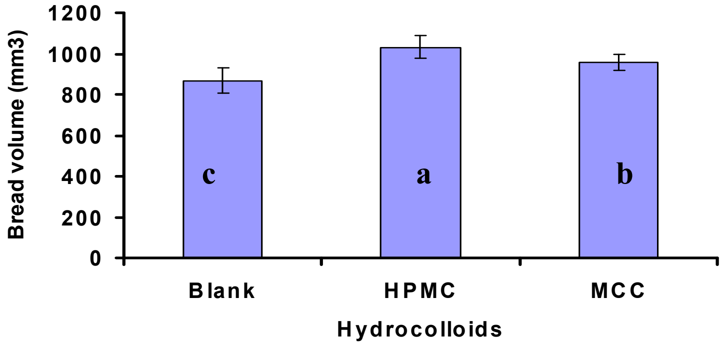

Fig 5. Effect of HPMC and MCC on bread volume. Different letters on the figure show significant difference between the samples (α<0.05)

Crumb hardness

One of the main parameters determines the hardness of bread samples is the volume or specific density. Generally there is negative relationship between the bread volume and its hardness (7). Figure 6 shows that the hardness of bread crumbs decreased when either MCC or HPMC were added. Moreover bread made with HPMC had the softest crumb texture compared to the others.

Similar results were obtained when some cellulose derivatives were incorporated in bread formula (4, 13 and 22). It has been reported that breads made with cellulose derivatives had higher moisture content. On the other hand, a reverse relationship between the moisture content of the bread and its hardness has been widely reported (19, 20 and 22). Therefore, it can be concluded that the addition of hydrocolloids can increase the moisture content of the bread and consequently increase bread softness. Moreover, according to Bell (5) and Davidou et al. (10) it is possible that the hydrocolloids chains interfere with the interactions amongst the starch polymers and between the proteins and starch, which would lead to softer crumbs (5 and 10).

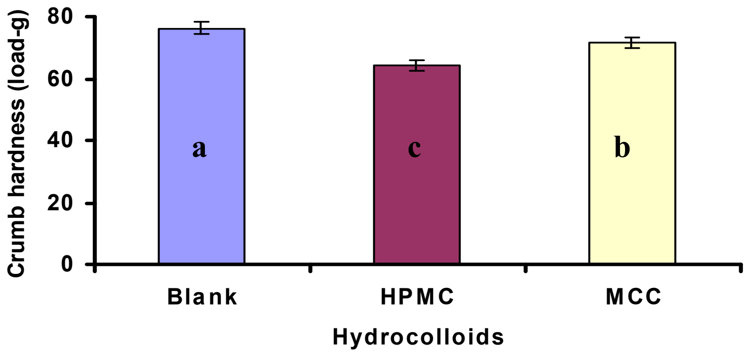

Fig 6. Effect of HPMC and MCC on bread crumb hardness. Different letters on the figure show significant difference between the samples (α <0.05)

Bread color

The L and a values of the bread crust color are shown in Figure 7 and 8, respectively. As the results show, the lightness of the bread crust made with HPMC was similar to that of the control while the bread made with MCC was slightly darker (lower L-value) than the others. Moreover, the crust redness of the control bread and the one made with HPMC were similar, whilst the bread made with MCC had greater a-value, indicating greater redness of the crust. Shalini and Laxmi (22) did not find any exact correlation between bread color and the type or dosage of CMC or HPMC used for making Chapatti bread. However they indicated that the breads made with HPMC were slightly lighter in color than those made with carboxymethyl cellulose (CMC).

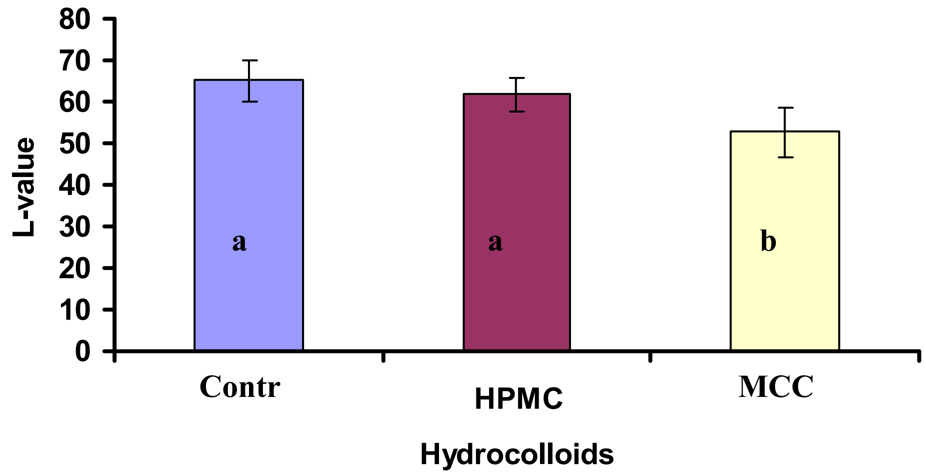

Fig 7. Effect of HPMC and MCC on bread redness-greenness (L-value). Different letters on the figure show significant difference between the samples (α<0.05)

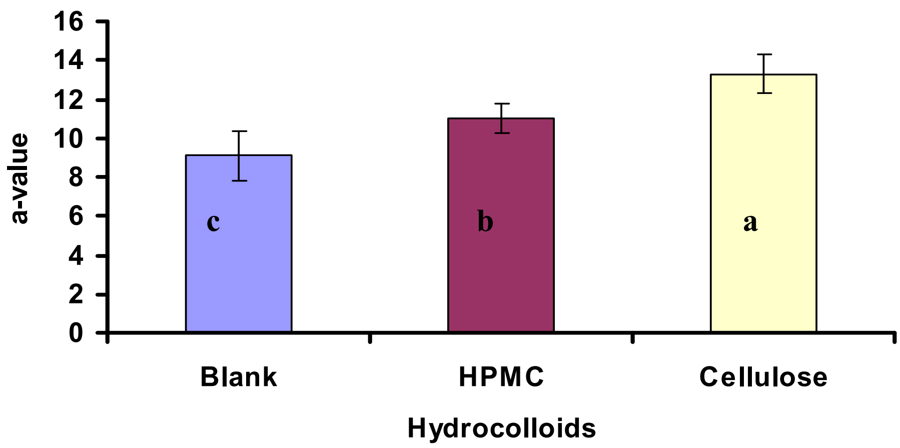

Fig 8. Effect of HPMC and MCC on bread redness-greenness (a-value). Different letters on the figure show significant difference between the samples (α<0.05)

Sensory evaluation of the breads

The results of sensory evaluation of the breads made with hydrocolloids in terms of aroma, taste, texture and appearance are given in Table 1. The results show that the bread made with HPMC received highest scores. Bread made with MCC received similar scores to the control. In terms of aroma all samples received similar scores. Guarada et al. (13) reported better acceptance of the bread containing 0.5%

hydrocolloids compared to the control and the one made with κ-carrageenan (13). Barcenas and Rosell (4) reported that bread containing HPMC obtained better scores in all organoleptic characteristics than the control. However, in terms of taste and texture there was no significant difference (α <0.05) between the samples made with hydrocolloids and the control. Shalini and Laxmi (22) also found that addition of CMC and HPMC could improve sensory attributes of the bread. Even when HPMC and CMC were added to frozen dough, improvement of the bread appearance and general acceptability of the bread was reported (15 and 23). The improvement effect of HPMC on the sensory quality of bread could be due its effect on the crumb texture that yields softer crumb.

Table 1. Effect of HPMC and MCC on organoleptic properties of barbari bread

Characteristics	Control	HPMC	MCC
Aroma	**3.0 [a]**	**3.2 [a]**	**3.0 [a]**
Taste	**3.0 [a]**	**4.1 [b]**	**2.8 [a]**
Texture	**3.2 [a]**	**3.6 [b]**	**3.1 [a]**
Appearance	**3.5 [a]**	**4.0 [b]**	**3.5 [a]**
General acceptability	**3.0 [a] (Fair)**	**4.2 [b] (Very good)**	**3.1 [a] (Fair)**

Different letters in each row show statistical differences between the samples (α<0.05)

CONCLUSIONS

The results of this study showed that both MCC and HPMC can be used in making flat bread, however HPMC had more positive effects on the quality of dough and bread. As the results showed the dough made with HPMC had higher dough stability time, which may indicate that the addition of HPMC may be useful in longer dough making processes to produce proper dough. Moreover, the volume of the breads made with hydrocolloids, especially HPMC was higher than the control. This may not be of interest when flat breads are made, however this effect may be compensated by shaping the dough with smaller height before baking (i.e. equal weight but thinner).

The bread made with HPMC had the best sensory attributes in terms of texture, taste and appearance. Producing a bread of high quality can increase consumer satisfaction and hence reduce bread waste due to poor quality. This can be achieved using HPMC in the bread recipe. Since hydrocolloids can retain more water during dough and bread making, they contribute to the air bubble cell wall structure leading to higher bread volume and also preventing starch retro gradation (22 and 23). Bread staling may also be retarded using hydrocolloids (12 and 20).

Comparison of the results obtained for flat bread (this study) with those reported for leavened breads indicates that HPMC and MCC may have generally similar effects on the properties of dough and bread. However an important attribute of leavened bread is the volume, which is not of much interest in flat bread. Based on the results, the volume of flat bread increased as a result of the addition of MCC and HPMC. However a slight increase in the volume of Barbari bread did not have any effect on its general acceptability and hence these hydrocolloids can be used successfully to improve the quality of flat breads.

REFERENCES

1. American Association of Cereal Chemists (AACC). 1995. Approval Methods of American Association of Cereal Chemists.
2. Amero, E., and C. Collar. 1996. Antistaling additive effects of fresh wheat bread quality. Food Sci. Tech. Int. 2: 323-333.
3. Arias, R., T. C. Lee, L. Logendra and H. Janes. 2000. Correlation of lycopene measured by HPLC with the L, a, b colour readings of a hydroponic tomato and the relationship of maturity with colour and lycopene content. J. Agric. Food Chem. 48:1697–1702.
4. Barcenas, M. E., and C. M. Rosell. 2005. Effect of HPMC addition on the microstructure, quality and aging of wheat bread. Food Hydrocol.19: 1037-1043.
5. Bell, D. A. 1990. Methylcellulose as a structural enhancer in bread baking. Cereal Food World. 35: 1001-1006.
6. Caballero, P. A., M. Gomez and C. M. Rosell. 2007. Improvement of dough rheology, bread quality and bread shelf-life by enzymes combination. J. Food Eng. 81: 41-53.
7. Chinachoti, P., and Y. Vodovotz. 2001. Bread Staling. Boca Raton, FL. CRC Press.
8. Coffey, D. G., D. A. Bell and A. Henderson. 2006. Cellulose and cellulose derivatives. Chapter 5 ***In:*** A. M., Stephan, G. O. Phillips, and P. A. Williams **(*eds.*),** Food Polysaccharides and Their Applications. 2nd ed. CRC Press. Baca Raton, New York.
9. Collar, C., P. Andreu, J. C. Martinez and E. Amero. 1999. Optimization of hydrocolloid addition to improve wheat bread dough functionality; a response surface methodology study. Food Hydrocol. 13: 467-475.
10. Davidou, S., M. Le Meste, E. Debevern and D. Bekaert. 1996. A contribution to the study of staling of white bread: effect of water and hydrocolloids. Food Hydrocol. 10: 375-383.
11. Farahnaky, A., and M. Majzoobi. 2008. Physicochemical properties of partbaked breads. Int. J. Food Properties 11: 186-195.
12. Gray, J. A., and J. N. Bemiller. 2003. Bread staling: molecular basis and control. Comp. Rev. Food Sci. Food Safety 2: 1-21.
13. Guarada, A., C. M. Rossel, C. Benedito and M. J. Galotto. 2004. Different hydrocolloids as bread improvers and antistaling agents. Food Hydrocol. 18: 241-247.
14. John, M. J., and S. Thomas. 2008. Review, Biofibers and biocomposites, Carbohyd. Polym. 71: 343-364.
15. Mandala, I., D. Karabela and A. Kostaropoulos. 2007. Physical properties of breads containing hydrocolloids stored at low temperature. I. Effect of chilling. Food Hydrocol. 21: 1397-1406.
16. Miyazaki, M., P. Van Hung, T. Maeda and N. Morita. 2006. Recent advances in application of modified starches for breadmaking. Trends Food Sci.Tech. 17: 591-599.

17. Murray, J. C. F. 2002. Cellulosic. Chapter 12 ***In:*** G. O. Phillips, and P. A. Williams **(*eds*.)**, Handbook of Hydrocolloids. CRC Press. Baca Raton, New York.

18. Qarooni, J. 1996. Flat Bread Technology. Springer, London.

19. Roger, S. D. E., K. J. Zeleznak, C. S. Lai and R. C. Hoseney. 1988. Effect of native lipids, shortening and bread moisture on bread firming. Cereal Chem. 65: 398-401.

20. Rosell, C. M., J. A. Rojas and C. Benedito de Barber. 2001. Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocol. 15: 75-81.

21. Sanderson, G. R. 1990. Gums and their use in food systems. Food Tech. 50: 81-84.

22. Shalini, K. J., and A. Laxmi. 2007. Influence of additives on rheological characteristics of whole-wheat dough and quality of Chapatti (Indian unleavened flat bread). Part I. Hydrocolloids. Food Hydrocol. 21: 110-117.

23. Sharadanant, R., and K. Khan. 2003. Effect of hydrophilic gums on the quality of frozen dough: II. Bread characteristics. Cereal Chem. 80: 773-780.

24. Yam, K. L., and S. E. Papadakis. 2004. A simple digital imaging method for measuring and analyzing color of food surfaces. J. Food Eng. 61: 137-142.

25. www.ard.ir. (last visited 7/2008).

تاثیرات سلولز میکروکریستاله و هیدروکسی پروپیل متیل سلولز بر خصوصیات خمیر و نان مسطح (نان بربری ایرانی)

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چکیده - تحقیقات بسیاری در ارتباط با استفاده از هیدروکلوئیدهای مختلف در تولید نان های حجیم انجام شده است. نتایج به دست آمده نشان داده است که بیشتر آنها اثرات مثبتی بر کیفیت نان های حجیم داشته اند. اگرچه اطلاعات کمی در مورد تاثیر مثبت این ترکیبات بر نانهای مسطح وجود دارد. هدف اصلی این تحقیق بهبود کیفیت خمیر و نان بربری (نان مسطح ایرانی) از نظر بافت ، طعم و مزه و قابلیت پذیرش کلی نان تازه بود. این کار با استفاده از دو نوع هیدروکلوئید شامل سلولز میکروکریستاله و هیدروکسی پروپیل متیل سلولزکه هر یک در سطح ۰/۵ ٪ آرد گندم در فرمولاسیون خمیر اضافه شدند انجام شد. نتایج نشان داد که استفاده از هر یک از این هیدروکلوئیدها اثرات مثبتی بر کیفیت خمیر و نان دارد. اگرچه افزودن هیدروکسی پروپیل متیل سلولز اثرات مثبت بیشتری نشان داد. این امر به دلیل ساختار آبدوست این مولکول می باشد. افزایش جذب آب ، افزایش زمان پایداری خمیر ، نرمی بافت و حجم بیشتر و افزایش مقبولیت محصول توسط مشتری از نتایج افزودن هیدروکسی پروپیل متیل سلولز به فرمول نان بود.

واژه های کلیدی: نان مسطح ، هیدروکلوئیدها ، کیفیت نان ، هیدروکسی پروپیل متیل سلولز و سلولز میکروکریستاله

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*به ترتیب استادیار ، استادیار و دانشجوی کارشناسی ارشد

** مکاتبه کننده