

Research Article

Effects of selected food gums on wheat flour or dough properties

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Abstract

Effects of selected food gums on wheat flour pasting and dough behaviour were studied. Gums such as sodium alginate (Alg), carboxymethylcellulose (CMC), locust bean gum (LBG), psyllium husk (Psy) and konjac glucomannan (KGM) were added into wheat flour at levels of 0.2% and 0.8% w/w (wheat flour basis). Pasting properties were determined using Rapid Visco Analyser. The results revealed that incorporation of anionic gums (Alg, CMC) especially at 0.8% addition level resulted in higher pasting temperature and lower peak viscosity, trough, breakdown, final viscosity and setback values as compared to the control. A reverse effect was shown by non-ionic gums (LBG, Psy, KGM). Mixing properties of the dough was assessed with a farinograph. Water absorption was found to decrease when 0.2% gum was added whereas increase upon addition of 0.8% gum. Opposite trend was shown in dough stability and time to breakdown. In general, dough development time was increased with addition of gums. Dough handling characteristics were studied using extensograph. It was shown that maximum resistance of dough increased with a longer resting period. Alg added sample was found to show a higher maximum resistance than the control while CMC and KGM seem to contribute higher dough extensibility. In conclusion, gums addition appeared to improve wheat dough characteristics to varying degrees which may be attributed to their different chemical structures.

Keywords: Dough, gums, pasting, farinograph, extensograph, Malaysia

Introduction

Wheat is a good source of energy for human consumption in the world and it provides more than 60% calories of the total dietary requirement [1]. It can be transformed into a diverse product range such as bread, buns, noodles, biscuits, cakes and others. Hence, understanding changes in wheat dough quality with respect to variation in variety [2,3], wheat flour blending

[4-6], baking ingredients [1, 7-11], flour constituent [12, 13] is essential. This is to facilitate product development and enhancement, knowing that different product has different requirements and characteristics [14].

Wheat dough is a viscoelastic material which exhibits an intermediate rheological behaviour between a viscous liquid and elastic solid [15]. This viscoelastic material is probably the most dynamic and complicated rheological system and its properties are correlated with proofing time of dough, loaf volume and quality attributes of final product [16].

There is an increasing interest for the application of food gums as additives in baking industry to confer various functionalities [17, 18]. The incorporation of hydrocolloids into flours mixture has the potential to improve texture characteristics and freeze-thaw stability besides serves as anti-staling agent [19, 20]. Food gums are widely used in baking industry to improve water holding capacity, to modify product's texture, volume, cell structure, and to maintain the product quality during storage [1].

This research is devised to study the effect of certain selected food gums on the wheat flour pasting properties and the rheological properties in terms of farinography and extensography of the dough made from wheat flour supplemented with food gums.

Materials and Methods

Materials and flour preparations

Wheat flour was obtained from SIM Company Sdn. Bhd. (Penang, Malaysia). Konjac glucomannan (KGM) was purchased from Hung Thong Food Technology Sdn. Bhd. (Penang, Malaysia). Psyllium husk (*Plantago ovata*) (Natural Psyllium Husk, 99.29 % purity) was provided by Country Farms Sdn. Bhd. (Selangor, Malaysia). Alginic acid Sodium salt from brown algae (Fluka, United Kingdom), Carboxymethylcellulose Sodium salt (Fluka, Switzerland), and Locust bean gum from *Ceratonia siliqua* seeds (Sigma-Aldrich, Morocco) were procured from Sigma-Aldrich (M) Sdn. Bhd. (Selangor, Malaysia). Food gums were added into wheat flour at levels of 0.2% and 0.8% w/w (wheat flour basis). Wheat flour alone without any food gums incorporated was designated as control.

Pasting properties analysis

A Rapid Visco Analyser (Model RVA Series 4, Newport Scientific Pty. Ltd, Warriewood, Australia) was used to determine the pasting properties of wheat flour with or without addition of gums according to Approved Method 76-21 [21].

The samples were tested according to Standard Profile 1 where the dispersions were first held at 50 °C for 1 min, heated from 50 °C to 95 °C at a constant rate of 12 °C/min and then held at 95 °C for 2.5 min before cooled to 50 °C at the same stirring rate and lastly held at 50 °C for 2 min. Agitation speed was fixed at 960 rpm for the first 10 s in order to ensure thorough dispersion. After that, agitation speed was maintained at 160 rpm throughout the rest of the measurement.

Dough mixing properties determination

Farinograph test was carried out by mixing 300 g of flour (14 % moisture basis) using a Brabender farinograph with a 300-g bowl (Brabender OHG, Duisberg, Germany) according to Approved Method 54-21 [21].

Mechanical resistance properties measurement

Extensograph test was performed followed the procedure in Approved Method 54-10 [21]. After 45 min and 135 min of rest time, the dough was stretched until rupture by extensograph.

Statistical analysis

Where necessary, differences between treatment means were determined using the Duncan test ($P < 0.05$) by SPSS software for Windows Release 15.0 (SPSS Inc., Chicago, Illinois, USA).

Results and Discussion

Effects of food gums addition on the pasting properties of wheat flour

Figure 1 shows the pasting properties of wheat flour suspension with or without addition of food gums. The pasting temperature was found to decrease with addition of PSY, LBG or KGM, but increase when ALG or CMC was added at 0.8% (wheat flour basis). Insignificant difference was evident at 0.2% addition level. This may be caused by the fact that these gelling agents could swell much more easily than starch and resulting in an increase in viscosity. In other words, this earlier detection of increase in viscosity is caused by the non-ionic gums thickening rather than starch granule swelling. Christianson et al. (1981) stated that the early onset of initial viscosity is due to detection of the first stage of swelling and is dependent on media viscosity rather than starch granules swelling [22]. As for ALG or CMC added samples, swelling of starch granule is delayed. One plausible explanation for this observation is that the ionic gums (ALG and CMC) were adhering on the starch granules and the net negative charge prevails on the surface has prohibited water molecules from reaching starch granules. Hence, a relatively higher temperature is required to swell the starch granules. According to Mira et al. (2005), restricted or delayed swelling and amylose leaching would lead to higher pasting temperatures, while lower pasting temperatures would result from the opposite effect [23].

Peak viscosity was shown to be higher with PSY, LBG or KGM addition, but lower with ALG or CMC addition. Peak viscosity denotes the maximum swelling capacity of starch granules. From the results obtained, it is clearly shown that with the presence of PSY, LBG or KGM, starch granules can swell to a higher capacity as compared with the control and this was not reached when ALG and CMC was present.

Generally, ionic gums (ALG and CMC) were found to lower trough, breakdown and setback values of the wheat flour suspension, whereas non-ionic gums (PSY, LBG and KGM) showed higher trough, breakdown and setback values. As for final viscosity, lowest values were shown by samples added with ALG and CMC. This could be a good sign that molecules rearrangement or interaction was interrupted with the presence of ALG and CMC.

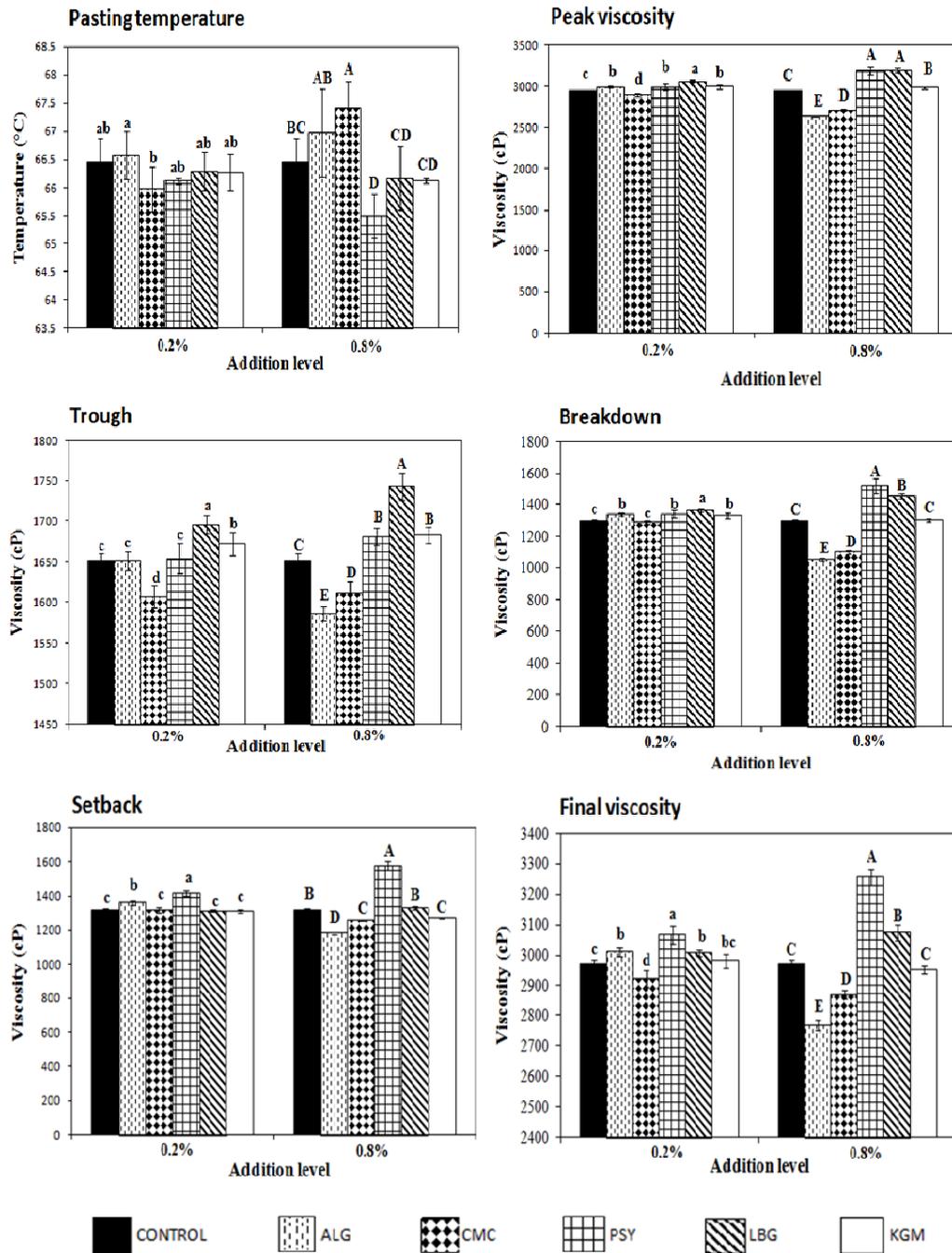


Figure 1. Pasting parameters of wheat flour suspension with or without food gums incorporated. The error bar represents \pm standard deviation ($n=3$). Bars within a specific addition level followed by the same letter (lower or upper case) are not significantly different at 95% confidence interval.

Effects of food gums addition on the mixing properties of wheat flour dough

Mixing properties of the dough studied are tabulated in Table 1. As evident, dough containing 0.2% of gums (ALG, CMC, PSY, LBG, KGM) decreased water absorption by 0.7 – 3.5% as compared with the control sample. The reverse was true for 0.8% addition. To explain this, one would have to understand that water absorption is the measurement defined as the amount of water required to center the farinogram curve on 500-FU line for flour-water dough. When water is added and mixed with wheat flour, the water-soluble and water-insoluble wheat proteins will hydrate and form gluten with starch and other components embedded [24]. Hence, gluten formation is vital in conferring a strong skeleton of wheat flour dough. So, as the water absorption decreases with lower level of gums addition, one may deduce that low level of gums may interact with wheat proteins and help in developing a better gluten network. However, as the gums level increases, gums will compete with wheat proteins for water due to its high hygroscopicity. Hence, relatively more water is needed for wheat proteins hydration.

For dough development time, it is noted that a longer mixing time is required when gum was added, however the mixing time was found to decrease with higher level of addition. An anomaly was seen in KGM sample, where a decrease in dough development time was recorded at both level of addition. According to Sharadanant and Khan (2003), a lower dough development time is desirable to make frozen dough because it allows shorter yeast fermentation time [25].

As can be seen in Table 1, dough added with 0.2% gums are generally shows higher tolerance to mixing over the 0.8% counterpart, for all gum types. It is found that addition of ALG, CMC, PSY and LBG at 0.2% enhances the dough mixing tolerance as compared to the control. This was not shown in 0.8% samples. A similar trend was shown in time to breakdown. These observations are in line with the water absorption results, in which gums at low level of addition was believed to strengthen the gluten network.

As for KGM, relatively lower stability and time to breakdown values were recorded. This could be attributed to the fact that insufficient time was given for the formation of optimally developed gluten, as the captured short dough development time could be an erratic mistake happened due to KGM showing high thickening effect.

Table 1. Mixing properties of wheat flour with or without addition of food gums.

	Addition Level*	
	0.20%	0.80%
Water absorption (%)		
CONTROL	61.3 ± 0.265 a	61.3 ± 0.265 F
ALG	58.5 ± 0.058 c	68.4 ± 0.361 A
CMC	60.6 ± 0.208 b	62.5 ± 0.100 E
PSY	58.5 ± 0.208 c	66.3 ± 0.153 C
LBG	57.8 ± 0.100 d	64.5 ± 0.100 D
KGM	60.8 ± 0.058 b	67.2 ± 0.252 B
Dough development time (min)		
CONTROL	9.5 ± 0.624 c	9.5 ± 0.624 B
ALG	12.3 ± 0.954 a	11.6 ± 0.115 A
CMC	10.5 ± 0.289 b	10.0 ± 0.265 B
PSY	11.6 ± 0.551 a	9.8 ± 0.907 B
LBG	11.6 ± 0.173 a	9.6 ± 0.265 B
KGM	7.6 ± 0.513 d	7.0 ± 0.874 C
Dough stability (min)		
CONTROL	24.2 ± 0.321 c	24.2 ± 0.321 A
ALG	32.8 ± 0.379 a	10.2 ± 0.153 E
CMC	27.9 ± 0.608 b	13.3 ± 0.416 D
PSY	31.2 ± 1.662 a	20.3 ± 0.608 B
LBG	28.5 ± 2.122 b	15.4 ± 0.896 C
KGM	13.1 ± 0.115 d	9.8 ± 0.000 E
Time to breakdown (min)		
CONTROL	31.9 ± 0.850 c	31.9 ± 0.850 A
ALG	44.9 ± 2.152 a	20.1 ± 0.656 C
CMC	38.3 ± 0.737 b	20.3 ± 0.306 C
PSY	38.0 ± 2.458 b	25.9 ± 1.277 B
LBG	37.3 ± 1.069 b	19.4 ± 0.656 C
KGM	14.3 ± 0.624 d	11.8 ± 0.265 D

* Mean ± standard deviation (n=3). Values followed by the same letter (upper or lower case) within the same row and columns are not significantly different at 95% confidence interval.

Effects of food gums addition on the mechanical resistance of wheat flour dough

Figure 2 and Figure 3 display maximum resistance and extensibility of the dough samples studied. Generally, it is noticed that maximum resistance and extensibility was increased and decrease with higher resting time, respectively. This indicates that as the dough is rest, a cohesive gluten network was developed through inter- and intra-molecular bonding, which render the dough stronger and less stretchable.

When comparing the level of addition, the results show that increase the gum level had a marginal effect, wherein an increase in maximum resistance and decrease in extensibility was evident with higher gum level. Among all the gums used, addition of ALG, PSY and LBG at 0.8% was found to increase maximum resistance and decrease extensibility, whereas the reverse effect was shown by CMC and KGM. Irregular trend for dough added with different food gums was observed. This might be ascribed to the different chemical structures of food gums.

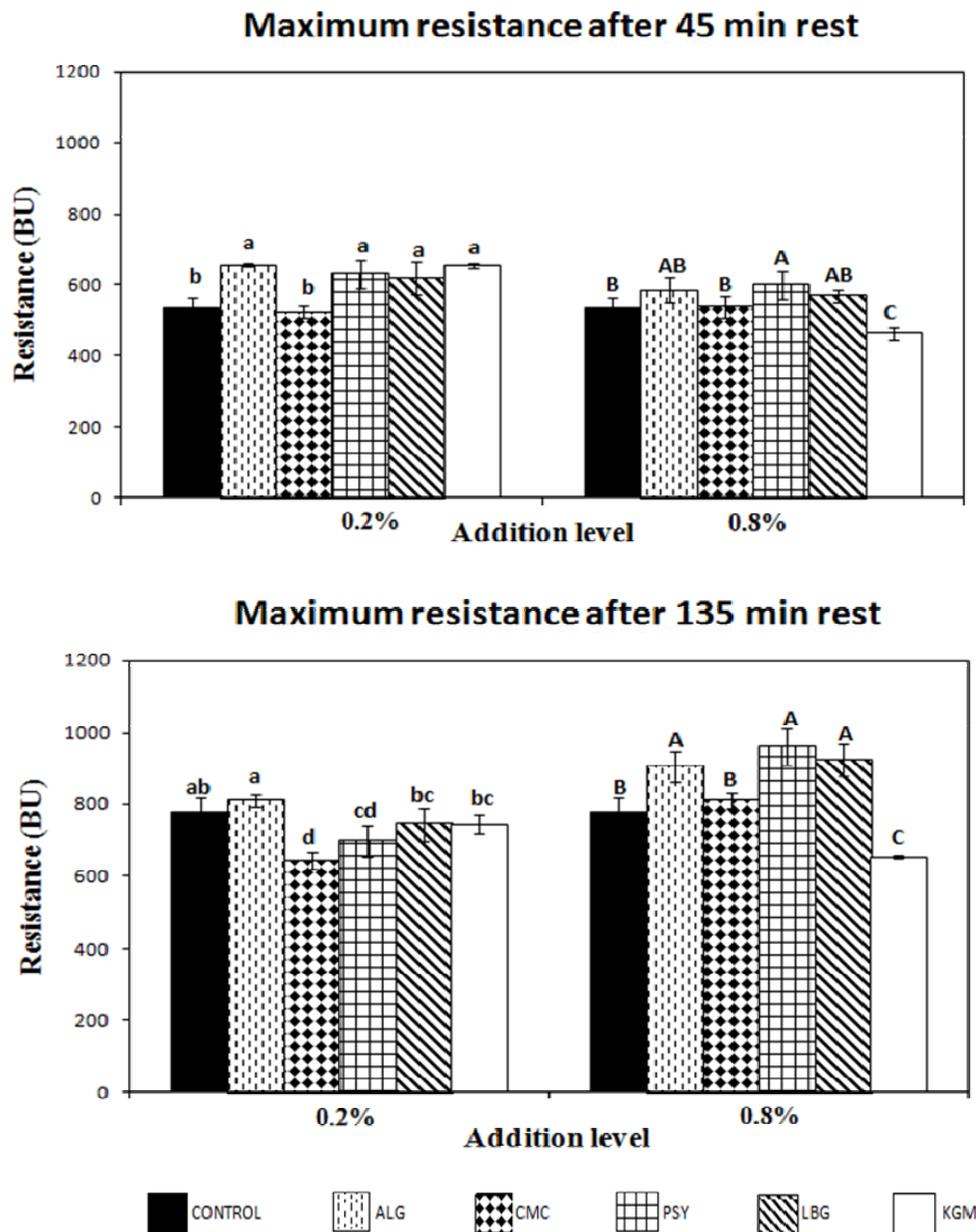


Figure 2. Maximum resistance of dough during stretching after 45 min and 135 min rest. The error bar represents \pm standard deviation (n=3). Bars followed by the same letter (upper or lower case) are not significantly different at 95% confidence interval.

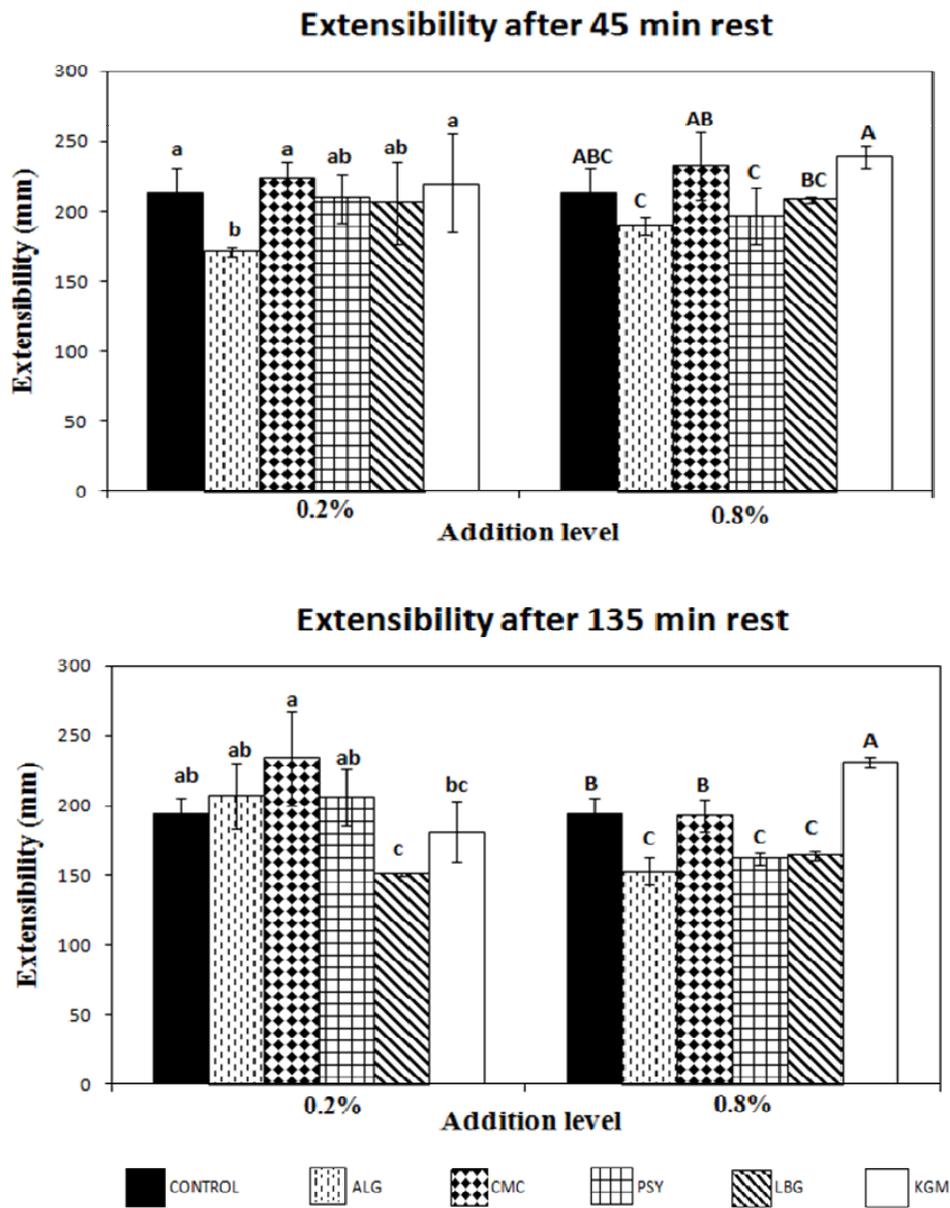


Figure 3. Extensibility of dough during stretching after 45 min and 135 min rest. The error bar represents \pm standard deviation ($n=3$). Bars followed by the same letter (upper or lower case) are not significantly different at 95% confidence interval.

Conclusions

Pasting and rheological properties of wheat flour suspension and dough are influenced to different extent by the type and amount of gums added. This can be manipulated for further product development purposes.

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