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# Impact of Pullulan and/or Four Hydrocolloids Incorporation on Rheological Properties and Shelf Life Stability of Wheat-Soy Baladi Bread

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**Key words:** Baladi bread, soy flour, hydrocolloids, rheological properties, staling

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**Abstract:** The incorporation of anti-staling agents into wheat-soy dough has the potential to improve the quality of bread. The aim of this study was to evaluate the impact of pullulan and/or four hydrocolloids combinations on rheological properties and quality attributes of wheat-soy baladi bread. Nine treatments of flour without/with hydrocolloids (Arabic Gum; AG, K-Carrageenan; K-C, pectin; P, Xanthan Gum; XG and Pullulan; Pu) was evaluated. The effects of the pullulan and/or hydrocolloids on rheological properties, crust color, staling rate and sensory attributes were investigated. For the Wheat Flour (WF), the water absorption, dough stability, extensibility, resistance to extension and dough energy had lesser than Wheat-Soy Flour (WSF). However, the addition of Pullulan and/or Hydrocolloids to (WSF) dough caused a noticeable increment in the above parameters and yielding reinforced doughs. A significant difference was observed in crust colorbecause of hydrocolloids addition. Moreover, all hydrocolloids made bread fresher than the control while (Pu; at 0.4%) recorded the highest value of AWRC after 1, 3 and 5 days of storage at (25±2°C). The results of this study demonstrate that hydrocolloids could be effectively used to improve dough properties, baking quality, sensory acceptability and retarded staling of wheat-soy baladi bread.

## INTRODUCTION

Baladi bread is a staple food in Egypt which serves a reliable source of carbohydrates, dietary fibers, minerals and vitamins. In Egypt, there has a major gap between wheat production and consumption around 45% (Capms, 2014). The best way to overcome this issue is to look for the local grain sources that could be utilized with wheat flour for bread making. Recently, the Egyptian Government supplanted wheat flour with corn flour up to 20% as economically display. However, the outputted bread has many technical problems, fast staling and speed deterioration (Yaseen *et al*., 2010).

Soy flour (*Glycine max* L.) is an important ingredient, inexpensive and high nutritive value. As well contains nearly 45% protein and bioactive proteins including a-amylase and lipoxygenase which has exceptionally helpful for the bread making procedure (Rosales-Juarez *et al*., 2008). The addition of soy flour within 10%, not affected of bread process (Ribotta *et al*., 2010), increased the protein, micro and macro-nutrient contents (Bibiana *et al*., 2014) also increased the dough resistance, intensification of crust color and the center color of the bread (Akbari *et al*., 2013).

In recent years, there have been reports that hydrocolloids can be utilized to improve moisture retention, control water mobility, regulation of rheological properties and decreases the staling of bread (Das *et al*., 2013). Meanwhile, the effects of hydrocolloids on dough and bread properties depend on many factors including particle size, molecular structure and an amount of hydrocolloids. According to Gambus *et al*. (2007), the hydroxyl groups in the hydrocolloid structure permit more water associations through hydrogen holding in a wheat dough.

The utilize of the hydrocolloids such as Arabic Gum (AG), K-Carrageenan (K-C), Pectin (P), Xanthan Gum (XG) has previously been evaluated in the cake. (Poonnakasem *et al*., 2015) found that XG and AG conditionally increased the batter density and the consistency of cake samples. As well, the inclusion of XG, AG or Hydroxypropyl Methylcellulose (HPMC) improved the panelist’s overall sensory score of yellow layered cakes (Gomez *et al*., 2007).

One study demonstrated that HPMC improved volume and reduced crumb hardening of bread (Guarda *et al*., 2003). Likewise, the addition of XG or Sodium Alginate (SA) was found to give a softening impact to the white bread because it inhibits the gluten-starch interactions (Shittu *et al*., 2009). Other studies (Correa *et al*., 2012) demonstrated High Methoxyl Pectin (HMP) reinforced dough rheological properties and improved specific volume of the loaf because forming of hydrophilic complexes between anionic groups of pectins and gluten proteins. Additionally, K-carrageenan has increased the stability of wheat dough during the proofing(Ghanbari and Farmani, 2013).

Pullulan (Pu) is a polysaccharide-extracellular produced by aureobasidium pullulans fungus. It is made of linearly polymerized a-trisaccharide units (Leathers, 2003). The degree of pullulan polymerization ranges 100-5000 a-glucopyranoside units. The molecular weight of the polymer may fluctuate between 103 and 106 amu. Pullulan was affirmed GRAS by food and drug administration. Moreover, its additional advantages are that it is tasteless, odorless and is highly soluble in water (Diab *et al*., 2001). Recently pullulan utilized as an edible film and coating in meat products and eggs (Morsy *et al*., 2014; Morsy *et al*., 2015). Unfortunately, there is no article which gives a general perspective of functional properties of pullulan in bread making.

From the current literature, there are a few reports about the hydrocolloids use as anti-staling agents in bread. However, there is no evidence in the literature about the impact of pullulan on bread quality. Hence, the aim of this work was to investigate the influence of (AG, C, P, XG and Pu) hydrocolloids on the rheological characteristics of dough and the quality of baladi bread made from wheat-soy flour.

## MATERIALS AND METHODS

**Experimental materials:** Commercial Wheat Flour (WF; 82% extraction) was purchased from the North Cairo Flour Mills Company, Egypt. Defatted soy flour (DSF; 60 mesh sieved) was obtained from the Agricultural research center, Giza, Egypt. Arabic Gum (AG; E-414), K-Carrageenan (K-C; E-407), Pectin (P; E-440) and Xanthan Gum (XG; E-415) were purchased from Sigma-Aldrich (St. Louis, USA). The pullulan (Pu) was supplied from the Hayashibara Company (Okayama, Japan). Other ingredients such as fine salt (S; Bono, Egyptian Salts and Minerals Co., Egypt) and instant dry active yeast (Saccharomyces cerevisiae) was obtained from a local supermarket in Cairo, Egypt. All the Additives Are Generally Recognized as Safe (GRAS).

**Preparation of flour blends:** Five types of hydrocolloids were used with different concentrations as follows; Arabic gum (0.5 and 1%, w/w), K-carrageenan (0.2 and 0.4%, w/w), pectin (0.5 and 1%, w/w), xanthan gum (0.5 and 1%, w/w) and pullulan (0.1, 0.2 and 0.4%, w/w) based on flour dry weight. The five examined hydrocolloids were added (individually and/or combination) to wheat-soy flour (WF: DSF; 90:10) in seven baking trails according to Table 1. All samples were blended well, stored in airtight containers and kept at 5-7°C until used.

**Breadmaking procedure:** Baladi bread was made according to Hussein *et al*. (2013) with some modifications. Briefly, dry ingredients [1000 g of flour (wheat or wheat/soy mixture), (5 g; 0.5%) of dry active yeast (15 g; 1.5%) of salt] was mixed at low speed for 1

Table 1: Hydrocolloids types and concentrations used in baladi bread production

| | Hydrocolloids types | | | | |
|---|---|---|---|---|---|
| Treatments[a] | AG | C | P | XG | Pu |
| T1 | 5 | 2 | - | - | - |
| T2 | 10 | 4 | - | - | - |
| T3 | - | - | 10 | 5 | - |
| T4 | - | - | 5 | 10 | - |
| T5 | - | - | - | - | 1 |
| T6 | - | - | - | - | 2 |
| T7 | - | - | - | - | 4 |

[a]Weight of hydrocolloids based on (1000 g flour); AG; Arabic gum; C; K-carrageenan; P: Pectin, XG; Xanthan gum and Pu: pullulan

min using Orlandi mixer (Model G.P.A. Orlandi mixer, Italy). Water was added (based on Farinograph absorption) at 30°C and mixed for 6-8 min till forming a consistent dough. After 45 min of bulk fermentation at 30°C and 85% Relative Humidity (RH), the dough was divided into pieces of 125±5 g. The pieces were arranged on a wooden board that has been sprinkled with a fine layer of bran and allowed to relax for 30 min in the same fermentation cabinet. Dough pieces were flattened by hand up to (15-20 cm diameter). All flattened doughs were proofed at 30°C and 85% RH for 10 min and then were baked at 380-400°C for 1-2 min. The baked loaves were cooled 10-15 min before wrapped in plastic bags. All processing of baladi bread was done via an automatic commercial baking line in the official baking house, Toukh city, Qaluobia, Egypt.

**Chemical analytical:** Moisture, protein, fat and total ash contentsof raw materials and bread were determined using (AACC, 2002). Total carbohydrates were calculated by difference.

**Physical characteristics:** The normal weight (g) of baked baladi bread was determined individually within one hour after baking and the average was calculated. The volume ($cm^3$) of different bread samples was measured by rape seed displacement method according to Aacc (2002). The specific volume ($cm^3/g$) was calculated for different bread samples.

**Dough properties:** Different properties of dough (wheat or wheat/soy flour blends) were conducted. Dough stability, dough development time, tolerance index and dough softening were determined by Farinograph (Brabender OHG, Duisburg, Germany) according to AACC (2002). Water absorption was assessed using (AACC, 2002). However, extensibility, resistance to extension and energy of dough were measured by Extensograph (Brabender, Extensograph, Germany HZ 50) as a method described (AACC, 2002). The falling number was determined using (AACC, 2002) Perten instrument (model 1700, Hagberg, Sweden). Gluten index was determined using Glutomatic (Perten Instrument AB, Stockholm, Sweden) according to Aacc (2002).

**Bread freshness test:** Freshness rate of baladi bread was determined by Alkaline Water Retention Capacity test (AWRC) according to the methoddescribed by Js and Gl (1971). Bread was stored in sealed polyethylene bags at room temperature (25±2°C). The values of AWRC were measured after 1, 3 and 5 days of storage.

**Crust color evaluation:** The crust color of baladi bread samples was determined by measuring L*(lightness), a*(redness/greenness) and b*(yellowness/blueness) values using a Minolta spectrophotometer CM-508d (Minolta Corp., Ramsey, NJ., USA). The instrument was calibrated using a standard white tile L-value of 92.46, a value of -0.86 and b value of -0.16 (Lanier, 1992). Color differences, ΔE* were calculated by the equation (Berns, 2000). ΔE* = (ΔL*2+Δa*2+Δb*2)1/2, where, ΔL*, Δa* and Δb* represents the differences in the color parameters between the sample and the white standard.

**Sensory evaluation of baladi bread:** The sensory evaluation of baladi bread was performed by a 12 trained panelists according to Hussein *et al*. (2013). The panelists were selected from staff members and students (aged 19-40 years) of the Food Technology Department, Faculty of Agriculture, Benha University. The bread sample was tested for its general appearance (20), separation of layers (20), roundness (15), crumb distribution (15), crust color (10), taste (10) and odor (10). Results were expressed as mean±SD.

**Statistical analysis:** Statistical analysis of the obtained results was carried out using ANOVA with one factor, followed multiple comparisons with (LSD) under significance level of 0.05 for the whole results using SPSS and data were treated as a complete randomization design according to Steel *et al*. (1997).

## RESULTS AND DISCUSSION

**Chemical composition of flours:** The Wheat Flour (WF), Defatted Soy Flour (DSF) and Wheat-soy Flour (WSF) were analyzed for chemical composition Table 2. The obtained results indicated that the moisture, fat and carbohydrate in DSF were lower than WF. Meanwhile, the protein and ash content of the DSF was about three and five times that of the WF, respectively. A significant difference (p = 0.05) in protein content was found between WF and DSF. Additionally, the mixing soy and Wheat Flours (WSF) increased nearly 22% the protein content of mixtures and raising their nutritional status compared with WF. These results are in agreements with those reported by Mashayekh *et al*. (2008).

As shown in Table 3 the gluten content and gluten quality in WF and WSF were evaluated. The WF was exhibited high wet gluten weight compared to WSF. Similar observations were noticed for gluten index and dry gluten. This finding is in agreement with (Aleid *et al*., 2014) who reported that the gluten index for WF (80% extraction) was 99.36%. At the same table, the falling number of WSF was greater than WF (Brain, 2005; Kitterman *et al*., 1971) demonstrated that a falling number value of 350 sec or longer refers to low enzyme activity and very stable wheat. As well, found that as the enzymes activity increase, the falling numbers decrease. The values below 200 sec indicate an elevated level of enzyme activity.

**Rheological properties of dough:** The effect ofhydrocolloids on the Farinograph test is presented in Table 4. The development time, water absorption, stability and weakening of dough increased with a DSF and hydrocolloids added. It was observed that the highest amount of water absorption was recorded in (T7) while the lowest water absorption capacity was shown in (WF) sample. Also, the addition of (Pu, P and XG) to WSF positively affected on dough development time and dough stability compared to other hydrocolloids. Meanwhile, the (AG and C) negatively affected on mixing tolerance index and dough weakening. The increase in water absorption, dough development time and dough stability may be due to the protein content and the ability of hydrocolloid to absorb water in their interrelated network and interaction with starch granules. Meanwhile, the (T7) recorded the highest water absorption because the pullulan allows more water absorption due to hydrogen bonding. This result supported by the data obtained by Yaseen *et al*. (2010), Salve (2011), Elhassaneen *et al*. (2014) and Correa *et al*. (2012).

As shown in the same table, the extensibility, resistance to extension and energy of dough (Extensograph parameters) were investigated. The extensibility and energy of dough were decreased while resistance to an extension was increased by the addition of DSF and hydrocolloids. This effect may be due to the presence of DSF dilute the wheat gluten complex of dough. Previously, it was shown (Ribotta *et al*., 2005) that the inclusion of soy flour at different levels increased the maximum resistance and decreased the extensibility and the area under the curve in comparison with wheat dough (Table 4).

**Chemical composition and energy value of baladi bread:** Data presented in Table 5 show the composition and energy value of blended wheat-soy bread incorporation hydrocolloids. The obtained results indicated that the wheat-soy bread characterized by higher moisture, protein, fat and ash contents and lower total carbohydrate content than wheat bread. Whereas, wheat bread was higher energy value compared with all samples. A significant difference (p = 0.05) in moisture and protein contents had been found between the wheat-soy bread incorporation hydrocolloids and wheat bread. The increase of moisture in bread due to hydrocolloids which keeping the moisture content however, the increase of

Table 2: Chemical composition of Wheat Flour (WF), Defatted Soy Flour (DSF) and wheat-soy flour (WSF; WF 90%: DSF 10%)

| | Chemical composition (mean±SD, n = 3) | | | | |
|---|---|---|---|---|---|
| Flour type | Moisture | Protein | Fat | Ash | Total carbohydrate |
| WF | 11.14[a] | 12.56[c] | 1.53[a] | 1.12[c] | 73.65[a] |
| | ±0.29 | ±0.37 | ±0.09 | ±0.04 | ±0.95 |
| DSF | 9.79 c | 42.77[a] | 1.17[a] | 6.80[a] | 39.47[b] |
| | ±0.32 | ±0.87 | ±0.04 | ±0.09 | ±0.82 |
| WSF | 10.36[b] | 15.35[b] | 1.51[a] | 1.62 b | 71.16[a] |
| | ±0.31 | ±0.42 | ±0.14 | ±0.08 | ±0.77 |

[abc]There is no significant difference between any two means 'in the same column' have the same superscript letter (p = 0.05)

Table 3: Gluten content and falling number in wheat flour (WF) and wheat-soy flour (WSF; WF 90%: DSF 10%)*

| Flour type | Wet gluten weight (g) | Gluten index ( %) | Dry gluten (g) | Falling No. (sec) |
|---|---|---|---|---|
| WF | 29.45[a] | 99.25[a] | 11.96[a] | 285 b |
| | ±0.16 | ±0.32 | ±0.08 | ±5.46 |
| WSF | 28.69[b] | 98.02[b] | 11.45[b] | 310[a] |
| | ±0.13 | ±0.27 | ±0.11 | ±6.11 |

[abc]There is no significant difference between any two means 'in the same column' have the same superscript letter (p = 0.05). *These results were basically calculated on 14% moisture basis in WF Mean±SD, n = 3

Table 4: Effect of hydrocolloids on rheological properties of dough (Farinograph-Extensograph parameters)

| | Dough formula | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameters | WF | WSF | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
| **Farinograph** | | | | | | | | | |
| Water absorption (%) | 63 | 65 | 66 | 66 | 66.5 | 67 | 66 | 67 | 68.5 |
| Arrival time (min) | 1.5 | 2 | 2 | 2 | 1.75 | 2 | 1.75 | 2 | 2 |
| Dough development time (min) | 2 | 2.5 | 2.5 | 2 | 2 | 2.5 | 2 | 2.5 | 3.5 |
| Dough stability (min) | 5 | 4 | 4.5 | 5 | 6 | 8 | 7 | 8 | 9.5 |
| Mixing tolerance index (BU) | 40 | 65 | 70 | 80 | 60 | 50 | 45 | 50 | 50 |
| Dough weakening (BU) | 90 | 110 | 120 | 130 | 110 | 100 | 95 | 90 | 80 |
| **Extensograph** | | | | | | | | | |
| Extensibility (mm) | 120 | 110 | 100 | 95 | 100 | 105 | 105 | 110 | 115 |
| Resistance to extension (BU) | 240 | 280 | 220 | 230 | 260 | 280 | 260 | 280 | 320 |
| Dough energy ($cm^2$) | 90 | 80 | 80 | 70 | 75 | 85 | 80 | 90 | 90 |

WF; Wheat Flour and WSF; Wheat-Soy Flour (WF 90%; DSF 10%)

Table 5: Chemical composition and energy value of baladi bread without/with hydrocolloids

| | Bread formula (Mean±SD, n = 3) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Components | WF | WSF | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
| Moisture (%) | $34.26^{c}$ | $35.08^{b}$ | $35.62^{b}$ | $36.04^{a}$ | $36.1^{a}$ | $36.52^{a}$ | $35.78^{b}$ | $36.34^{a}$ | $37.02^{a}$ |
| | ±0.53 | ±0.19 | ±0.79 | ±0.49 | ±0.22 | ±0.22 | ±0.36 | ±0.45 | ±0.59 |
| Protein (%) | $11.36^{b}$ | $13.21^{a}$ | $13.36^{a}$ | $13.17^{a}$ | $13.21^{a}$ | $13.34^{a}$ | $13.15^{a}$ | $13.19^{a}$ | $13.26^{a}$ |
| | ±0.54 | ±0.27 | ±0.27 | ±0.55 | ±0.88 | ±1.13 | ±1.3 | ±0.64 | ±1.41 |
| Fat (%) | $1.34^{b}$ | $1.59^{a}$ | $1.48^{b}$ | $1.55^{a}$ | $1.54^{a}$ | $1.53^{a}$ | $1.57^{a}$ | $1.59^{a}$ | $1.69^{a}$ |
| | ±0.1 | ±0.09 | ±0.18 | ±0.34 | ±0.28 | ±0.06 | ±0.06 | ±0.11 | ±0.15 |
| Ash (%) | $1.19^{b}$ | $1.70^{a}$ | $1.73^{a}$ | $1.75^{a}$ | $1.78^{a}$ | $1.89^{a}$ | $1.68^{a}$ | $1.77^{a}$ | $1.81^{a}$ |
| | ±0.09 | ±0.26 | ±0.23 | ±0.09 | ±0.05 | ±0.02 | ±0.12 | ±0.06 | ±0.19 |
| Total carbohydrate (%) | $52.10^{a}$ | $48.42^{b}$ | $47.81^{b}$ | $47.49^{b}$ | $47.37^{b}$ | $46.72^{b}$ | $47.82^{b}$ | $47.1^{b}$ | $46.22^{b}$ |
| | ±0.33 | ±0.25 | ±0.22 | ±0.51 | ±0.68 | ±0.73 | ±1.11 | ±0.54 | ±0.98 |
| Energy value | $274.87^{a}$ | $266.51^{b}$ | $265.94^{b}$ | $264.44^{b}$ | $264.03^{b}$ | $261.83^{b}$ | $265.88^{b}$ | $263.34^{b}$ | $260.91^{b}$ |
| (Kcal 100 $g^{-1}$) | ±6.45 | ±4.89 | ±5.47 | ±3.67 | ±4.23 | ±5.34 | ±3.66 | ±4.82 | ±5.35 |

WF: Wheat Flour and WSF; Wheat-Soy Flour (WF 90%; DSF 10%); $^{abc}$There is no significant difference between any two means 'in the same row' have the same superscript letter (p = 0.05)

Table 6: Physical properties of baladi bread without/with hydrocolloids

| | Properties (Mean±SD, n = 3) | | |
|---|---|---|---|
| Samples | Weight (g) | Volume ($cm^3$) | Specific volume ($cm^3$/g) |
| WF | $116.36^{e}$ | $291.33^{a}$ | $2.5^{a}$ |
| | ±0.77 | ±1.86 | ±0.03 |
| WSF | $117.69^{d}$ | $282^{d}$ | $2.4^{a}$ |
| | ±0.39 | ±1.53 | ±0.01 |
| T1 | $118.91^{cd}$ | $283^{c}$ | $2.38^{ab}$ |
| | ±0.39 | ±2.08 | ±0.03 |
| T 2 | $119.96^{bc}$ | $284.33^{c}$ | $2.37^{b}$ |
| | ±0.49 | ±2.33 | ±0.02 |
| T 3 | $120.48^{b}$ | $285^{b}$ | $2.37^{b}$ |
| | ±0.42 | ±1.15 | ±0.02 |
| T 4 | $121.29^{a}$ | $286.67^{ab}$ | $2.36^{b}$ |
| | ±0.38 | ±2.03 | ±0.02 |
| T 5 | $119.88^{c}$ | $284.67^{bc}$ | $2.37^{b}$ |
| | ±0.89 | ±2.33 | ±0.02 |
| T 6 | $120^{b}$ | $286.33^{b}$ | $2.39^{a}$ |
| | ±0.51 | ±1.2 | ±0.01 |
| T 7 | $119.41^{c}$ | $289.67^{a}$ | $2.43^{a}$ |
| | ±0.24 | ±1.76 | ±0.02 |

$^{abc}$There is no significant difference between any two means 'in the same column' have the same superscript letter (p = 0.05)

flour added. The addition of DSF to WF was played an important role in increasing the nutritional value (Das *et al*., 2013).

**Physical properties of baladi bread prepared with DSF and/or hydrocolloids:** The effect of hydrocolloids incorporation on the physical properties of bread was investigated and presented in Table 6. A significant difference (p = 0.05) in loaf weight, loaf volume and specific volume had been found between the wheat-soy bread incorporation hydrocolloids and control sample. The addition of DSF 10% caused to increase the loaf weight while decreasing the volume of the loaf. The reduction of volume may due to the dilution of gluten because of adding soy flour to wheat flour. Meanwhile, loaf volume and specific volume were improved upon the addition of hydrocolloids and bread samples contained (Pu, P and XG) were recorded the highest volume. The previous changes could be due to Pu, P and XG improving the gas-cell stability of gluten. This result supported by Yaseen *et al*. (2010) and Aleid *et al*. (2014).

**Crust color of baladi bread supplemented with DSF and/or hydrocolloids:** Crust color is an important characteristic of bread, contributing to consumer predilection. The crust color of baladi bread samples was evaluated as shown in Table 7. It was found that an incorporation of DSF modified the crust color of the bread from creamy white to dull brown where lightness (L*) and redness (b*) were decreased while Browning Index (BI) and color difference (ΔE) increased. A significant difference was observed in crust color as the consequence of hydrocolloids addition. The bread sample incorporation of hydrocolloids (T1 and T2) was darker than samples (T3 and T4) however, the sample contained (Pu) was the lightest in color. The variation of color may be due to the AG and C was darkness while P XG and Pu were lightness. These results are in agreements with those reported by Eissa *et al*. (2007).

**Freshness in baladi bread:** Alkaline Water Retention Capacity (AWRC) is a quick test to follow staling of bread, the higher values of AWRC indicate the higher freshness of the bread. The changes occurring in freshness characteristics of baladi bread after 1-5 days of storage at room temperature (25±2°C) are shown in Fig. 1. It could be observed that wheat bread was fresher than wheat-soy bread (10% soy flour) under the same conditions. This means that wheat-soy bread staled faster than the wheat bread sample. This might be more due to the loss of moisture content in the former than the later.

Similar findings were observed by Ribotta *et al*. (2010). The addition of AG, C, P, XG and/or Pu made bread fresher than the wheat and/or wheat-soy bread. Pullulan protein in bread return to soy Similar findings

Table 7: Crust color of baladi bread supplemented with DSF and/or hydrocolloids (Hunter color parameters)

| | Hunter color parameters | | | | | |
|---|---|---|---|---|---|---|
| Samples | L* | a* | b* | Chroma | Browning index (BI) | ΔE* |
| WF | 60.14 | 5.43 | 22.47 | 23.12 | 95.62 | 39.86 |
| WSF | 57.58 | 6.74 | 21.78 | 22.80 | 100.64 | 41.82 |
| T1 | 55.82 | 6.23 | 21.94 | 22.81 | 104.10 | 43.29 |
| T2 | 56.33 | 6.15 | 21.85 | 22.70 | 102.29 | 42.80 |
| T3 | 58.46 | 5.89 | 22.05 | 22.82 | 98.08 | 41.08 |
| T4 | 58.78 | 5.87 | 22.19 | 22.95 | 98.05 | 40.89 |
| T5 | 58.85 | 6.03 | 22.07 | 22.88 | 97.71 | 40.79 |
| T6 | 59.65 | 5.55 | 22.29 | 22.97 | 96.02 | 40.18 |
| T7 | 60.54 | 5.24 | 22.51 | 23.11 | 94.60 | 39.53 |

L*, a*, and b*: color parameters

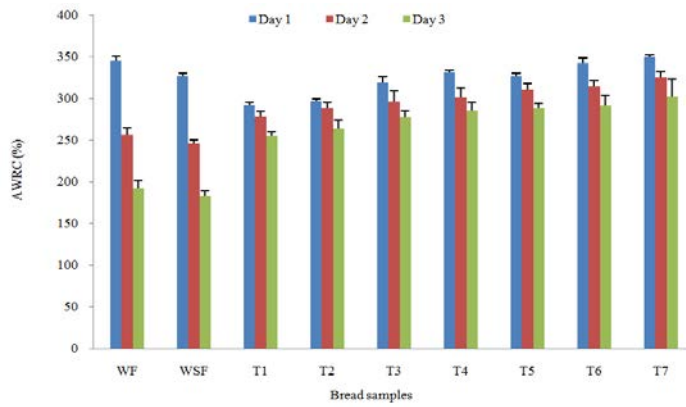


Fig. 1: AWRC of baladi bread supplemented with DSF and/or hydrocolloids stored at room temperature (25±2°C)

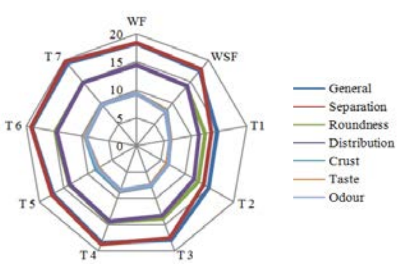


Fig. 2: Sensory characterization of baladi bread formulated with DSF and/or hydrocolloids

were observed by Ribotta *et al*. (2008). The addition of AG, C, P, XG and/or Pu made bread fresher than the wheat and/or wheat-soy bread. Pullulan at 0.4% recorded the highest value of AWRC after 1, 3 and 5 days of storage. The softening of bread was attributed to the delay of gluten-starch interactions in the presence of hydrocolloids molecules. The obtained results confirmed the data presented by Shittu *et al*. (2009).

**Organoleptic characteristics of baladi bread:** The influence of DSF and/or hydrocolloids on the organoleptic properties of baladi bread was evaluated. Results in Fig. 2 show that all baladi bread formulae containing hydrocolloids received significantly higher scores ($p = 0.05$), compared to the control sample. Among all formulae (those with/without hydrocolloids), T4 and T7 gained highest scores with the latter obtaining the highest acceptability among them ($p = 0.05$). It has been documented that hydrocolloids usually improve the cohesion of starch granules, producing the required bread structure and mouth feeling which is comparable in quality to those of the commonly accepted bread (Ozboy, 2002). Furthermore (Demirkesen *et al*., 2009) reported higher consumer preference by adding pectin, locust bean, HPMC, xanthan, guar, xanthan-guar and xanthan-locust bean compared with the control with xanthan producing the better values. Our results showed that the highest score in the formulae (T4) containing XG and P. Xanthan improved the structure of bread and made them comparable in attributes with most commercial bread (Ozboy, 2002). Also, the formulae containing both Pu (T5-7), increase in concentration of pullulan up to 0.4%, strongly increased the total score, with T7 being scored highly by the assessors ($p = 0.05$), findings which confirmed the results obtained by Demirkesen *et al*. (2009), Gambus *et al*. (2007). As well Shittu *et al*. (2009) reported that the inclusion of xanthan gum had significant effects on the sensory acceptability of fresh composite bread.

## CONCLUSION

This study demonstrates thatthe addition of Pu and/or hydrocolloids (AG, C, P and XG) combinations has positively affected by dough stability, dough energy and proved higher water absorption capacity. These compounds also improved crust color and sensory properties of final products in different ways. For the reduction of the staling, P, XG and Pu are the best additives due to its softening and retarding the firming of the bread crumb effects. As an outcome of the great variation in the impact promoted by the different hydrocolloids, a systematic study is necessary about the effect of a range of hydrocolloids in the quality of wheat bread. The beneficial aspects of pullulan-incorporation in baladi bread as demonstrated in this study, clearly warrant scale-up trials under a large production volume typical of commercial conditions in Egypt.

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