

Evaluation of Egg Replacers in a yellow cake System

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Abstract: The egg alternatives (replacers) were used to replace egg as a functional ingredient in yellow cake system productions. Egg replacers were substituted at the levels of 50% and 100% of the dried whole eggs in the yellow cake system. The egg replacers were composed of whey protein isolate, wheat starch, guar gum, xanthan gum or their blends. At 50% substitution, treatments performed closer to that of control compared to 100 % substitution. The blends of guar/whey/starch (GPS) and xanthan/whey/starch (XPS) performed the best, having the closest volume and texture measurement compared to the control. A quantitative descriptive analysis (QDA) was performed on blends of GPS and XPS at 100% replacement. Six attributes of cake-crust stickiness, crumb color, springiness, moistness, firmness, and egg flavor--were quantified by a panel. These treatments were competitive to the control across all attributes measured. In the consumer acceptability test, the XPS formulation was significantly higher in acceptability for all attributes to that of the control. These alternatives can deliver functionality at a lower cost and can be incorporated to produce a suitable yellow cake system, especially blends of guar/whey/starch (GPS) and xanthan/whey/starch (XPS). These results may help producers in formulating yellow cake system.

Key words: dried whole-egg, egg replacers, yellow cake, sensory analysis, Texture analysis.

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تقييم بدائل البيض في الكيك الأصفر

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المخلص: استخدمت بدائل البيض كمكونات وظيفية لإنتاج الكيك الأصفر. تم استبدال كل مسحوق البيض المستخدم في الكيك الأصفر أو 50% منه ببدايل البيض. تحتوي بدائل البيض على مستخلص بروتينات الشرش - نشا القمح - صمغ القوار - صمغ الزانان أو خليط منهم. الكيك المحتوى على 50% من بدائل البيض مشابه للكيك المحتوى على البيض مقارنة بالكيك المحتوى على 100% بدائل البيض. الكيك المحتوى على البدائل (القوار/بروتينات الشرش/النشا) أو (الزانان/بروتينات الشرش/النشا) مشابه للكيك المحتوى على البيض من حيث الحجم والقوام. استخدام التحليل الوصفي الكمي لتقييم الكيك المحتوى على 100% بدائل للبيض. استخدم المقيمين صفات التصاق القشرة الخارجية - لون اللب - المرونة - الرطوبة - التماسك و نكهة البيض في تقييم الكيك. بينت النتائج أن صفات الكيك المحتوى على بدائل الكيك مشابه لصفات الكيك المحتوى على البيض. الكيك المحتوى على (الزانان/بروتينات الشرش/النشا) كبديل للبيض أفضل تقبلا من أنواع الكيك الأخرى. بينت النتائج إمكانية استخدام بدائل البيض لإنتاج كيك أصفر ذو خصائص جيدة وبتكلفة أقل.

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Introduction

Eggs have high nutritional value and multi-functional properties, including emulsification, coagulation, foaming, and flavor (Yang and Baldwin, 1995). In the past, fresh eggs served as the primary ingredient for cakes made at home and in retail bakeries around the country (Pyler, 1988). As culture has changed over the last 100 years, the production of cakes moved from home and small retail bakeries to the widespread use of box mixes and large production facilities. Although egg's unique properties provide many advantages, a multitude of concerns from consumers and processors have led the baking industry to search for ingredients to replace eggs (Hard et al., 1963; Lin et al., 2003; Swaran et al., 2003). These concerns include a desire for low-cholesterol foods, reduced allergens, less expensive ingredients, increased shelf life, no refrigeration requirements, and fewer microbial concerns (Romanoff, 1949; Lin et al., 2003; Swaran et al., 2003)

Different egg replacers have been tried over the years to partially or completely replace eggs. Some of these egg replacers include: whey protein (Borstein and Bartov, 1966; Vitti, 1981; Arunepanlop et al., 1996; Swaran et al., 2003) and gums (Miller and Setser, 1983; Dogra et al., 1989; Conrad et al., 1993; Miller and Hosney, 1993; Mott et al., 1999). Much of the research completed is old and a substantial portion of the work did not include any sensory evaluation which is very essential in product development (Lawless and Heymann, 1999). Patino et al. (2007) indicated that the foaming capacity increases with increasing the sunflower protein concentration (SPI) and its hydrolysates in solution. Foams retain a higher amount of liquid, are denser, and the air cells are smaller when the protein concentration increases. The foam stability also increases with the amount of protein in solution. Ashwini et al. (2009) found that addition of some types of the hydrocolloids

increased the overall quality of eggless cake with sodium stearoyl-2-lactylate (SSL) and the highest improvement was brought about by hydroxypropyl methylcellulose (HPMC). Comparisons of the physical and sensory properties of several commercial egg alternatives in angel food cake formulation were studied (Abu-Ghoush et al., 2010).

With the advent of new technologies, many new food ingredients are being advertised. However, there is very little literature that compares these ingredients to eggs in a scientific study. The hypothesis of this study is that some commercial ingredients may be available to processors to emulate some of the functional characteristics of whole-egg and compete in all physical and sensory attributes in a yellow cake system. Therefore, the objective of the study was to evaluate and compare the physical and sensory characteristics of egg replacers to dried whole egg in a yellow cake.

Materials and Methods

Yellow cake preparation

The ingredients used in all yellow cake formulations included iodized salt (Kroger Co., Cincinnati, OH), pure cane sugar (C&H Sugar Co., Crockett, CA), and corn oil (Kroger Co., Cincinnati, OH). The egg and egg substitutes evaluated in the yellow cake formula were either donated or purchased; including dry whole egg (Cutler Egg Products, Abbeville, AL), wheat starch (MGP Ingredients, Atchison, KS), xanthan and guar gum (PB-S-GSP) (TIC Gum, Belcamp, MD), and whey protein isolate (WPI) (Davisco International, Eden Prairie, MN).

Cake batters were made according to the formula and method described in the AIB standard procedure for cake (American Institute of Baking, 1996). Eight treatments and a control were analyzed (Table 1). Cakes were mixed in a Hobart A-200 12-quart mixer (Hobart Corp., Troy, OH). Four cakes from each

treatment were made by pouring 400 g of batter into 20.32 cm (8 in) diameter circular cake pans. Cakes were baked in a Reed four-reel oven (Reed Oven Co., Kansas City, MO) at 176.7°C (350°F) for 30 min. After baking, cakes were cooled

for 10 min. before being de-panned and cooled to ambient temperature. Once cakes were fully cooled, they were individually bagged in a polyethylene film bag until testing.

Table 1. Selected treatments for the study.

Treatment	
Control	18.2%* dry whole egg
WPI	18.2% whey protein isolate
WS	18.2% wheat starch
GS	1% gum guar/17.2% wheat starch
GP	1% gum guar/17.2% whey protein isolate
GPS	1% gum guar/8.6% whey protein isolate/8.6% wheat starch
XS	1% xanthan gum/17.2% wheat starch
XP	1% xanthan gum/17.2% whey protein isolate
XPS	1% xanthan gum/8.6% whey protein isolate/8.6% wheat starch

Percentage flour basis, percentages reflect 100% replacement of egg

Cake volume, symmetry, and contour

Cakes volume, symmetry, and contour indexes were determined one day after baking by AACC Baking Quality Method 10-91 (AACC, 2000). The cakes were sliced into halves. The index template was placed up against the cut edges of cakes, and the heights of designated positions B, C, and D were recorded (Figure 1). These recorded heights were used to compute volume, symmetry, and

contour as instructed in AACC method 10-91 (2000). Volume is computed by $B + C + D$, symmetry by $|B - D|$, and contour by $2C - B - D$. Measurements were then averaged. Contour and symmetry describe the flow and setting of the cake batter. Excessive contour and poor symmetry can be a sign of early or irregular setting of crumb structure. These typical characteristics can relate to poor and non-uniform cell structure of crumb.

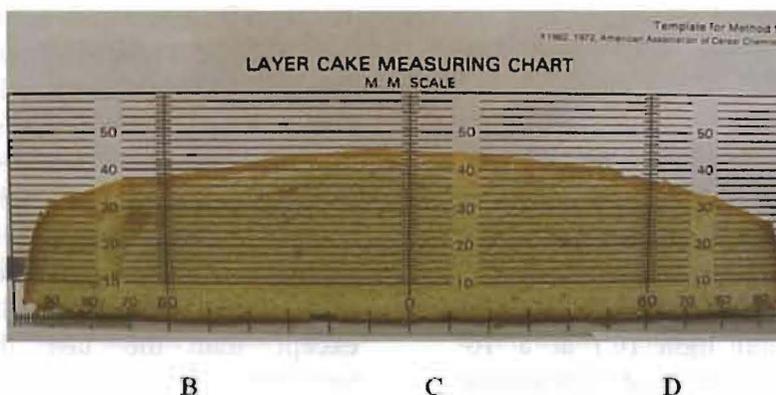


Figure 1. American Association of Cereal Chemists template used to measure volume, contour, and symmetry.

Cake texture

Texture of cake is most commonly found by using a compression test and measuring the strain. The strain force measurements, as well as other measurements, can be used to determine the hardness. A frequently used type of texture measurement is the texture profile analysis (TPA). The TPA imitates the mouth and palate, and can quantify texture characteristics of hardness, cohesiveness, springiness. The TPA is a technique using a two-cycle compression test, which imitates two bites. Texture was determined with TA-XT2 Texture Analyzer (Texture Technologies Scarsdale, NY) according to the AIB standard procedure for cake (American Institute of Baking, 1996). The 20.32 cm round cakes were sliced down the center, and two cuts were made 3.81 cm on either of the center slice. Cutout sections were placed on their side with the center cut face up, and were tested with a 2.54 cm-diameter cylinder probe. Individual sections were probed in three different locations near the center of the pieces. This procedure was performed on two cakes per treatment per evaluation day, thus producing 12 measurements per treatment. The hardness and springiness of each measurement was recorded. Cakes were tested at 1 and 5 d after baking. Measurements on the texture analyzer used the following setting: test mode T P A, pre-test speed 3 mm/s, test speed 1.7 mm/s, post-test speed 1.7 mm/s, distance 6 mm, trigger auto at 20 g, acquisition rate 200 pps.

Cake color

Crumb color was measured with a Hunter Miniscan portable colorimeter (HunterLab, Reston, VA). The colorimeter was calibrated by a light trap and white tile, according to procedure set forth by the Hunterlab owner's manual. Color was measured in natural light (C) at a 10° angle. Three measurements of each sample were taken and then averaged. The *L* value (lightness) was recorded and hue angle,

($\tan^{-1} b/a$), was calculated to define crumb color (in the case of this study yellowness). Procedures for color were adapted from Lee et al. (1991).

Quantitative descriptive analysis (QDA)

Ten panelists (6 female and 4 male) were selected from Kansas State University and recruited to participate in the panel. Panelists were between the ages of 22 and 30, and all successfully completed the study.

Training was adapted from Archilla (2001). Panelists took part in three training sessions, each of which lasted approximately 1 h. During training periods, panelists were introduced to testing procedures that allowed them to build skill and confidence to achieve valid and reliable results (Meilgaard et al., 1999). The QDA panelists were trained in a quiet room that was 23C and 50% RH. Panelists were asked to rate cakes based on six characteristics: crust stickiness, color, springiness, moistness, firmness, and egg flavor.

The group of panelists was trained on the first three cake attributes (crust stickiness, color, and springiness) in the first training session, whereas the other three attributes were presented in the second training session using scale from 1-15 point. Panelists were given attribute definitions and testing protocol. Reference samples for word anchors (Table 2) were presented to panelists during training to reduce variability and increase confidence. These references and definitions used in the QDA were adapted from earlier studies (Munoz, 1986; Bramescio, 1991; Lin et al., 2003). Panelists were presented samples that fell between reference samples in each category. The group then came to a consensus on where each sample fell between the reference anchors. The second training session was similar to the first, except that the last three attributes (moistness, firmness, and egg flavor) were presented.

Table 2. Reference samples for sensory word anchors in descriptive analysis.

	0	10
Surface Stickiness	White bread (not sticky)	fudge topping (very sticky)
Color	Paint sample "Rime (white)	paint sample "Yolk" (Yellow)
Springiness	Fudge brownie (no springiness)	polyethylene foam (very springy)
Moistness	Saltine cracker (very dry)	pound cake (very moist)
Firmness	Pound cake (very soft)	white cake w/egg white replaced w/whey (very firm)
Egg Flavor	White bread (no Egg)	pound cake (very eggy)

In the third training session, all attributes were examined and reviewed by panelists. At the end of this training, a practice sensory test was performed to determine the consistency of the panel as a whole. Two different cake formulations were presented to panelists. Each cake sample consisted of a 24.58 cm³ cube of crumb and a 9.7 cm² piece of cake crust, at ambient temperature. Samples were placed on a white paper plate with a three-digit code and were given to panelists along with a glass of distilled water, some napkins, and a list of reference anchors. Results were recorded on the sensory ballot by placing a vertical mark on a 5-inch unstructured line. At the end of the practice sensory tests, each individual shared their approximate results with the group to compare consistency

To avoid sensory fatigue, the panelists evaluated only three cake formulations, a control (whole-egg), and two 100% replacement blends at a session (Harper et al., 1991; Lee and Resurreccion, 2004; Gallardo-Escamilla, et al., 2005). The blends were GPS (guar/whey protein isolate/wheat starch) and XPS (xanthan/whey protein isolate/wheat starch), which were selected because they showed the most potential in emulating the physical attributes of whole-egg in yellow cake. Each sample was again assigned a three-digit random code and was presented in a random order to each panelist. Two replications of the sensory test were performed over the course of 1 wk. Each testing session lasted approximately 15 min. Testing procedures, test location, and

room environment were the same as during the practice test procedures performed in session three. Sample presentation consisted of three 24.58 cm³ cubes and a 9.7 cm² piece of cake crust.

Consumer acceptance test

A total of 104 untrained consumers of both genders (57 females and 47 males) volunteered to participate in the acceptance test. Panelist ages ranged from 18 to 80 years old. All panelists were prescreened for food allergies and for how frequently they consumed cake. Consumer acceptance test procedure was adapted from Khouryieh (2003). This laboratory was equipped with white light and individual stations for evaluation. Each panelist evaluated two samples of cake during the session. One sample was the whole-egg control and the other sample was a 100% replacement of whole-egg with xanthan/whey protein isolate/wheat starch. The XPS was selected because this treatment possessed both the physical and QDA attributes that provided the highest probability of emulating the whole egg treatment. Both cake formulations had FD&C Yellow #5 added to batter to provide color to crumb. Added yellow color negated differences between crumb colors to prevent bias by consumers. Cake samples were served to panelists in 24.58 cm³ cubes on white paper plates at room temperature. Each sample was given a three-digit random number and samples were given to panelists in a random order. Sensory ballots, distilled water, and unsalted crackers were given along with

cake samples. Panelists were instructed to cleanse mouth before tasting each sample. Cake was evaluated according to a 9-point hedonic scale to determine liking of product (9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely). The cake samples were evaluated on appearance, texture, flavor, and overall acceptability. For each cake, consumers were also asked if they would be willing to buy a product like this in stores.

Statistics analysis

Treatments were analyzed in a complete-block design. Three replications and two sub-samples per replication per day were performed for both a 50% replacement group and 100% replacement group. The experimental design included 11 different samples. For QDA, each mark was measured from the left end of the line scale. Marks were measured in inches and then converted to numbers by multiplying by 2 (i.e., 1 inch = 2). This resulted in a 10-point scale for each attribute. Treatments were compared for each attribute. Statistical analysis was performed by using the Statistical Analysis System version 9.0 (SAS Institute, Inc.,

SAS Circle, Box 8000, Cary, NC). An analysis of variance (ANOVA) and least significant difference (LSD) comparisons were performed on all data. Significant differences between treatments were detected at a $p < 0.05$ level.

Results and Discussion

Volume

Data showed that a single ingredient egg replacer used at 100% substitution did not produce volumes significantly greater than the control cake (Figure 2). However, the addition of gums did result in significantly higher volume cakes. At 50% replacement, cake volume significantly improved compared to 100% replacement volumes. Only GP, GPS and XPS exhibited significantly ($p < 0.05$) greater volume than the control cake, however, GPS had a crumb with large holes and an open grain. Miller (1981) found that the addition of xanthan and wheat starch improved cakes with a reduced amount of eggs. Mott et al. (1999) found that adding xanthan gums to whey may increase foam stability. Pernell et al. (2002) found that adding xanthan may increase the volume of angel food cakes.

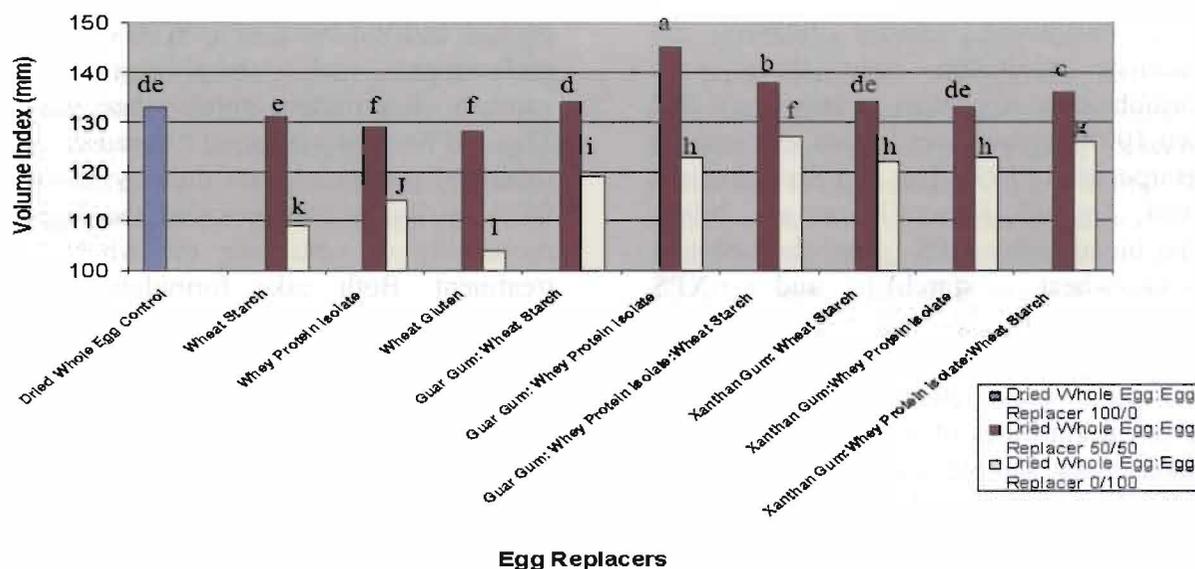


Figure 2. Comparison of volume index of yellow cake formulated with either dried whole egg or egg replacers. Means with different letters indicate significant differences among all treatments, ($p < 0.05$).

Contour

Figure 3 exhibited contour indexes of cakes with ingredients used individually and in combination with either guar gum or xanthan gum. At 100% substitution, WPI to mimic the contour of the whole-egg cakes. At 100% replacement of eggs with treatments containing GP and all the xanthan gum blends significantly improved the contour compared to the WS and WPI. Furthermore, GP, XS, XP and XPS exhibited a significantly higher contour compared with the control. At 50% substitution the gum blends significantly decline except for the GP which improved over the 100% substitution compared to the control. Actually, there were no significant differences among different treatments regarding the symmetry found.

Texture

Texture was affected by replacing whole eggs with other ingredients. Hardness data showed that at 100%

replacement, all treatments containing whey protein (WPI, GP, GPS, XP, and XPS) had significantly higher values, whereas those without whey protein (WS, GS, XS) were significantly less firm (Table 3). GPS and XPS were close to control in hardness value, but not statistically the same. When substitution was 50%, hardness for all cake treatments decreased. All cake treatments increased in hardness from d1 to d5. At d1 and 100% substitution, GPS was the only egg replacers that exhibited a springiness value significantly greater than the control. GPS and WPI were significantly higher in springiness compared to the control at d5 (Table 4). At 50% substitution, GPS exhibited a significantly higher springiness compared to the other egg replacers at d1. GP and XP were significantly greater in springiness than the other treatments at d 5. These treatments decreased in springiness approximately 1% from d1 to d5.

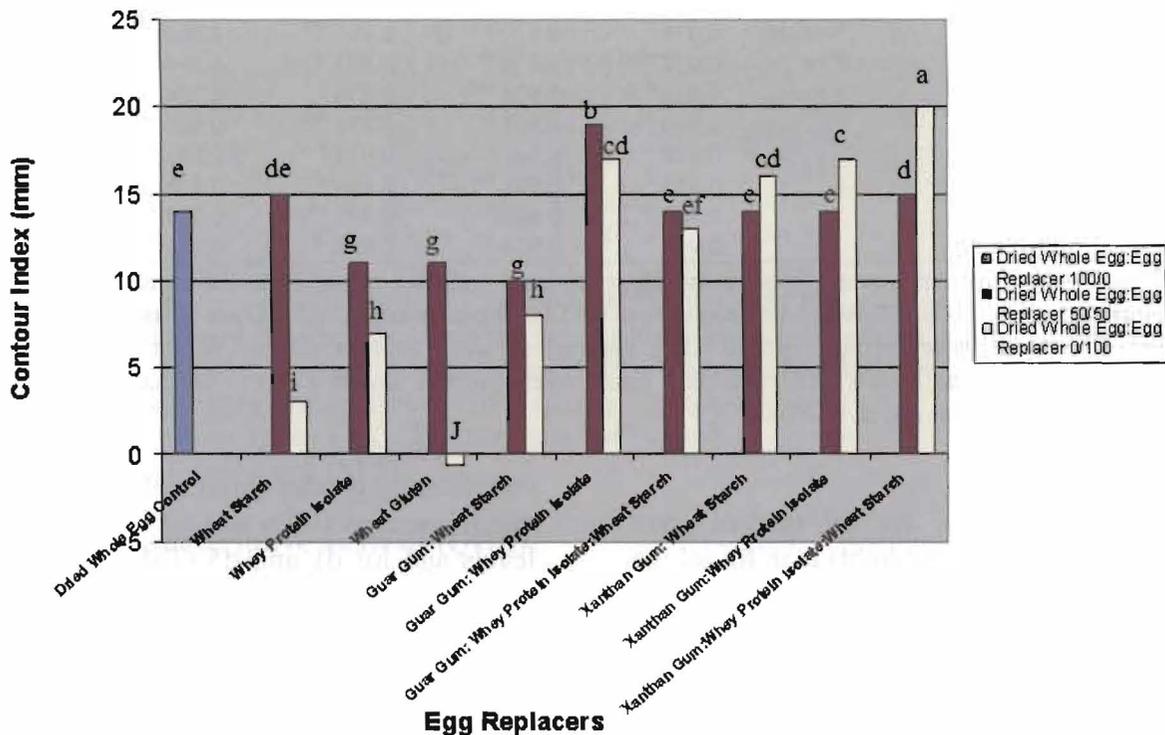


Figure 3. Comparison of contour index of yellow cake formulated with dried whole egg or egg replacers. Means with different letters indicate significant differences among all treatments, (p<0.05).

Table 3. Comparison of the hardness of yellow cake formulated with either dried whole egg or selected replacers measured at day 1 and day 5 after baking by using textre analyzer.

Treatments**	Day 1		Day 5	
	100:0	50:50	100:0	50:50
Control	295.33* ^f		400.80 ^d	
WS	261.15 ^g	230.43 ^g	363.23 ^e	311.25 ^{ef}
WPI	720.29 ^a	364.42 ^b	921.89 ^a	489.03 ^{bc}
GS	245.58 ^h	234.31 ^{fg}	332.26 ^f	344.66 ^e
GP	606.82 ^c	376.29 ^b	775.50 ^b	470.75 ^c
GPS	329.35 ^e	280.00 ^{de}	450.12 ^c	395.75 ^d
XS	258.14 ^{gh}	295.84 ^{cd}	342.94 ^{ef}	426.74 ^d
XP	618.03 ^b	446.43 ^a	795.43 ^b	556.95 ^a
XPS	355.06 ^d	314.41 ^c	470.66 ^c	415.50 ^d

*Means with different superscripts in the same column indicate significant differences among all treatments, ($P \leq 0.05$). ** Whey protein isolate (WPI), Wheat starch (WS), Guar gum/ wheat starch (GS), Guar gum/ whey protein isolate (GP), Guar gum/ whey protein isolate/ Wheat starch (GPS), Xanthan gum/ wheat starch (XS), Xanthan gum/ whey protein isolate (XP), Xanthan gum/ whey protein isolate/ Wheat starch (XPS).

Table 4. Comparison of the springiness of yellow cake formulated with either dried whole egg or selected replacers measured at day 1 and day 5 after baking by using textre analyzer.

Treatments**	Day 1		Day 5	
	100:0	50:50	100:0	50:50
Control	0.945* ^b		0.896 ^{cde}	
WS	0.934 ^c	0.930 ^{bcd}	0.901 ^{cde}	0.865 ^d
WPI	0.937 ^c	0.926 ^{de}	0.963 ^{ab}	0.896 ^b
GS	0.913 ^d	0.928 ^{cde}	0.836 ^f	0.884 ^c
GP	0.910 ^{de}	0.931 ^{bc}	0.921 ^{bcd}	0.920 ^a
GPS	0.970 ^a	0.941 ^a	0.977 ^a	0.896 ^b
XS	0.914 ^d	0.931 ^{bcd}	0.866 ^{ef}	0.878 ^c
XP	0.907 ^{de}	0.920 ^f	0.898 ^{cde}	0.919 ^a
XPS	0.945 ^{bc}	0.934 ^b	0.883 ^{de}	0.881 ^c

*Means with different superscripts in the same column indicate significant differences among all treatments, ($P \leq 0.05$). ** Whey protein isolate (WPI), Wheat starch (WS), Guar gum/ wheat starch (GS), Guar gum/ whey protein isolate (GP), Guar gum/ whey protein isolate/ Wheat starch (GPS), Xanthan gum/ wheat starch (XS), Xanthan gum/ whey protein isolate (XP), Xanthan gum/ whey protein isolate/ Wheat starch (XPS).

Color

The L value for the control were significantly less (less light) than for all the egg replacers incorporated at 100% and 50% substitution at d 1 and d 5 (Table 5). A Hue angles for the control was

significantly greater (more yellow) than all egg replacer at 100% and 50% substitution levels and for d1 and d5 (Table 6). There are no clear relationships between any treatment or added ingredient and the hue angle.

Table 5. Comparison of the lightness (L) value of yellow cake formulated with either dried whole egg or selected replacers measured at day 1 and day 5 after baking by using a colorimeter.

Treatments**	Day 1		Day 5	
	100:0	50:50	100:0	50:50
Control	76.94 ^f		76.29 ^e	
WS	80.35 ^{de}	81.58 ^{cd}	79.90 ^{cd}	80.05 ^{bc}
WPI	82.79 ^{abcd}	81.95 ^{bcd}	81.76 ^{abc}	81.21 ^{abc}
GS	80.65 ^{bcd}	81.21 ^{cd}	81.28 ^{abc}	80.00 ^{abc}
GP	84.68 ^a	83.92 ^a	83.57 ^{ab}	82.24 ^a
GPS	84.10 ^{ab}	81.13 ^d	83.28 ^a	80.77 ^{abc}
XS	80.33 ^{cde}	82.67 ^{abc}	81.04 ^{bcd}	81.05 ^{abc}
XP	84.61 ^a	82.14 ^{bcd}	84.12 ^{ab}	81.78 ^{ab}
XPS	83.71 ^{abc}	82.18 ^{vcd}	84.39 ^{ab}	80.24 ^{bc}

*Means with different superscripts within the same column indicate significant differences among all treatments, ($P \leq 0.05$). ** Whey protein isolate (WPI), Wheat starch (WS), Guar gum/ wheat starch (GS), Guar gum/ whey protein isolate (GP), Guar gum/ whey protein isolate/ Wheat starch (GPS), Xanthan gum/ wheat starch (XS), Xanthan gum/ whey protein isolate (XP), Xanthan gum/ whey protein isolate/ Wheat starch (XPS).

Table 6. Comparison of the hue angle ($\tan^{-1} b/a$) color values of yellow cake formulated with either dried whole egg or selected egg replacers measured at day 1 and day 5 after baking by using a colorimeter.

Treatments**	Day 1		Day 5	
	100:0	50:50	100:0	50:50
CONTROL	85.08 ^a	84.67 ^a	86.12 ^a	85.22 ^a
WS	83.32 ^b	83.10 ^{bcd}	83.95 ^{bc}	83.81 ^{bc}
WPI	79.97 ^d	82.52 ^{ef}	80.52 ^e	83.30 ^{bcd}
GS	83.74 ^b	83.44 ^b	83.24 ^c	84.05 ^b
GP	79.52 ^d	81.99 ^f	80.11 ^e	82.29 ^e
GPS	80.93 ^{cd}	83.23 ^{bcd}	81.86 ^d	83.10 ^{cd}
XS	83.64 ^b	83.28 ^{bc}	84.39 ^b	83.89 ^{bc}
XP	79.44 ^d	82.65 ^{de}	79.87 ^e	82.60 ^{de}
XPS	81.77 ^c	82.89 ^{bcd}	81.85 ^d	83.43 ^{bc}

*Means with different superscripts within the same column indicate significant differences among all treatments, ($P \leq 0.05$). ** Whey protein isolate (WPI), Wheat starch (WS), Guar gum/ wheat starch (GS), Guar gum/ whey protein isolate (GP), Guar gum/ whey protein isolate/ Wheat starch (GPS), Xanthan gum/ wheat starch (XS), Xanthan gum/ whey protein isolate (XP), Xanthan gum/ whey protein isolate/ Wheat starch (XPS).

Quantitative descriptive analysis (QDA)

The QDA of cake attributes is shown in Table 7. Panelists reported that crust surface of cake variations containing xanthan and guar gums were stickier than that of the whole-egg control. Cake crust on GPS and XPS treatments in some instances actually adhered so firmly to fingers that the crust detached from crumb upon removing finger.

Cakes containing xanthan and guar gums have been found to produce sticky cakes (Villaudy et al., 1989). A similar phenomenon was found by Neville (1986), who reported that cakes with reduced foaming ability were gummy, with softer and stickier crusts. The stickiness/gumminess on the cake surface comes from the foam's instability and drainage of liquid (Mizukoshi, 1983a, b). A moisture

gradient may exist that forms from drainage in cakes (Miller et al., 1967). This moisture most frequently accumulates at the bottom of cake (Mizukoshi, 1983a). The addition of gums may reduce moisture migration and

gummy layers in cake (Miller et al., 1967) by holding excess water, thereby reducing foam instability (Miller, 1981). A small amount of moisture may have migrated to the crust, causing the sticky character.

Table 7. Quantitative descriptive analysis by a trained panel of control, compared with two formulations of yellow cake without whole egg.

Treatments**	Surface stickiness*	Crumb yellowness	Springiness ss	Moistness s	Firmness s	Egg favor
CONTROL	1.64 ^b	4.94 ^a	7.99 ^a	6.13 ^b	4.87 ^a	5.74 ^a
XPS	3.87 ^a	1.79 ^b	7.42 ^{ab}	6.60 ^{ab}	4.73 ^a	2.17 ^b
GS	3.65 ^a	2.02 ^b	7.18 ^b	6.90 ^a	3.97 ^b	2.28 ^b

*Means with different superscripts in columns indicate significant difference ($P \leq 0.05$). ** Xanthan gum/ whey protein isolate/ Wheat starch (XPS), Guar gum/ wheat starch (GS).

Sensory data showed that the whole-egg control was significantly more yellow than both the XPS and GPS variations. The XPS and GPS did not contain any added colors to account for whole-egg xanthophyll content. Whole-egg control cakes exhibited higher springiness values than did XPS and GPS. Panelists found that XPS was not statistically different from the control, but GPS was different from control. The decrease in springiness may have been caused by the decreased foaming abilities of whey protein over that of dried whole egg. Lee et al. (1993) found that substitution of 25% or more of eggs caused a decrease in springiness.

Control cakes had lower moistness values than did XPS and GPS. Data showed that the whole-egg control was significantly less moist than GPS, but there was no difference in moisture between the control and XPS. Villaudy et al. (1989) reported that the addition of hydrocolloids increased moistness in chocolate cake. Increased moistness may be caused by foam drainage, causing excessive free water in cake. Differences between XPS and GPS may be due to the water-binding ability of xanthan, compared with guar.

Firmness of control was not significantly different than that of XPS. Treatment GPS was significantly different than both control and XPS. The decrease in

firmness of GPS may have been caused by excess free water leading to gumminess. Egg flavor of whole-egg control cakes was significantly greater than the egg flavor of XPS and GPS treatments. Because variations contained no egg, this result was expected. This attribute was used more to gauge the ability of panelists and the effectiveness of training; panelists did report that XPS and GPS contained a small amount of egg flavor. This result may be caused by background flavors of vanilla and butter. The panel reported a slight off flavor in treatment with GPS. This flavor was characterized as "beany"; this may be a result of guar in the treatment. According to the ingredient sheet, guar may have a slight odor and flavor (TIC Gums, 2003).

Consumer acceptance test

One hundred and four consumers participated in the acceptance test. The prescreening data showed that the majority of consumers were between the ages of 18 and 25 and had completed at least some college, 56.7% and 54.8% respectively. Data showed that almost 75% of consumers consumed cake once every two weeks to once a month. Consumers found that the cake formula XPS was significantly more favorable than the whole-egg control cake in appearance, texture, flavor, and overall acceptability (Table 8).

Table 8. Consumer acceptance of control compared with formulation without whole- egg

Treatments**	Appearance*	Texture	Flavor	Overall acceptability
CONTROL	6.12 ^b	5.88 ^b	6.12 ^b	6.09 ^b
XPS	7.09 ^a	6.62 ^a	6.82 ^a	6.90 ^a

*Means with different superscripts in columns indicate significant difference ($P \leq 0.05$).

Hedonic Scale: 1- dislike extremely, 5- neither like nor dislike, 9- like extremely. ** Xanthan gum/ whey protein isolate/ Wheat starch (XPS).

Mean values of 104 consumer panelists indicated that the control was drier than the XPS formulation. Others stated that the control needed more flavor. Only 54% of consumer stated they would be willing to purchase the whole-egg control, whereas 70% stated they would purchase the XPS formulation.

Conclusion

The XPS cake was closest to control cake in firmness, springiness, and moistness, whereas, in the consumer acceptance test, replacement blend XPS had significantly higher ratings than did dry whole egg in cake appearance, texture, flavor, and overall acceptability. With the fast pace of changing technology in both processing technology and ingredient functionality, a competitive egg replacer may be available to processing in the near future.

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