

Corn-Wheat Pan Bread Quality as Affected by Hydrocolloids

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Abstract: The study was carried out to use hydrocolloids for improving quality of corn-wheat pan bread. The use of composite flour for bread making is gradually gaining prominence world wide due to some economic and nutritional reasons. However, the wheat-corn bread is suffering from many technological problems. This study examines the functional role of gum arabic and pectin on dough properties and pan bread from corn wheat flour. Addition of gum arabic or pectin was 1, 2 and 3% levels to wheat-corn flour mixture (80:20). Rheological properties of dough, baking quality and organoleptic properties of bread were investigated. Bread was stored at room temperature for 5 days and staling rate was also studied. Results showed that wheat-corn flour had lesser water absorption, dough stability, extensibility, resistance to extension and dough energy than wheat flour dough. However, addition of gum arabic or pectin to wheat-corn flour dough caused a noticeable increase in the above parameters and yielding strengthened doughs. Loaf volume, specific loaf volume and crumb moisture were improved upon the addition of gum arabic or pectin. Both two hydrocolloids made bread more fresh than the control. Pectin addition caused higher values of alkaline water retention capacity than gum arabic. It was found that gum arabic or pectin could be effectively used to improve dough handling, baking quality, sensory acceptability and retarded staling of corn-wheat bread up to 2 and 3%, respectively. [Journal of American Science 2010;6(10):721-727]. (ISSN: 1545-1003).

Key words: gum arabic, pectin, corn flour, wheat flour, pan bread quality

1. Introduction:

In Egypt, the total yield of wheat grain does not satisfy the needs of the population. The total production of wheat grains covers only about 55% of the total needs. The way to overcome this problem is to search for the native cereal sources which could be used with wheat flour bread making. Recently, the Egyptian Government replaced wheat flour using corn flour up to 20% as economically view. Meanwhile, the blended bread is suffering from many technical problems and fast staling characteristics. Consequently, loss of bread which led to negative economically trend.

Hydrocolloids have specifically found a wide application as additives in bread and baked products. The functional effects of hydrocolloids stem from their ability to modify dough or batter rheology (or handling) and keeping qualities of finished baked products. They are often used as gluten substitutes in gluten-free breads (Toufeili *et al.*, (1994). Carboxy methyl cellulose (CMC), guar gum and xanthan gum have been added to rye bread and cassava-bread recipes to improve their quality and extending the shelf- life (Mettler and Seible, 1993 and Shittu *et al.*, 2009). Hydroxyl propyl methyl cellulose (HPMC) and apple pectin have been used as improvers and anti-staling agents in wheat bread, yielding higher specific volume, softer crumb and enhanced sensory characteristics (Collar *et al.*, 1999; Rosell *et al.*, 2001 and Yaseen *et al.*, 2001). On the other hand, Kegoya-Yoshino (1997) reported that

pectin can be effectively used to improve the shelf-life of bread.

Although, it has been shown in previous studies that substitution of wheat flour up to 20% level is possible to give acceptable composite bread loaf (Gujral *et al.*, 2003; Hsu *et al.*, 2004 and Khalil *et al.*, 2000), generally increasing substitution of wheat with other flours progressively reduced the quality of bread. This has been attributed to reduced flour strength and gas retention capacity due to reducing gluten content, thereby reducing bread volume and the sensory appeal of most baked composite bread (Shittu *et al.*, 2009).

Thus, the present study was designed to investigate improving quality of pan bread of composite flour 80:20%, (wheat-corn flour) , respectively through using hydrocolloids (pectin and gum arabic). The study included the evaluation of rheological properties, baking tests and staling of composite bread as affected by hydrocolloids.

2. Materials and Methods:

Materials:

Wheat flour (72% extraction) and corn flour (97% extraction) were obtained from South Cairo Mill Company, Giza, Egypt. Pectin and gum arabic were purchased from Sigma Company, Germany. Other ingredients such as salt (sodium chloride), shortening, sugar, bread improver and active dry yeast (*Saccharomyces cerevisiae*) were purchased from local market.

Methods:

Preparation of flour blends

Wheat flour 72% extraction was well blended with corn flour 97% extraction to produce mixture containing 80% wheat flour and 20% corn flour. Hydrocolloids (pectin and gum arabic) were added to corn-wheat mixture at 1, 2 and 3% levels. All samples were stored in airtight containers and kept at 5-7°C until required.

Rheological properties

Rheological properties of doughs were evaluated using farinograph and extensograph according to AACC methods No. 54 -10 and 54 – 21 (1983), respectively.

Preparation of pan bread

Pan bread was prepared as follow: yeast (1%) was dissolved in warm water (35°C) then added to the dry ingredients (2% NaCl, 1% sugar, 1% bread improver and 100g wheat-corn flour and shortening (2%), then the mixture was kneaded. The dough was fermented at 30 °C and 80-85% relative humidity for 45 min in a fermentation cabinet, then the dough was divided into 150g pieces and placed in the pan and proofed under the same conditions for 45 min. Bread dough loaves were baked at 230 °C for 20–25 min following steaming for 10s. Baked loaves were cooled down at room temperature for 60 min and packed.

Physical evaluation of bread

Volumes of cold loaves were measured by rape seed displacement method. Specific volumes were calculated from loaf volume and loaf weight taken after 1h of baking.

Sensory evaluation of bread

Sensory evaluation of bread was performed by 10 trained panelists as described by Kulp *et al.* (1985) for symmetry of shape (5), crust color (10), break & shred (10), crumb texture (15), crumb color (10), aroma (20), taste (20) and mouthfeel (10).

Freshness of bread

The freshness of bread samples was tested at 1,3 and 5 days of storage at room temperature by alkaline water retention capacity (AWRC) according to method of Yamazaki (1953), as modified by Kitterman and Rubenthaler (1971).

Chemical analysis

Moisture, ash, crude protein, fat and crude fiber contents were determined according to AOAC methods 14.004, 14.006, 2.057, 14.018 and 7.065 (2000), respectively. Carbohydrates were calculated by difference.

Statistical analysis

The obtained results were statistically analyzed by analysis of variance (ANOVA) and least significant difference (LSD) was calculated according to McClave and Benson (1991).

3. Results and Discussion:

Chemical composition of wheat and corn flour

Chemical composition of wheat and corn flour is given in Table (1). Corn flour has higher content of fat, crude fiber and ash and lower content of protein and carbohydrate than that of wheat flour. These values agreed with those reported by Khorshid *et al.*, (1996). They found that the total protein, fat, ash, crude fiber and starch of corn flour were 9.17, 4.32, 2.36, 2.27 and 70.75%, respectively.

Table (1): Chemical composition of wheat and corn flours (%on dry weight basis)*

Sample	Moisture	Protein	Fat	Fiber	Ash	CHO**
Wheat flour (72%)	12.9±0.40	11.9±0.04	1.7±0.08	0.7±0.07	0.6±0.121	85.1±0.70
Corn flour (97%)	12.5±0.18	9.8±0.08	4.5±0.24	2.1±0.12	2.3±0.10	81.3±0.72

*values are the average of three determinations.

**Total carbohydrates was calculated by differences.

Rheological properties of dough

The effect of replacing wheat flour with corn flour at 20% level and hydrocolloids at 1, 2 and 3% levels on the farinograph test is presented in Table (2). The water absorption of wheat flour doughs was 68.5% and decreased by the addition of corn flour to 66.5%. This reduction in water absorption could be attributed to the ability of wheat starch to absorb water (2.47 times) more than corn starch (2.40 times)

(Whistler *et al.*, 1984). Also, because of the significant positive correlation between water absorption and protein content. The higher protein content of flour, the higher of water absorption obtained as shown in table (1).

Data in the same table showed that water absorption of wheat-corn flour dough increased from 66.5 to 70.0% for all treatments by adding gum arabic or pectin. However, flour-pectin showed

higher capacity or water absorption compared to flour-gum arabic. Dough development time of wheat and corn flour blends increased from 2 min to 4.5 min, this increase might be due to higher gluten content in wheat flour than the sample of corn flour. Moreover, dough stability was decreased and dough weakening was increased by adding corn flour, which could be attributed to the reduction in protein content, consequently, gluten in the blend. Also, the protein in corn flour contains zein instead of gliadin in wheat flour, which has much lower molecular weight (about 20.000) compared to wheat gliadin (30.000-40.000). This indicates the reduction in the total

gliadin of the blend and hence the formed gluten and its network.

With respect to the effect of hydrocolloids on dough stability and wakening the results in Table (2) revealed that, stability of the dough increased and dough weakening decreased with increasing the level of addition of gum arabic or pectin. These results indicated that dough, which contained hydrocolloids exhibited higher tolerance index to over mixing. This advantage is preferred on industrial scale. This result supported by the data obtained by Rosell *et al.*, (2001).

Table (2): Effect of corn flour and hydrocolloids on farinograph parameters.

Sample	Water absorption (%)	Arrival time (min)	Dough development time (min)	Dough stability (min)	Mixing tolerance index (BU)	Dough weakening (BU)
Control (100% WF)	68.5	2.0	1.5	8.5	20	170
80% WF + 20% CF	66.5	4.5	5.0	5.0	65	210
Gum Arabic (%)						
1	66.5	4.0	4.5	5.5	70	160
2	67.0	3.0	3.0	6.5	30	150
3	67.4	3.0	7.5	7.5	60	160
Pectin (%)						
1	67.0	3.0	2.5	5.0	40	160
2	68.5	2.5	2.0	5.0	30	150
3	70.0	2.0	2.5	6.0	30	155

WF = wheat flour

CF = corn flour

The results in Table (3) indicate that there are remarkable differences between the wheat and wheat-corn flour in all extensogram parameters. Wheat corn flour has less extensibility, resistance to extension and energy than wheat flour dough. This decrement may be due to the deficiency of gliadin and glutenin in corn protein. These results are in

agreement with the findings of Mohy El-Din (2004). However, addition of hydrocolloids e.g. gum arabic or pectin to wheat-corn flour dough caused a noticeable increase in extensibility, resistant to extension and dough energy. Such findings were also observed by Lazaridou *et al.*, (2007) and Shittu *et al.*, (2009).

Table (3): Effect of corn flour and hydrocolloids on extensograph parameters.

Sample	Extensibility (E) (mm)	Resistance to extension (R) (BU)	Proportional number (R/E)	Dough energy (cm ²)
Control (100% WF)	90	270	3.0	70
80% WF + 20% CF	60	200	3.3	50
Gum Arabic (%)				
1	80	230	2.88	60
2	85	250	2.94	65
3	90	260	2.89	65
Pectin (%)				
1	80	240	2.80	60
2	80	260	2.89	68
3	70	260	2.89	68

WF = wheat flour

CF = corn flour

Baking quality and moisture content of pan bread

Data presented in Table (4) show the results of baking quality and moisture content of bread. For control bread, loaf volume and specific volume were 388 cc and 2.9, while 20% addition of corn flour caused 25 and 28% reduction of these parameters, respectively. The reduction of volume was due to the dilution of gluten as a result of adding corn flour to wheat flour. Meanwhile, the bread sample treated with corn flour showed approximately no differences in loaf weight, when compared with control sample.

Loaf volume and specific volume were improved upon the addition of gum arabic and pectin. For instance, when 3% pectin or gum arabic were mixed with wheat-corn flour dough, the improvement of loaf volume and specific volume reached 27 and 29%, 25 and 24%, respectively. The previous changes could be explained by the pectin and gum arabic appeared to act by improving gas-cell stability of gluten. This result supported by Hsu *et al.* (2004) and Shittu *et al.* (2009).

Table (4): Effect of corn flour and hydrocolloids on baking quality and moisture content of bread crumb.

Sample	Weight (g)	Volume (cc)	Specific volume (cc/g)	Crumb moisture (%)
Control (100% WF)	135±0.76	388±9.61	2.9±0.13	35.20±0.57
80% WF + 20% CF	135±1.76	290±10.41	2.1±0.19	34.00±0.76
Gum Arabic (%)				
1	136±0.76	332±4.51	2.4±0.16	36.10±0.55
2	136±1.0	347±6.66	2.6±0.18	35.40±0.46
3	137±0.50	362±5.13	2.6±0.14	37.60±0.74
Pectin (%)				
1	136±0.50	337±4.58	2.5±0.11	36.30±0.50
2	137±0.76	358±6.66	2.6±0.15	37.40±0.65
3	138±0.50	369±6.81	2.7±0.16	38.50±0.60

WF = wheat flour

CF = corn flour

Results in Table (4) shows that the moisture content of loaves varied between samples. After baking, the moisture content of fresh bread was 35.0% for what flour bread and 34.0% for wheat-corn bread. The reduction was 3.4% when wheat flour was replaced up to 20%. Meanwhile, the bread samples treated with gum arabic or pectin showed improvement in loaf moisture, when compared with wheat-corn bread. For instance, when 3% gum arabic or pectin were mixed with wheat-corn flour dough, the improvement in loaf moisture reached 11 and 13%, respectively. This is partially due to the higher amount of water required for bread preparation in the case of hydrocolloids, either gum arabic or pectin. Hydrocolloids, commonly can bind as much as 100 times of their weight from water (Ward, 1997).

Sensory evaluation of bread

The mean scores from the sensory evaluation test of the bread samples are shown in Table (5). As seen in this table, corn-wheat bread was significantly rated lower scores than the control bread in all sensory characteristics. These results agreed with those reported by Mohy El-Din (2004). Seleem

(2000) found that addition of corn meals at 5 and 10% to wheat flour gave an average mean values for the organoleptic characteristics of the bread loaves almost as those from wheat flour doughs. Moreover the mean values were significantly affected by corn varieties at 5 and 10%.

It is clear that adding gum arabic or pectin improved the organoleptic properties of pan bread. At 2% of gum arabic or pectin all sensory characteristics were superior to the corn-wheat bread. Shittu *et al.* (2009) reported that inclusion of xanthan gum had significant effects on the dough consistency and sensory acceptability of fresh composite bread. The oven spring, specific volumes of bread loaf and crumb softness were higher when 1% xanthan was added. As the concentration increased, the surface roughness and dryness of bread increased. The crispiness of bread crust has been explained in terms of the amount of water available, extent of starch gelatinization and protein modification during baking as well as the water activity of the baked product (Primo-Martin *et al.*, 2006).

Table (5): Effect of hydrocolloids on the sensory properties of composite corn-wheat bread.

Sample	Sym-metry of Shape (5)	Crust color (10)	Break & shred (10)	Crumb texture (15)	Crumb color (10)	Aroma (20)	Taste (20)	Mouth feel (10)
Control (100% WF)	4.5 ^a	8.7 ^a	8.7 ^a	13.8 ^a	8.9 ^a	18.2 ^a	18.2 ^a	8.5 ^a
80% WF + 20% CF	3.5 ^b	6.5 ^c	6.7 ^d	10.3 ^c	7.1 ^c	14.8 ^c	14.0 ^d	6.5 ^c
Gum Arabic (%)								
1	3.9 ^{ab}	7.5 ^{abc}	7.3 ^{cd}	10.7 ^c	7.2 ^{bc}	15.0 ^{bc}	14.4 ^{cd}	7.0 ^{bc}
2	4.0 ^{ab}	7.5 ^{abc}	8.1 ^{abc}	12.8 ^{ab}	8.0 ^{abc}	16.5 ^{abc}	16.8 ^{ab}	7.7 ^{ab}
3	4.2 ^{ab}	8.5 ^{ab}	8.5 ^{ab}	13.1 ^{ab}	8.5 ^a	17.1 ^{abc}	17.3 ^{ab}	8.3 ^a
Pectin (%)								
1	3.7 ^{ab}	6.9 ^{bc}	7.5 ^{bcd}	11.7 ^{bc}	7.8 ^{abc}	16.2 ^{abc}	15.5 ^{bcd}	7.1 ^{bc}
2	3.9 ^{ab}	7.7 ^{abc}	8.0 ^{abc}	12.11 ^{abc}	8.4 ^{ab}	16.4 ^{abc}	16.3 ^{abc}	7.7 ^{ab}
3	4.2 ^{ab}	8.3 ^{ab}	8.5 ^{ab}	13.3 ^{ab}	8.5 ^a	17.3 ^{ab}	17.3 ^{ab}	8.4 ^a
LSD	0.942	1.577	1.014	1.782	1.283	2.440	1.890	0.997

WF = wheat flour

CF = corn flour

Staling rate of bread

Alkaline water retention capacity (AWRC) is a simple and quick test to follow staling of bread. Higher values of AWRC mean higher freshness of bread. The changes occurring in freshness characteristics of pan bread at zero time and after 1.3 and 5 days of storage at room temperature are shown in Table (6). It can be observed that wheat bread was more fresh than wheat-corn bread (20% corn flour) under the same conditions, consequently, the staling rate was increased for the later. This means that wheat-corn bread staled faster than the wheat bread sample. This might be due to the loss of moisture content in the former than the later. Similar findings were observed by Seleem (2000), who found that adding 20% corn flour decreased freshness to 24.37, 26.09 and 27.92% after 24, 48 and 72 hrs, respectively.

Data in the same table show that, gum arabic or pectin made bread more fresh than the wheat-corn bread. Pectin caused higher values of AWRC than gum arabic. The freshness reductions were 11.97, 19.01 and 27.82% for 3% pectin at 1,3 and 5 days, respectively. At the same level of gum arabic these values reached 12.27, 20.97 and 30.14% being 16.98, 35.85 and 66.04% for wheat-corn bread. These results confirmed the data presented by Yaseen *et al.* (2001) and Guarda *et al.* (2004). Also, the results of Shittu *et al.* (2009) could explain the above-mentioned values. They stated that moisture loss and crumb firming during bread storage were less reduced when 1% xanthan gum was added to bread formulations. According to Davidou *et al.* (1996), the softening effect of bread was attributed to the increasing hindrance of gluten-starch interactions in the presence of hydrocolloids molecules.

Table (6): Freshness properties of stored pan bread.

Sample	Alkaline water retention capacity (%)				Loss of freshness (%)		
	0 day	1 day	3 day	5 day	1 day	3 day	5 day
Control (100% WF)	296	268	220	140	9.46	25.68	52.10
80% WF + 20% CF	265	220	170	90	16.98	35.83	66.04
Gum Arabic (%)							
1	373	240	200	120	12.10	26.74	56.04
2	280	248	206	125	11.43	26.43	55.36
3	282	246	210	130	12.77	25.53	53.90
Pectin (%)							
1	276	244	205	130	11.59	25.72	52.90
2	281	255	212	140	9.25	23.49	50.17
3	284	250	225	142	11.97	20.77	50.00

WF = wheat flour

CF = corn flour

Chemical composition of bread

Data presented in Table (7) show gross chemical composition of corn-wheat bread in comparison with the wheat bread. Corn-wheat bread was lower in protein and carbohydrates and higher in

fat content than wheat bread. Addition of gum arabic or pectin to corn-wheat bread did not appreciably change the chemical composition of bread samples except the carbohydrate content.

Table (7): Chemical composition of pan bread (% on dry weight basis).

Sample	Protein	Fat	Ash	Fiber	CHO
Control (100% WF)	12.20±0.35	3.2±0.30	1.3±0.05	1.2±0.09	82.1±0.79
80% WF + 20% CF	11.82±0.17	3.7±0.29	1.6±0.05	1.5±0.11	81.4±0.62
Gum Arabic (%)					
1	11.85±0.40	3.7±0.36	1.6±0.10	1.5±0.08	81.4±0.94
2	11.90±0.31	3.8±0.30	1.7±0.11	1.5±0.11	81.1±0.83
3	11.95±0.23	3.8±0.46	1.8±0.06	1.7±0.16	80.8±0.91
Pectin (%)					
1	11.92±0.20	3.7±0.31	1.6±0.07	1.6±0.08	81.1±0.66
2	11.96±0.33	3.8±0.21	1.6±0.7	1.6±0.09	80.9±0.72
3	12.00±0.34	3.9±0.40	1.8±0.17	1.8±0.10	80.5±0.97

WF = wheat flour

CF = corn flour

CHO = Carbohydrate

4. Conclusion:

On the basis of this study, addition of gum arabic or pectin to wheat-corn bread improved volume and specific volume, enhanced sensory characteristics and retarded staling of bread. The best levels of gum arabic and pectin were 2 and 3%, respectively.

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