Effect of Egg Replacers in Soft Drop Cookies

By
Kate Brackebusch
Food Science and Industry
University Honors Program
Ag Scholars Program

March 2017

Abstract

The purpose of this research was to find an optimal method of replacing eggs in soft drop cookies. This avenue of research is valuable because many large-scale bakeries can improve their production process through the elimination of this ingredient. Eggs are part of a volatile agricultural market, making their availability and price vary greatly. They also contribute a food safety concern and a common allergen. By eliminating eggs from their formulas, industry professionals can not only improve the price stability of their process, but also increase the safety of their product and reach a larger consumer base that now includes individuals avoiding eggs. This research evaluates the effectiveness of several commercial egg replacers as well as the benefit of adding additional functional ingredients, a dough conditioner and an emulsifier, to commercial egg replacers.

Literature Review

Eggs contribute many functional and nutritional properties to baked products and are one of the most important ingredients in baking. Unfortunately, when a process relies on eggs, it is relying on an ingredient that is part of a volatile agricultural market. The supply of eggs has decreased in recent years as flocks have been affected by the Avian Flu, but demand has remained strong as clean labels and high protein products are trending. Both factors have caused an increase in the price of eggs (Gorton 2014). A conflicting force is also on the rise as an increasing number of consumers are choosing not to eat eggs for dietary preference reasons or to avoid the common allergen (Berry 2013). For all of these reasons, food manufacturers can improve their process by decreasing their reliance on eggs.

When considering adopting an egg replacement system, the functionality of an egg must first be understood. Eggs provide foaming ability, structure, volume, texture, flavor, emulsification, coagulation properties, color, solubility, binding, leavening, moisture control, and nutrition to a baked product. (Geera and others 2011). Egg whites provide the majority of an egg's foaming abilities and egg yolks provide the majority of an egg's emulsifying and binding properties (Pyler 2008). A replacement system is generally comprised of multiple ingredients, each intended to replicate a specific function normally performed by an egg.

Wide ranges of egg replacement methods in baked products have been studied, with varying levels of success. In the early 1990s one study claimed near perfect results of replacing eggs in peanut butter and sugar cookies and it generated much excitement, but, unfortunately, the substitutes still contained egg ingredients and no longer qualify as egg replacers (Totheroh, Ries 1994). Some egg replacers have been recognized as moderately effective at a one hundred percent replacement level for dried whole eggs (Spencer 2013). Generally, these successful trials were in products that are less reliant on eggs in their formula (waffles, cookies, and brownies). Products requiring large amounts of support from the eggs (cakes and muffins) were most successful when egg substitutes replaced only part of the total egg amount (Berry 2013). In an examination of egg replacers in a yellow cake formulation, each of the replacements caused changes in the moisture-retaining ability, bulk density, color, texture, and flavor of the product. These changes were not readily detected in sensory analysis, but further analysis showed that the quality of the product had decreased. The researchers of this study noted that most egg replacers studied at a pilot-scale level have not been successful in commercial production (Geera and others 2011).

Protein isolates are commonly used in egg replacement systems because they compensate for the protein that is taken away when eggs are removed. Examples of protein substitutes include: skimmed milk, whey powder, bovine blood plasma, soy protein isolates, and lupine protein isolates (Arozarena and others 2001). A study done by these authors found that lupine protein isolates have good foaming and emulsifying properties. A second study found that whey protein used as a complete egg substitute (replacing 100% of the egg) in a yellow cake formula provided a comparable flavor to dried whole eggs, but resulted in a cake that was difficult to de-pan. A replacement level of 75% with whey protein produced an acceptable cake. A soy flour blend used as a substitute in this test provided an off-flavor at 100% replacement and was deemed acceptable at a 70% replacement level (Geera and others 2011). Another trial examining whey protein as an egg substitute in muffins showed an acceptable replacement level of 50%. A soy flour blend was an acceptable substitute in muffins up to 75%. The muffins made with egg replacers differed in several areas from control, but the biggest detractor from their acceptability was the undesirable moistness the replacers contributed (Geera and others 2011).

A second common method of replacing eggs is to use a combination of different hydrocolloids. In yellow cake production, xanthan gum has been noted to improve crumb structure, reduce shrinkage, and increase height (Arozarena and others 2001). A second hydrocolloid, carboxymethyl cellulose (CMC) has been determined to cause high amounts of springiness and resilience in yellow cake production. This study noted that adding CMC or xanthan gum resulted in cakes with harder crumbs than the control, but compared to the loss of integrity in eggless cakes made without the addition of hydrocolloids, these additives improved the cake. These additives produced cakes with low baking loss, low water activity, and increased firmness (Shao and others 2015).

Emulsifiers are a third method of replacing eggs in baked products. This approach follows the mindset that emulsifiers can provide necessary aeration and bubble stability during the baking process in a similar manner to eggs. One study evaluated three emulsifiers [distilled glycerol monostearate (DGMS), lecithin, and sorbitan monostearate (SMS)] as egg replacers in a layer cake formula. Each emulsifier produced a cake with greater volume and increased tenderness. Each cake was also highly accepted in the sensory analysis evaluation, suggesting that an emulsifier may make a suitable egg replacer (Rahmati and others 2014). A second study looked at emulsifiers as part of an egg replacement system instead of as a sole substitute. Emulsifiers were combined with a lupine protein isolate in a yellow cake formula. Cakes made with an emulsifier and the protein isolate were noted to have greater cake stability than cakes made without the emulsifier (Arozarena and others 2001). Commercially available dough conditioners are a method of easily incorporating emulsifiers into baked goods. The conditioners function like emulsifiers by modifying the surface behavior of liquids in which they are dispersed while adding strength to the dough. Many dough conditioners are emulsifiers, but those that are not can still mimic the behavior. These conditioners are generally added to cakes and breads to improve crumb quality and volume of the products, mimicking functions of eggs (Pyler 2008).

Replacing eggs in baked products is a difficult process, but commercial producers should consider the benefits of lower production costs, more control over their final products, and increasing consumer demand for eggless products. Several methods for replacing eggs in baked products have been tested, but few have received widespread commercial acceptance. Current studies have not yet produced a perfect egg replacer, indicating that further research in this area should be encouraged. Protein isolates and the addition of dough conditioners or emulsifiers have yielded promising results and present a reasonable avenue for future research.

Objective

Evaluated the effectiveness of several commercial egg replacers as well as the benefit of adding additional functional ingredients, a dough conditioner and an emulsifier, to commercial egg replacers in order to determine an optimal method of replacing eggs in a soft drop cookie formula.

Materials and Methods

Soft drop sugar cookies were prepared using a proprietary cookie formula and procedure provided by Specialty Bakery LLC (Indianapolis, IN). Formula ingredients, commercial egg replacers, dough conditioners, protein isolates, and emulsifiers were provided by Specialty Bakery and the Kansas State University Wheat Quality Lab (WQL). Products tested are listed in Table 1.

Table 1. Commercial egg replacers evaluated

Egg Replacer	**Type**
A	Wheat protein isolate
B	Wheat protein isolate
C	Wheat protein isolate
D	Wheat protein isolate
FiberGel	Citrus fiber
HCF	Emulsifier
GMS 540	Emulsified shortening
SSL	Emulsifier
Datem	Dough Conditioner

After thirty minutes of cooling, the height and diameter of each cookie was measured in three places using a digital caliper. Cookies were evaluated subjectively on flavor, texture, and appearance by WQL lab personnel. Observations were noted in comparison to the control formula which contained liquid whole eggs.

Results and Discussion

Initially, each egg replacer was added at 100% replacement equivalent of the level of liquid whole egg in the formula. The water level was adjusted to account for the liquid lost when replacing liquid egg with a dry egg replacer. Control cookies were made without eggs and also with liquid whole egg (no added egg replacer). Cookies that were most desirable had large diameters, were thin, and had many surface cracks. These are indicators of quality and signify a successful replacement.

At a level of 100% replacement, FiberGel had a significantly smaller diameter than the control. Each of the other egg replacers did not produce significantly different diameters. The egg replacers were less successful at creating similar heights. Replacer A was the only one to have a similar height; the others were all significantly different. FiberGel produced the most desirable flavor and similar texture to the control, but many of the replacers produced undesirable results. FiberGel, HCF, and GMS 540 produced appearances similar to the control. Replacer D produced the least similar appearance. Results of egg replacers added at 100% equivalent of egg level are listed in Table 2.

Table 2. Egg Replacers added at 100% of egg level

Egg Replacer	Diameter (cm)[a]	Height (mm)[a]	Flavor vs Control	Texture vs Control	Surface Cracks
Egg Control	8.8 abc	12.3 a	----------------	---------------	many
Eggless Control	8.5 cd	9.6 ef	bad	harder	some
A	8.5 cd	11.7 ab	ok	harder	some
B	8.5 cd	10.9 bcd	ok	harder	some
C	8.8 bcd	10.1 de	aftertaste	harder	some
D	8.4 cd	11.3 bc	bad	grainy	few
FiberGel	8.3 d	11.1 bcd	good	similar	many
HCF	8.7 bcd	10.4 cde	aftertaste	softer	many
GMS 540	8.8 abc	8.7 fg	sl greasy	softer	many
SSL	9.3 a	7.8 g	greasy	softer	few

[a] values in a column followed by different letters are significantly different ($p<0.05$)

Following tests at 100%, egg replacer levels were reduced to demonstrate the effectiveness of the replacer at a lower level. This testing was done to determine a minimum threshold of effectiveness and demonstrate potential cost-savings for commercial use. The amount of water was scaled to match the liquid lost from replacing the liquid egg, but the amount of dry egg replacer was added at 75% of the initial egg level.

At a 75% replacement, Replacers B and D, as well as FiberGel, GMS 540, and SSL produced significantly similar diameters as the egg-containing control cookies. Replacer A, Replacer C, and HCF produced significantly smaller diameters than the control. SSL was the only egg replacer to produce a significantly different (lower) height. Replacer A, Replacer C, and FiberGel produced good flavors. HCF and SSL produced bad flavors. Replacers B, C, and D, FiberGel, and GMS 540 produced good textures. HCF and SSL produced unacceptable textures. Each of the replacers produced an appearance similar to the control. Results of egg replacers added at 75% equivalent of egg level are listed in Table 3.

Table 3. Egg replacers added at 75% of egg level

Egg Replacer	**Diameter (cm)**[a]	**Height (mm)**[a]	**Flavor vs Control**	**Texture vs Control**	**Surface Cracks**
Egg Control	8.8 a	12.3 a	---------------	---------------	many
A	8.3 b	11.7 a	good	ok	many
B	8.5 ab	11.1 ab	ok	close	many
C	8.3 b	11.2 ab	good	close	many
D	8.4 ab	11.5 ab	ok	close	many
FiberGel	8.4 ab	11.0 ab	good	close	many
HCF	8.1 b	12.0 a	bad	gummy	many
GMS 540	8.4 ab	11.2 ab	ok	close	many
SSL	8.5 ab	10.2 b	bad	too soft	many

[a] values in a column followed by different letters are significantly different ($p<0.05$)

FiberGel and Replacer A were found to be the most successful replacers at the 75% replacement level. The final round of tests added either GMS 540 or Datem at varying amounts in addition to these two egg replacers, each at 100% replacement equivalent of egg level,. The purpose of these tests were to determine if these functional ingredients (GMS 540 and Datem) could improve upon the performance of the egg replacers.

With the addition of Datem to FiberGel, diameter and height at each additional level was significantly similar to the control. Each level produced a flavor and texture close to that of the control. Results of the addition of Datem to FiberGel are listed in Table 4.

Table 4. FiberGel at 100% replacement of egg level plus Datem

Level of Datem	Diameter (cm)[a]	Height (mm)[a]	Flavor vs Control	Texture vs Control
Egg Control	7.9 a	13.5 a	---------------	---------------
0.2g Datem	7.9 a	13.0 a	close	same
0.4g Datem	7.9 a	12.1 a	close	close
0.6g Datem	8.2 a	11.1 a	close	close
0.8g Datem	8.2 a	11.7 a	close	close

[a] values in a column followed by different letters are significantly different ($p<0.05$)

With the addition of each level of GMS 540 to FiberGel, there was no significant difference between the diameters and the heights to those of the control. Each level produced flavors and textures that matched that of the control. Results of the addition of GMS 540 to FiberGel are listed in Table 5.

Table 5. FiberGel at 100% replacement of egg level plus GMS 540

Level of Datem	Diameter (cm)[a]	Height (mm)[a]	Flavor vs Control	Texture vs Control
Control	7.9 a	13.5 a	---------------	---------------
0.2g GMS 540	7.8 a	12.2 a	same	same
0.4g GMS 540	7.9 a	11.9 a	same	same
0.6g GMS 540	7.8 a	13.3 a	same	same
0.8g GMS 540	8.0 a	12.5 a	same	same

[a] values in a column followed by different letters are significantly different ($p<0.05$)

Each level of Datem added to Replacer A had no significant difference on the diameters or heights of the soft drop cookies. Results of Datem added to Replacer A are listed in Table 6.

Table 6. Replacer A at 100% of replacement of egg level plus Datem

Level of Datem	**Diameter (cm)** [a]	**Height (mm)** [a]	**Flavor vs Control**	**Texture vs Control**
Control	7.9 a	13.5 a	---------------	---------------
0.2g Datem	8.2 a	12.1 a	close	same
0.4g Datem	8.0 a	12.4 a	close	same
0.6g Datem	8.2 a	11.6 a	off-flavor	hard
0.8g Datem	8.0 a	12.1 a	off-flavor	soft

[a] values in a column followed by different letters are significantly different ($p<0.05$)

Each level of GMS 540 added to Replacer A produced no significantly different diameters or heights compared to those of the control. Each of the levels, except 0.4g, produced off-flavors and similar textures to the control. Addition of 0.4g Datem produced a similar flavor to that of the control but had a a coarse texture. Results of GMS 540 added to Replacer A are listed in Table 7.

Table 7. Replacer A at 100% of replacement of egg level plus GMS 540

Level of Datem	Diameter (cm) [a]	Height (mm) [a]	Flavor vs Control	Texture vs Control
Control	7.9 a	13.5 a	---------------	---------------
0.2g GMS 540	7.8 a	13.5 a	off-flavor	same
0.4g GMS 540	7.8 a	13.3 a	same	coarse
0.6g GMS 540	7.9 a	13.0 a	off-flavor	same
0.8g GMS 540	7.9 a	12.6 a	off-flavor	same

[a] values in a column followed by different letters are significantly different ($p<0.05$)

Conclusion

Complete replacement of the liquid whole egg in this formula with commercial egg replacers at an equivalent level of 75% plus scaled water to account for all of the liquid lost with the omission of the liquid whole egg, yielded successful results. FiberGel produced the best results with similar flavors, texture, and appearance to the control and a height and diameter most similar to the control. Replacers A and B followed as the next most successful. Least successful were HCF and SSL due to bad flavors and textures.

The addition of GMS 540 or Datem to FiberGel were each successful. The results of the flavor and texture analysis indicated slightly greater success with the addition of GMS 540 to FiberGel than with the addition of Datem. Both methods produced acceptable product. There was limited success from either addition to Replacer A due to the off-flavors present.

Citations

Arozarena I, Bertholo H, Empis J, Bunger A, Sousa I. "Study of the total replacement of egg by white lupine protein, emulsifiers and xanthan gum in yellow cakes." Eur Food Res Technol. 213: 312-16. Available from: Springer Link (springerlink.com). Posted Mar 5, 2014.

Berry D. 2013 July 1. Clean-label egg replacement systems. Baking Business (web). [Accessed 2016 Dec 6]. Available from: http://www.bakingbusiness.com/features/formulations/2013/7/clean-label%20egg%20replacement%20systems.aspx.

Fennema O, Parkin K, Srinivasan D. 2007. Food chemistry. Cleveland: CRC Press. 1160 p.

Geera B, Reiling JA, Hutchison MA, Rybak D,Santha B, Ratnayake WS. 2011. A comprehensive evaluation of egg and egg replacers on the product quality of muffins. J Food Qual. 34:333-342.

Gorton G. 2014. Egg white tightness explained. Baking Business (web). [Accessed 2016 Dec 6]. Available from: http://m.bakingbusiness.com/articles/news_home/Business/2014/06/Egg_white_tightness_explained.aspx?ID=%7BBDE6E24B-EBB9-4255-A405-F012409A1056%7D&cck=1.

Meyer G. 2014. Health craze whips up prices for egg whites. Financial Times (web). [Accessed 2016 Dec 7]. Available from: https://www.ft.com/content/86c7f974-de43-11e3-ba13-00144feabdc0?ftcamp=published_links/rss/markets_commodities/feed//product.

Pyler EJ. 2008. Baking science & technology. Merriam, Kansas: Sosland. 768 p.

Rahmati A, Fatemeh N, Tehrani MM. 2014. Influence of different emulsifiers on characteristics of eggless cake containing soy milk: modeling of physical and sensory properties by mixture experimental design. J Food Sci Technol. 51.9:1697-710. Available from: Springer Link (springerlink.com). Posted Jan 5, 2014.

Shao Y, Lin K, Chen Y. 2015. Batter and product quality of eggless cakes made of different types of flours and gums. J Food Process Preserv. 39.6: 2959-968. Available from Springer Link (springerlink.com). Posted Sep 10, 2015.

Spencer J. 2013. Instead of one good egg. Baking Business (web). [Accessed Dec 7, 2016]. Available from: http://www.bakingbusiness.com/features/formulations/2013/9/instead-of-one-good-egg.aspx.

Totheron B, Ries CP. 1994. Palatability of peanut butter and sugar cookies made with egg substitutes. J Am Diet Assoc. 94.3: 321-23. Available from: Academic OneFile (galegroup.com). Posted Mar 3, 2015.