

Trakia Journal of Sciences, Vol. 7, No. 1, pp 1-6, 2009 Copyright © 2008 Trakia University Available online at: <u>http://www.uni-sz.bg</u>

ISSN 1313-7050 (print) ISSN 1313-3551 (online)

Original Contribution

EFFECT OF DIFFERENT HYDROCOLLOIDS ON GELATINIZATION BEHAVIOUR OF HARD WHEAT FLOUR

F. Alam*, A. Siddiqui, Z. Lutfi, A. Hasnain

Department of Food Science & Technology, University of Karachi, Pakistan

ABSTRACT

The effects of different hydrocolloids on the gelatinisation behaviour of hard wheat flour were investigated. Influence of guar, xanthan, Arabic, carboxy methyl cellulose (CMC) and tragacanth gums on wheat flour was studied using micro viscoamylograph. It was found that all hydrocolloids except tragacanth greatly modified the gelatinisation properties of wheat flour. Guar and xanthan significantly lowered the gelatinisation temperature, enhanced peak viscosity, increased the breakdown during cooking, promoted the stability during cooling and thus decreased the tendency to setback. Gum Arabic lowers the peak viscosity, reduces breakdown during heating and thus provides increased stability during cooking. The addition of CMC to the wheat flour resulted in maximum stability during cooling. It also produced large breakdown during heating which provided maximum destabilization and made the cooking easier. These results suggest that by adding gums gelatinisation properties of wheat flour can be greatly modified and this could be used for the improvement of different wheat products.

Key words: Amylography, Guar gum, Tragacanth, Heating stability, Peak viscosity.

INTRODUCTION

Pakistan is among the leading wheat producing countries in the world, accounting for 2% of the total wheat production (1). Most of the wheat varieties in Pakistan have higher protein content in the range of 11-13%. Researchers have been working for a long time to modify the flour produced in their regions according to their requirements (2, 3). Hard wheat flour is used in processing of numerous number of products including bread, noodles, pasta and home made Chapati and Naan. Although each hard wheat product is made by a system, a wide range of bakery and extruded products are based primarily on a flour and water dough mix, which exhibits similar characteristics during heating.

Desired functional properties may be imparted to wheat flour through various modifications. Modifications with chemicals have a legal status as "food additives". Exploiting interactions between wheat flour and hydrocolloids may provide an alternative especially in chemical modifications. It provides the synergistic interaction between the hydrocolloids and starch of wheat flour. The intensity of interactions is dependent on the kind of gum (4, 5).

Hydrocolloids are used in food products as thickeners, stabilizer, gelling agents and emulsifiers. They improve the texture of the products, increase water retention while enhancing lower energy value; they are often employed in low-calorie foods (6, 7). In food industries hydrocolloids exhibit some like controlling the functions pasting properties of foods, improving moisture retention and to maintenance of overall product quality during storage (8). Several studies have been reported to clarify the role and potential usefulness of hydrocolloids in controlling rheology and in modifying texture starch-based food products. These of include investigations addition of hydrocolloids which enhances or modifies the gelatinisation and retrogradation behaviour of starches and flours, improves the water holding capacity and freeze-thaw stability (9-13). The presence of hydrocolloids also influences melting, gelatinisation, fragmentation, and retrogradation processes (9, 14). These additions have shown to affect

^{*} **Correspondence to**: *Feroz Alam, Lecturer;* Department of Food Science & Technology, University of Karachi. Karachi, Pakistan; Tel.: +92 21 482 3115, Fax: +92 21 924 3206; E mail: ferozalam12@hotmail.com

rheological pasting properties, dough bread behaviour and staling (15).Gelatinisation of cereal starch dispersions in the presence of different hydrocolloid strongly influences the viscosity of the hot starch paste (9, 16). This behaviour has been explained in terms of complex formation between starch polymers (amylose and /or amylopectin) and hydrocolloids during pasting.

In the present study different hydrocolloids were added to hard wheat flour to investigate gelatinisation properties on heating and retrogradation behaviour during cooling. The objective was to get information on the role and potential usefulness of hydrocolloids in controlling rheology and in modifying texture of hard wheat food products. This study will be helpful in promoting the use of indigenous wheat flour.

MATERIALS AND METHODS

Wheat flour was purchased from local market of Karachi, Pakistan, while hydrocolloids (Xanthan, Carboxy Methyl Cellulose, Guar, Arabic and Carrageenan) were purchased from Sigma Chemical Company (St. Louis, MO, USA).

Flour Compositional Analysis

The compositional analysis of wheat flour was carried out. Flour protein content was determined by the Kjeldahl method using Kjeltec System (Tecator, Sweden), fat by Soxhelt method (17) using ether. Moisture content was measured using Infrared Moisture Tester (Precisa H A60, Switzerland).Crude fibre and ash contents were measured by approved methods of AOAC (17).

Amylography

The gelatinisation and retrogradation behaviour of wheat flour were studied using Micro Viscoamylograph (Brabender, Germany). Wheat flour 15.0 g was mixed with 0.8 g of selected hydrocolloid in 100 ml of distilled water. The mixture was heated from 30°C to 95°C with a constant heating rate of 1.5°C/min. and held at 95°C for 30 min. The paste was cooled to 50° C with the same rate and finally kept at 50°C for 10 min. The resulting behaviour was studied for the following parameters: gelatinisation temperature, peak viscosity, breakdown during heating, heating stability, set back during cooling and cooling stability. All measurements were carried out in triplicate.

RESULTS AND DISCUSSION

Rheological properties of wheat flour are significantly influenced by cultivation environment (18). In fact, the cultivar, environment and their interactions greatly change wheat composition. In the wheat flour tested, the nitrogen, carbohydrate, fat, crude fibre and ash contents were 2.1%, 72.5%, 1.3%, 0.5%, 0.6% respectively (**Table I**). These values were obtained on 13.3% moisture basis. High temperature climate in Pakistan results in higher wheat protein (% nitrogen x 5.7 = 12.0 %) content and make it hard wheat.

The gelatinisation and retrogradation behaviour of wheat flour upon adding different hydrocolloid using Micro Viscoamylograph are shown in **Figure 1**, and the results obtained are discussed below.

Gelatinisation Temperature

Gelatinisation temperatures of wheat flourgum systems are shown in Figure 2. It was observed that wheat flour gelatinisation temperature was greatly reduced when guar and xanthan were added. Considering that gums did not produce changes in gelatinisation temperature, this decrease in gelatinisation temperature can be attributed to interactions between wheat flour starch (mainly leached amylose) and gums as pointed out by Shi and BeMiller (5). CMC and tragacanth have little effects on the gelatinisation temperature. Tragacanth slightly increased the gelatinisation temperature of wheat flour while it was decreased to a little extent by CMC. No significant effect was observed on addition of gum Arabic. Farrero al. (19) related the variation in et gelatinisation temperature to the availability of water for amylopectin melting. Generally, greater water availability is followed by a lower gelatinisation temperature (20). It seems that xanthan and guar absorbed little amount of water as compared to other gums and more water was available for the starch which resulted in reduction of gelatinisation temperature. Low gelatinisation temperature provides greater availability of starch to amylolytic enzymes during baking process which is desirable in bread making.

Peak Viscosity

All the hydrocolloids affected the peak viscosity of the wheat flour suspension (**Figure 3**). Guar gum and xanthan significantly increased the peak viscosity up to 1471 and 1279 BU respectively. A negative

effect was observed for the gum Arabic which greatly reduced the peak viscosity up to 890 BU. Addition of tragacanth and CMC showed little effect on peak viscosity, while tragacanth decreased it slightly and CMC caused an increase. Thickening effect of hydrocolloids due to interactions between hydrocolloid and swollen starch particles or leached amylopectin (Tester and Morrison 1990) might be responsible for variation in peak viscosities. Greater effect would give a greater peak viscosity. Leaching of amylopectin can occur in the presence of bimodal (21) or polymodal (22) distribution pattern of chain length of amylopectin, which depends on the botanical source. Amylopectin with long exterior chains can behave in a similar way to amylose. Among the hydrocolloids tested, guar was found to be the most effective hydrocolloid in increasing the peak viscosity of the suspension. The difference in the structural compatibility with amylopectin with long exterior chains among the hydrocolloids, including linearity and smoothness of the molecules, may be the reason. As a matter of fact, starch paste is the suspension of swollen particles dispersed in macromolecules medium. It may be suggested that guar gum is located within the continuous medium and thus the volume of the phase accessible to guar is reduced, which causes an increase in its concentration in the continuous medium, resulting in high viscosity of suspensions.



Figure 1. Micro Viscoamylograph of (1) Wheat flour + *Guar gum. (2) Plane wheat flour (3) Wheat flour* + *Xanthan gum (4) Wheat flour* + *CMC (5) Wheat flour* + *Tragacanth gum (6) Wheat flour* + *Gum Arabic.*

Breakdown During Heating

Breakdown of wheat flour during heating is measured by taking the difference between the peak viscosity and the viscosity at the beginning of first holding period. Breakdown for guar, xanthan and CMC systems were significantly larger than that for the control (**Figure 4**). It is therefore evident that the wheat starch granules would become less resistant to thermal treatment (11). The morphological change of the starch involving a radial expansion of the granules to rapture will thus be induced by addition of hydrocolloid. Among the hydrocolloids tested, guar was the most effective in increasing the breakdown up to 709 BU as in the case of peak viscosity. This suggests that the dissociations between starch and hydrocolloid through the structural shrinkage of these polymers due to decrease in temperature are responsible for the increase in breakdown. Gums systems with high viscosity drop at 95°C and make the swollen granules more fragile, thus reducing the cooking time. Gum Arabic, on the other hand, greatly reduced the breakdown up to 189 BU due to tightening of the wheat starch granules which made it more heat resistant needing more cooking time. No significant difference was observed for the Tragacanth gum system.

Heating or Cooking Stability

During the first holding period the flour-gum paste was heated at 95° C for 30 min. The inverse of the difference in viscosity before and after this period gives heating or cooking stability of the mixture. The higher value is a reflection of greater heating stability. It was observed that addition of hydrocolloids alter the heating stability of wheat flour (Figure 5). The maximum stability was observed in the case of gum Arabic and xanthan gum while CMC, tragacanth and guar gums showed the destabilization of wheat flour during heating. The maximum destabilization was observed for CMC mixture, as it made the flour more susceptible to heating and disruption of starch molecules occurred to a great extent, thus ease in cooking is expected.

Setback

Setback is the difference between the viscosity at 50°C and the viscosity after the first holding period during cooling of starch paste. The addition of hydrocolloids produced changes in setback of starch molecules during cooling period (Figure 6). Although each gum caused reduction in the setback of wheat starch molecules to some extent but it was noted that xanthan gum reduced the setback greatly, measured down to (303 BU) as compared to control (482 BU). These results suggested that retrogradation of starch may be reduced at early stage of storage by addition of hydrocolloids. The retrogradation is attributed to the amylose chain diffusion outside the starch granules during cooling stage that caused the re-association of amylose chains. It seems that the interaction between the hydrocolloids and leached amylose control the re-association of amylose chains results the reduction in setback. The

Figure 2

setback of starch is responsible for the staling of bread and results showed that in bread making process xanthan gum may be used as the best anti-staling additive.

Cooling Stability

The inverse of difference in viscosity before and after the second holding period is related to cooling stability of wheat flour, where paste was held at 50°C for 10 min. The results showed that addition of hydrocolloids altered the cooling stability of wheat flour (**Figure 7**). Among the different hydrocolloid maximum stabilization was promoted by CMC, guar and xanthan gums while tragacanth and gum Arabic increased it. Higher cooling stability could be useful for the storage of wheat flour dough or paste.

CONCLUSIONS

Wheat flour composition especially protein content and its quality determine the gelatinisation properties which vary with cultivar and climatic conditions. These properties may be modified by adding different hydrocolloids to wheat flour. The results indicated that gelatinisation temperature, peak viscosity, break down during cooking, cooking stability, setback and cooling stability were greatly effected by the addition of guar, xanthan, CMC and Arabic gums while the addition of tragacanth showed negligible effect on gelatinisation properties of wheat flour. These results suggest that by addition hydrocolloid the of а the gelatinisation properties of wheat flour can be modified which will help in product development.





Figure 2. Effect of the hydrocolloid addition on the pasting temperature of wheat flour paste. Figure 3. Effect of addition of hydrocolloid on the maximum viscosity of wheat flour paste.



Figure 4

Figure 4. Effect of hydrocolloid addition on the cooking ease or break down of wheat flour paste. *Figure 5.* Effect of the hydrocolloid addition on the cooking or heat stability of the wheat flour paste.



Figure 6. Effect of the hydrocolloid addition on the setback or retrogradation of the wheat flour paste. Figure 7. Effect of the hydrocolloid addition on the cooling stability of the wheat flour paste.

REFERENCES

- 1. Anjum, F.M. and Walker, C.E., Grain, flour and bread-making properties of eight Pakistani hard white spring wheat cultivars grown at three different locations for 2 years. International Journal of Food Science and Technology, 35:407-416, 2000.
- 2. Peter, K., Effect of ascorbic acid in dough: Reaction of oxidized glutathione with reactive thiol groups of wheat

glutenin. Journal of Agriculture and Food Chemistry, 51:4954-4959, 2003.

- Eleni, C., Arnand, R. and Martin, L.M. Rheological properties of soft wheat flour dough: Effect of salt and triglycerides. Cereal Chemistry, 81(4):459-468, 2004.
- Eidam, D., Kulicke, W.-M., Kuhn, K. and Stute, R., Formation of maize starch gels selectivity regulated by the addition of hydrocolloids. Starch/Stärke, 47(10):378-384, 1995.

- 5. Shi, X. and BeMiller, J.N., Effects of food gums on viscosities of starch suspensions during pasting. Carbohydrate Polymers, 50:7-18, 2002.
- Dickinson, E., Hydrocolloids at interfaces and the influence on the properties of dispersed systems. Food Hydrocolloids, 17:25-39, 2003.
- Juszczak, L., Witczak, M., Fortuna, T. and Babachowicz, A., Effect of some hydrocolloids on the rheological properties of rye starch. International Journal of Food Science and Technology, 10(2):125-131, 2004.
- Takahiro, F., Yohei, K., Toshio, O., Yasunori, G., Iwao, A. and Katsuyoshi, N., Effect of non-ionic polysaccharides on the gelatinization and retrogradation behavior of wheat starch. Food Hydrocoll. 19, 1-13, 2005.
- 9. Fanta, G.F. and Christianson, D.D., Starch-hydrocolloid composites prepared by steam jet cooking. Food Hydrocolloids, 10:173-178. 1996.
- Yoshimura, M., Takaya, T. and Nishinari, K., Effects of xyloglucan on the gelatinization and retrogradation of corn starch as studied by rheology and differential scanning calorimetry. Food Hydrocolloids, 13:101-101, 1999.
- 11. Lee, M.H., Baek, M.H., Cha, D.S., Park, H.J. and Lim, S. T., Freeze-thaw stabilization of sweet potato starch gel by polysaccharide gums. Food Hydrocolloids, 16:345-352, 2002.
- 12. Ghodke S. and Ananthanarayan L., Influence of additives on rheological characteristics of whole-wheat dough and quality of Chapatti (Indian unleavened Flat bread) Part I—hydrocolloids. Food Hydrocolloids 21(1):110-117, 2007.
- Manuel G., Felicidad R., Pedro A. C., Carlos A. B. and Cristina M. R., Functionality of different hydrocolloids on the quality and shelf-life of yellow layer cakes. Food Hydrocolloids, 21(2):167-173, 2007.

- Collar, C., Andreu, P., Martinez, J.C. and Armero, E., Optimization of hydrocolloid addition to improve wheat bread dough functionality: a response surface methodology study. Food Hydrocolloids, 13:467-475, 1999.
- 15. Davidou, S., Le Meste, M., Debever, E. and Bekaert, D., A contribution to the study of staling of white bread: Effect of water and hydrocolloid. Food Hydrocolloids, 10:375-383, 1996.
- 16. Bahnassey, Y.A. and Breene, W.M., Rapid Visco-Analyzer (RVA) pasting profiles of wheat, corn, waxy corn, tapioca and amaranth starches (A. hypochondriacus and A. Cruentus) in the presence of konjac flour, gellen, guar, xanthan and locust beans gum. Starch/Stärke, 46:134-141, 1994.
- AOAC, Official methods of analysis of AOAC international. 17th ed., USA. 2000.
- Mikhaylenko, G.G., Czuchajowska, Z., Baik, B.K. and Kidwell, K.K., Environmental influence on flour composition, dough rheology and baking quality of spring wheat. Cereal Chemistry, 77(4):507-511, 2000.
- Farrero, C., Martino, M.N. and Zaritzky, N.E., Effect of hydrocolloids on starch thermal transitions, as measure by DSC. Journal of Thermal Analysis, 47:1247-1266, 1996.
- 20. White, R.J., Abbas, I.R., Johnson, L.A., Freeze-thaw stability and refrigeratedstorage retrogradation of starches. Starch/Stärke, 41:176-180, 1989.
- 21. Kalichevsky, M.T., Orford, P.D. and Ring, S.G., The retrogradation and gelation of amylopectins from various botanical sources. Carbohydrate Research, 198:49-55, 1990.
- 22. Hizukuri, S., Polymodal distribution of the chain length of amylopectin and its significance. Carbohydrate Research, 147:342-347, 1986.