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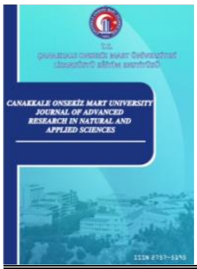

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Evaluation of the Effect of Quince Seed Extract On Physical and Sensorial Properties of Gluten-Free Cake Batter Formulations

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Research Article

Abstract − Celiac disease is a serious and lifelong disorder that is associated with gluten consumption. Celiac patients should commit to a strict gluten free diet. Besides celiac patients, gluten can also cause allergenic reactions in a significant portion of population. Thus, there is a growing trend in replacing sources of gluten with alternatives. This work concentrated on improving the quality and consumer acceptance of gluten-free cakes made out of rice flour by using quince seed extract, which is a unique hydrocolloid product that exhibits emulsification properties. The cake batter and cooked cakes were characterized in terms of water activity, color, porosity, emulsion stability, textural properties, rheological behavior and sensorial attributes. Emulsion stability results indicated an excellent improvement of physical stability of batter emulsions by addition of quince seed extract (QSE) and lecithin, which was identified with no visible phase separation in samples Q0.1E and Q0.2E. All cake batters displayed a pseudoplastic flow behavior with apparent viscosities and shear thinning behavior increasing substantially with increasing QSE concentrations. Hardness values gathered from texture profile analysis, implied that best cake texture was obtained via QSE and lecithin incorporation. Sensory analysis results also supported the same result in that, samples with egg yolk and QSE both, yielded a more preferable appearance and texture. Therefore, with this study, it was possible to observe the promising effects of QSE incorporation on cake batter and baked cake properties.

Keywords – *Celiac, emulsion stability, gluten network, hydrocolloid, sensory analysis, texture*

1. Introduction

The need for gluten-free products, is advancing as a result of the growth in number of people with celiac disease (Cureton & Fasano, 2009). Trends in the market and the increasing in the numbers of celiac disease patients have provoked comprehensive research for the establishing better gluten-free products (Houben et al., 2012). Regardless, it is a big challenge to produce gluten-free bakeries at comparable qualities to gluten-containing products, as gluten is essential for an extensive dough network and absence of it is detrimental on the viscoelastic properties of the dough. Typically, gluten-free formulations involve the use of various components and additives to mimic the viscoelastic properties that gluten confers to the dough which increases final product quality (Demirkesen et al., 2014; Hager & Arendt, 2013; Sciarini et al., 2010).

For this purpose, numerous gluten-free formulations were studied, with most of them involving gluten-free flours such as rice, sorghum or maize flour (Mancebo et al., 2015; Schober et al., 2005; Sciarini et al., 2010), or pseudocereals like amaranth, quinoa, buckwheat (Hager & Arendt, 2013; Mariotti et al., 2013), legume flours such as pea, soy, chickpea (Aguilar et al., 2015), starches like cassava, corn, potato (Lazaridou et al., 2007; Mahmoud et al., 2013). These ingredients are used in combination with emulsifiers, hydrocolloids, shortenings or combinations of these as alternatives to gluten. These added ingredients give gluten-like properties to the dough, this way the sensorial and nutritional properties as well as the shelf life of the breads

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can be improved. However, the addition of these ingredients also leads to a higher final price (Demirkesen et al., 2014; Ronda et al., 2015).

Hydrocolloids are a type of additive that is commonly applied for this purpose (Houben et al., 2012; Matos & Rosell, 2015). Incorporation of hydrocolloid type of additive is therefore a very promising application for increasing the quality of gluten-free dough formulations. Hydrocolloids, as the name suggests, are hydrophilic compounds that are abundant in polar groups and can be observed under various chemical structures. These compounds provide a can be used for a wide range of applications one of them being the improvement of the quality of gluten-free bakery products (Li & Nie, 2016). Though different hydrocolloids all function differently, the main mechanism of action is the increase in viscosity, which enhances dough development and strengthens the dough network that is particularly essential for gluten-free formulations. The strengthened network enhances dough development by improving air retention during baking (Capriles & Arêas, 2014).

Technical parameters such as bulk volume and crumb hardness are especially critical in gluten-free products and thus, are the most studied parameters followed by sensorial attributes (Houben et al., 2012; Kittisuban et al., 2014). The positive effect of some hydrocolloids (such as xanthan gum, guar gum, pectin) on gluten-free products have been well established, are being used widely commercially in gluten-free formulations. These hydrocolloids are not only used as gluten substitutes in gluten-free formulations, they are also applied to gluten containing products to modify texture, raise moisture retention, and improve the overall consumer acceptability of the products (Rojas et al., 1999).

Hydrocolloids are seldom used alone, and are usually coupled with other similar hydrocolloids and/or emulsifiers. Dough is a unique network in that it is both an emulsion and a suspension; increased physical stability introduced by addition of emulsifiers coupled with the improved elasticity of the continuous dough network, acts synergistically and greatly enhances quality of the final gluten-free product (Demirkesen et al., 2013; Turabi et al., 2008a). Some hydrocolloids display emulsification properties and these are especially more effective in helping develop a better dough structure in gluten-free products. Gum Arabic is such a hydrocolloid and is one of the most widely studied and commercially used hydrocolloids. It is chemical structure can be summarized as being a branched polysaccharide mainly composed of L-arabinose and D-galactose. The gum contains proteins (1–2% by wt) which confers it surface activity (Vernon-Carter et al., 2008). However, the gum's general application is limited by its high price (Dickinson, 2018).

Another such hydrocolloid that also shows surface activity is quince seed extract (QSE). Quince (*Cydonia oblonga*) is a fruit that is native to the West Asian region. It's especially highly grown in the Caucasus regions, Afghanistan, Iran, Dagestan, and southern regions of Turkey (Abbastabar et al., 2015). The seeds of the fruit contain hydrocolloids that demonstrate excellent gelling capacity. The seed extract is also shown to provide viscosity enhancement and increasing shear thinning behavior to solutions (Abbastabar et al., 2015). Some recent studies have also confirmed the emulsifying effects of quince seed extract in model and real food emulsions. The extract is especially effective as an emulsifier at a pH range of 6–8 (Kirtil & Oztop, 2016; Ritzoulis et al., 2014).

Nevertheless, to the best our knowledge, there are no studies that involve the use of this novel hydrocolloid source in improving the functional properties of gluten-free cake batter. The aim of this thesis is to investigate the effect of quince seed extract used by itself or in combination with a natural emulsifier (egg lecithin) on physical quality attributes and sensorial characteristics of cake batter and cake products. For this purpose, cake formulations were produced with different quince seed extract concentrations (0.1% and 0.2%) and with or without the addition of a lecithin as an additional emulsifier. The cake batter was analyzed for its water activity, rheological behavior and emulsion stability; whereas the baked cakes were analyzed for their textural properties, porosity and sensorial properties.

2. Materials and Methods

2.1 Materials

Wheat flour (Sinangil, Tekirdağ, Turkey), gluten-free flour (Riace flour, Sinangil, Tekirdağ, Turkey), sugar (Granulated sugar, Migros, İstanbul, Turkey), margarine (Becel, İstanbul, Turkey), salt (Iodized Table Salt, Billur Tuz, İzmir, Turkey), baking powder (Dr. Oetker, İzmir, Turkey) and drinking water (Nestle, Bursa, Turkey) was purchased from a local grocery store in İstanbul. Quinces for preparation of quince seed extract

(QSE) was purchased from a local grocery store in Ankara. Egg white powder and whole egg powder was purchased from Kor Agro Organik Gıda A.Ş (İstanbul, Turkey).

2.2 Methods

2.2.1. Sample Preparation

Batter formulation was based on the amount of flour (in terms of weight). The batter consisted of sugar (%100), margarine (%25), egg white powder or whole egg powder (%9), salt (%3), baking powder (%5) and water (%36) with the given percentages. These percentages give the weight of the ingredient used with respect to the weight of the flour. For 100 g flour, 100 g sugar, 25 g margarine, 9 g egg powder, 3 g salt, 5 g baking powder and 36 g water was used.

Sugar and egg powder was first whipped on a bowl and molten margarine was added to the mixture and further sheared for 1 min. Then, the remaining dry ingredients (flour, baking powder, salt and QSE) were mixed at a separate place, to which water was incorporated and homogenized with a high speed homogenizer (Ultraturrax, WiseTis HG-15D, Wertheim, Germany) at 2000 rpm for 2 min. The two mixtures were then combined in one single bowl and mixed for 5 min with a kitchen type mixer (Philips, HR1453, Holland). After batter is prepared, they were poured into small cylindrical porcelain cupcake cups (D=70 mm, h=40 mm) and baked in a conventional home-type oven at 175ºC for 30 min.

The formulations differ in the amounts of quince seed extract (QSE) and presence of either egg white powder or whole egg powder, and the flour type (wheat flour or gluten-free rice flour). **Table 1** lists the ingredients used for each sample formulation.

Table 1 Sample formulations

Formulation	**Control**	**GF Control**	**Q0.1**	**Q0.2**	**Q0.1 E**	**Q0.2 E**
Rice Flour	-	+	+	+	+	+
Wheat Flour	+	-	-	-	-	-
Sugar	+	+	+	+	+	+
Shortening	+	+	+	+	+	+
Egg White	+	+	+	+	-	-
Egg Whole	-	-	-	-	+	+
Salt	+	+	+	+	+	+
Baking Powder	+	+	+	+	+	+
QSE	-	-	0.1 % w/v	0.2 % w/v	0.1 % w/v	0.2 % w/v

"+" sign represents the ingredients that are in the formulation of that specific sample, "-" sign represents that the formulations lacks that ingredient.

2.2.2. Rheological Characterization

For rheological characterization, shear rate ramp and amplitude and frequency sweep tests were performed. Measurements were obtained using a parallel plate (40 mm diameter and 1 mm gap) rheometer (Kinexus Dynamic Rheometer, Malvern, UK) was used. In shear rate ramp experiments, shear stress values were measured for shear rates changing from 0.1 s^{-1} to 100 s^{-1}, with a total measurement time of 2 min and 20 sample points. Shear rate ramp results were fit to a power-law model (equation 2.1)

$$\tau = K\gamma^n \tag{2.1}$$

where τ is shear stress, K is the consistency index, γ is shear rate, n is flow behavior index. Amplitude sweep tests were performed to estimate the linear viscoelastic region with strains ranging between 0.01%–1% at a set frequency of 1 Hz. Elastic (G′) and viscous (G″) moduli were recorded for strains increasing at a fixed frequency. After amplitude sweep measurements, a strain of 0.1% was chosen to be used as a parameter for frequency sweep measurements. This strain lied within the linear viscoelastic region for all samples. Frequency sweep measurements were carried out to investigate the effect of frequency on elastic (G′) and viscous (G″) moduli. Frequency sweep tests were conducted with frequencies ranging between 0.1%–1% at a fixed strain of 0.1%. All rheological measurements were conducted at 25 ±0.1 °C within 2 h of cake batter preparation.

2.2.3. Water Activity

To investigate the water binding capability of each formulation, water activities of the cake batter samples were measured. For this purpose, a water activity device (Rotronic, HygroPalm HP23-Aw&HC2-Aw-USB, Switzerland) was used. Approximately 5 g of sample was placed into a sealed cup and placed into the device. After waiting for 30 min, for the water activity to come to equilibrium, measurements were recorded.

2.2.4. Emulsion Stability

Cake batter samples were centrifuged (Hettich Zentrifugen, EBA 20, Germany) at 4032 rcf (6000 rpm with a rotator radius of 10 cm) soon after preparation for 20 min at 25ºC. The supernatant was identified as the fat portion and the volumetric ratio of it was calculated by measuring the height of supernatant and dividing it by the total height of batter sample. This ratio was multiplied by 100 to report as percentage of emulsion stability. Percent creaming index results were calculated from equation 2.2;

$$\%CI = \frac{H_C}{H_T} \times 100 \tag{2.2}$$

Where H_C is the height of the cream later and H_T is the total height.

2.2.5. Porosity

For porosity measurements, a modified version of the displacement method from (Turabi et al., 2008b) was employed. To calculate the porosity of the cakes, first bulk and true volume of the cakes were calculated. To calculate bulk volume, cakes were cut into regular shaped rectangular prisms of which the volumes were calculated bv multiplication of the three sides. These samples were then compressed under a load of 20 N for 10 min until there was no pore left within the sample. The true volumes were calculated from the multiplication of the three sides of the final compressed samples. Porosity were then calculated from equation 2.3;

$$Porosity = 1 - \frac{True\ Volume}{Bulk\ Volume} \tag{2.3}$$

2.2.6. Color

The color of baked cakes were measured by a spectrometer (Konica Minolta, CM-5, Japan). The CIELAB color space system was utilized for the measurements. In this system, L* represents lightness, whereas a* and b* values stand for the four main colors of human vision: red, green, blue, and yellow. Color measurements were taken only from the crust and from 8 different locations (4 from the top, 4 from the bottom and 4 from the lateral section).

2.2.7. Texture Profile Analysis

Texture profile analysis of cake samples were performed with a texture analysis instrument (Stable Micro Systems, TA-XT Plus, UK) using a 35 mm diameter probe. A compression mode texture profile analysis was conducted with a pre-test speed, test speed and post-test speed of 10 mm/s, 2.0 mm/s and 2.0 mm/s, respectively. The samples were compressed with a trigger force of 5 g. until a target strain of 40% was achieved. From the TPA curves obtained, hardness of cakes were reported since these are considered to be one of the primary indicators of textural quality for cakes (Chakraborty et al., 2020).

2.2.8. Sensory Analysis

To investigate the sensorial properties of the cakes, consumer studies were performed. All cakes were freshly baked and sealed with a plastic film up until testing, and were tested within 2 h of preparation. Sensory attributes evaluated were taste, color, texture and odour. For scoring, a five-point hedonic scale was used. The higher the rating the better that quality attribute was. Scores ranged from “Dislike very much” (score 1) to “Like very much” (score 5) (Ballesteros López et al., 2004; Thybo et al., 2004). The tests were conducted on a total of 25 untrained panelists with ages ranging between 20-45.

2.2.9. Statistical Analysis

All measurements were carried out in at least three replicates. Statistical analysis software Minitab (Version 16, State College, PA, USA) was used for the analysis of variance (ANOVA) and Tukey's multiple comparison tests. Differences were considered significant for $p \leq 0.05$.

3. Results and Discussion

3.1 Water Activity

Cake photographs are given in Figure 1 and water activity measurement results are given in Table 2. As apparent from the table, there is no difference between water activities of different cake batters. The objective of measuring water activity was to investigate the difference in water binding capability of different formulations. Control and GF Control samples contained no additives. They only contained ingredients that a standard cake formulation would contain. Wheat flour and rice flour cake batter was apparently not different in terms of their interaction with water. Flours contain high amounts of starch, where wheat flour is composed mainly of wheat starch whereas rice flour mainly consists of rice starch (Mancebo et al., 2015; Steglich et al., 2014; Wilderjans et al., 2013). Different starches differed in the relative amounts of amylose and amylopectin and granule sizes and shapes. But non-gelatanized starch is not soluble in water, thus water-starch interactions are not sufficient to have a significant effect on water activity (Tananuwong & Reid, 2004). This explains why different flours do not effect water-binding capability of cake batter.

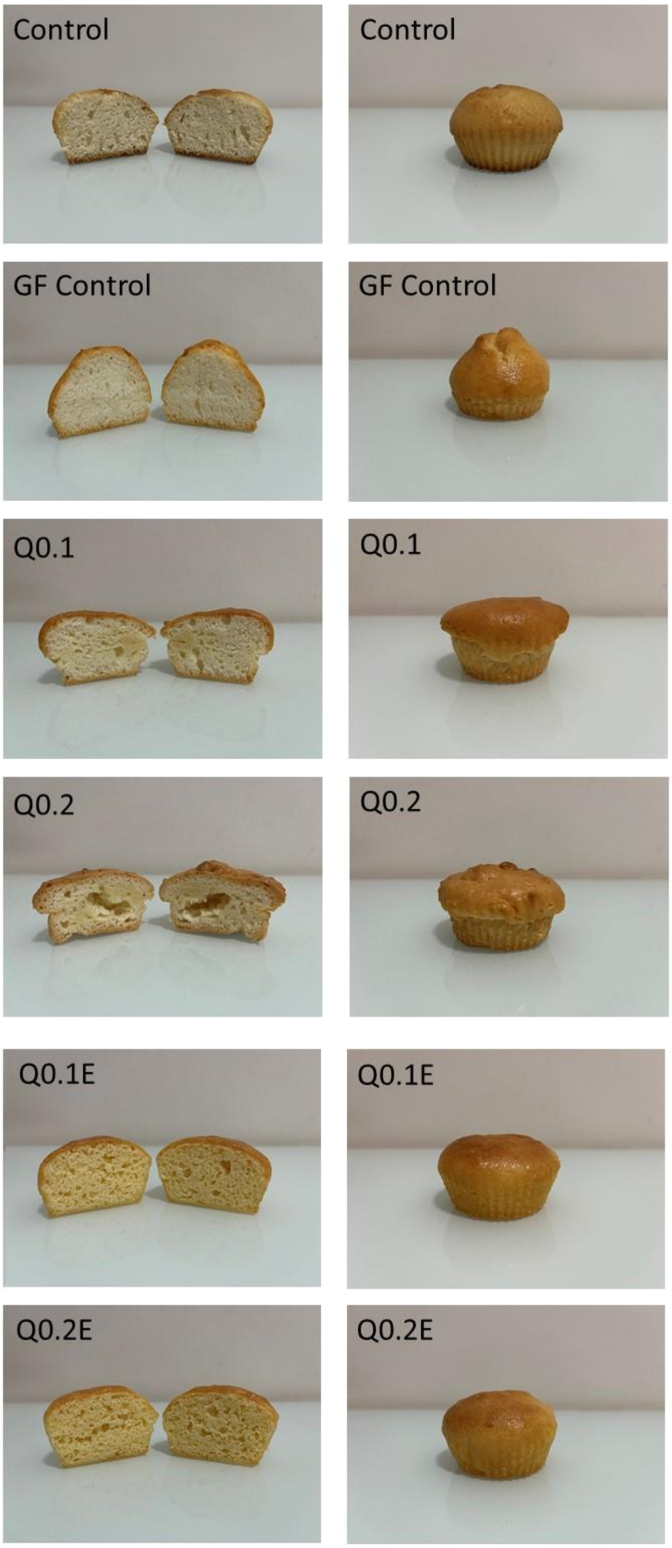

Figure 1 Photographs of cake samples

Table 2
Results of cake water activity, batter creaming index (%CI), cake porosity and cake hardness measurements

Samples	a_w	CI %	Porosity	Hardness (g)
Control	0.88±0.01^{a}	11.5±0.24^{a}	0.53±0.03^{ab}	2382±72.0^{a}
GF Control	0.88±0.01^{a}	6.73±0.34^{b}	0.59±0.03^{a}	906±56.4^{c}
Q0.1	0.87±0.01^{a}	7.21±0.38^{b}	0.46±0.04^{b}	1289±81.2^{bc}
Q0.2	0.87±0.01^{a}	7.21±0.31^{b}	0.32±0.04^{c}	1107±75.6^{bc}
Q0.1E	0.88±0.01^{a}	0	0.57±0.05^{a}	1465±92.5^{b}
Q0.2E	0.88±0.01^{a}	0	0.54±0.03^{ab}	1359±75.0^{b}

Means within the same column, followed by the different letters are significantly different ($p<0.05$).

Addition of egg yolk and quince seed extract also did not seem to effect water activities. As explained in introduction, the major portion of quince seed extract is polysaccharides, which are highly hydrophilic compounds. Thus, an increase in QSE concentration is normally expected to decrease water activities by hydrogen bonding with water molecules. However, the presence of starch-fat network dispersed in water seems to get in the way of QSE-water interactions. QSE being a surface active material, could instead position itself on the interface which decreases water-QSE interactions greatly (Kirtil et al., 2022). This coupled with the low concentrations of QSE might hinder the water binding capacity of the polymer. Hence, no difference in water activities could be observed even for samples with QSE.

3.2 Emulsion Stability

Creaming index (%CI) results can be seen in Table 2. Emulsion stability measurements involves the measurement of the height of the cream layer after a controlled destabilization procedure. Higher %CI values are associated with a lower resistance against destabilization. Control samples displayed the highest creaming index results (at 11.5%), which indicates that wheat flour was least effective in providing stability to cake batter. Rice flour was much better at providing a more stable emulsion. However, rather than the flour type, this is most likely related to the additives in GF flour used. The commercial GF flour used contained pectin and xanthan gum at unknown amounts. Both these additives are very large hydrophilic molecules. The presence of these large molecules in the aqueous phase, might have retarded the mobility of oil particles; which presumably retarded creaming rate (Kirtil & Oztop, 2016; Kontogiorgos, 2019). The same is true for samples that contain QSE. QSE has emulsification properties and is shown to be an effective emulsion stabilizer, yet in the cake batter network formed, QSE did not seem to show any emulsion stabilization properties. On the other hand, samples prepared with whole egg flour, did not show any creaming. This means lecithin in egg yolk was effective in providing thermodynamic stabilization to the cake network. Small lecithin phospholipids were much more effective than the much bulkier QSE molecules at providing stabilization at the oil-water interface. QSE molecules most likely dues to lack of water, was not hydrated enough to position itself effectively at the interface, and didn’t have effective volume to take the most favorable conformation that confers it surface activity (Kirtil et al., 2022).

3.3 Porosity

Porosity results are given in Table 2. There was no significant difference between Control and GF Control samples in terms of porosities ($p>0.5$). This means cake batters prepared from rice and wheat flour were similar in terms of their air entrapment capacities. QSE containing samples had lower porosities. Moreover, with increasing QSE concentration porosities seemed to decrease. QSE is a very large biopolymer and has viscosity enhancing and gelling properties (Farahmandfar et al., 2017; Kirtil & Oztop, 2016). QSE containing batter were visibly thicker and more solid-like in terms of texture. This tougher and stiffer batter network provides a higher resistance against the rising of batter during baking. Hence, air bubble could not be formed as effectively.

For optimal porosity, an elastic network is necessary. The cake batter needs to be in optimal flexibility and toughness. Gluten is particularly essential in conferring the batter its unique properties. Gluten increases the resistance of the batter against rupturing and gives it a stronger, more flexible texture. If the batter is too tough, then batter could not rise as efficiently during baking. If it is too soft then the raised batter network could rupture and air bubble would merge, thus cake would collapse. An optimal cake batter stiffness and elasticity would be soft enough to rise by air formation during baking and be strong enough to entrap the bubble without them merging (Milde et al., 2012; Sangpring et al., 2015).

Addition of egg yolk (samples Q0.1E and Q0.2E), increased porosities. This could be related with the softening effect of fat particles that are liquefied during cooking. The additional fat conferred softness to the batter, which decreased the stiffness of the batter network. The decreased stiffness aided with the air bubble formation and cake batter rise during cooking. This was observed as increased porosity values. Cake pictures that also give an idea of the porosity and internal structure of cakes can be seen in Figure 1.

3.4 Color

Table 3
Color measurement results

Top Surface	Control	GF Control	Q0.1	Q0.2	Q0.1E	Q0.2E
L*	88.3	88.4	88.4	88.4	88.4	88.4
a*	-0.292	-0.252	-0.257	-0.267	-0.340	-0.360
b*	0.2475	0.345	0.342	0.312	0.210	0.217
Bottom Surface						
L*	88.2	88.1	88.2	88.2	88.1	88.1
a*	-0.370	-0.380	-0.355	-0.335	-0.405	-0.400
b*	0.050	0.050	0.085	0.120	0.005	0.020
Lateral Surface						
L*	88.7	88.6	88.8	88.6	88.6	88,6
a*	-0.515	-0.555	-0.555	-0.550	-0.515	-0.515
b*	0.240	0.095	0.210	0.150	0.225	0.240

Color measurement results can be seen in Table 3. L* of the CIELAB coordinates represents lightness (total black gives L* = 0 and diffuse white gives L* = 100). For a*, the negative values represent green color and positive values represent red hues and similarly for b*, negative values represent blue color and positive values represent a yellowish hue. According to the results, regardless of formulation all cakes displayed similar lightness values (around L*=88.5). Therefore, we can say that addition of QSE or lecithin had no effect on color. The lightness of cakes is related to the Maillard reaction end products, particularly the melanoidin pigment formation (Bi et al., 2017). This shows that formulation changes had no influence on the rate and extend of Maillard reaction in cakes. The a* values of the cakes ranged between -0.25 and -0.55. Thus cakes displayed a more greenish color than a reddish color. For b* values, the measurements ranged between 0.005-0.34. This indicates that all cakes were yellowish in color. We could not observe any noteworthy trend in the change of a* and b* values with respect to formulation of position on the crust. However, the fact that L* values are identical on all points on cake crust shows that cakes were homogenously cooked, and no one surface was subjected to a higher heat transfer rate compared to others.

3.5 Rheological Characterization

Figure 2a and Figure 2b shows the change of shear viscosity (Pa.s) with shear rate (s^{-1}) in a normal and logarithmic scale, respectively. For all formulations, the apparent viscosity values decreased with increasing shear rates. This indicates that cake batter shows a pseudoplastic behavior. The pseudoplastic behavior is explained with the alignment of molecules in the mixture with the direction of flow. As the rate of shear increases more and more molecules are aligned with direction of flow and resistance against flow decreases, which is monitored as a decrease in apparent viscosity values (Turabi et al., 2008b). Control formulation prepared with wheat flour displayed the lowest apparent viscosities. There was a considerable (almost 10 fold) difference in viscosities for the whole range of shear rates studied between control sample and GF control sample. This indicates that Control sample batter network showed the lowest resistance to flow. On the other hand, Q0.2, which is the formulation with highest amount of QSE, displayed highest apparent viscosities; which means it displayed the highest resistance against flow. This flow could be air bubble formation and rise inside the cake batter. Q0.2 should be highly resistant against the formation and rise of air bubble and this result is confirmed with the low porosity values this sample also displays as shown in Table 2.

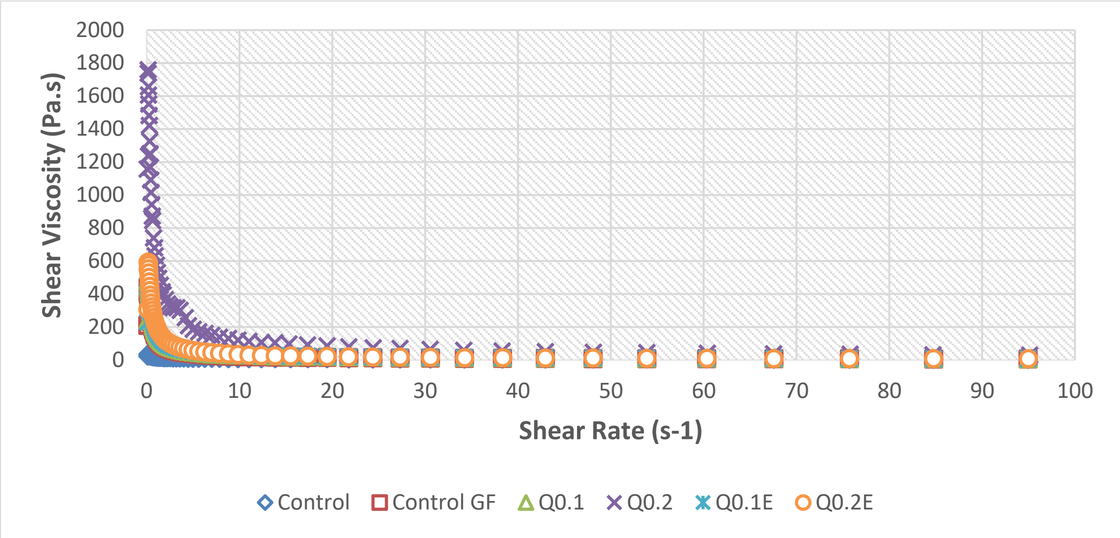

Figure 2a Change of shear viscosity with shear

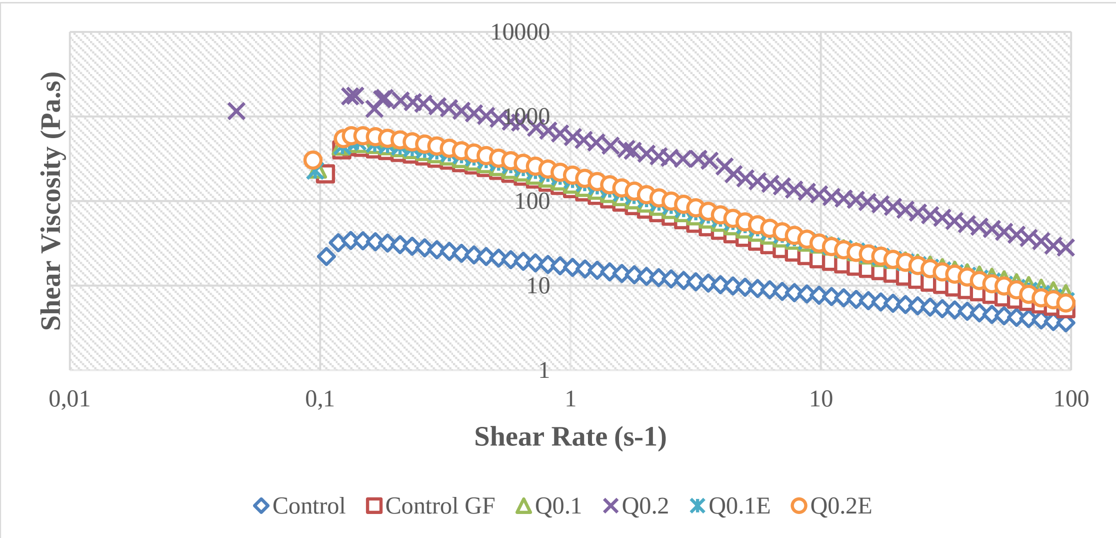

Figure 2b.Change of shear viscosity with shear rate in a logarithmic scale

As evident from the Figure 2, there is a linear trend between shear viscosities and shear rates if drawn on a logarithmic scale. This implies a shear thinning behavior. The shear rate and shear stress data were fit to a power law model and resulted in very high correlation coefficients (R^2>0.96). The results of the fittings were given in Table 4.

Table 4
Power law fitting results

	K	N	R^2
Control	16.6±0.48[e]	0.665±0.04[a]	0.99
Control GF	121.5±1.24[d]	0.292±0.02[c]	0.96
Q0.1	144.6±1.32[c]	0.358±0.02[b]	0.98
Q0.2	539.0±2.17[a]	0.374±0.02[b]	0.97
Q0.1E	153.3±1.23[bc]	0.330±0.03[bc]	0.96
Q0.2E	173.7±1.14[b]	0.288±0.02[c]	0.95

K are the consistency index value whereas n are power law index values. K can be identified as the apparent viscosities recorded at a shear rate of 1 s^{-1}, thus is a measure of the material's resistance to flow. All formulations flow behavior can be explained with a power law model and a shear thinning behavior. With increasing QSE concentration and lecithin addition, shear thinning behavior is enhanced. The batter network gets thicker and more viscous as hydrocolloid and emulsifier concentrations increase; yet it becomes easier to break this network and make it thinner with stress application. For increasing flow rates, the materials gets thinner and thinner and this effect is particularly enhanced for samples with higher QSE and lecithin content. Other studies have also reported similar flow behavior when shear thinning gums are added to gluten free flours (Turabi et al., 2008b, 2010).

3.6 Texture Profile Analysis

Hardness values are given in Table 2. Control cakes exhibited the highest hardness values. The cakes prepared from wheat flour with a standard formulation were the hardest. Gluten free cakes were significantly softer than all other formulations. This is a common problem with gluten free bakery products. Gluten is responsible for giving batter a texture that is more resistance against stretching. Without gluten, cake batters and the cakes formed from that batter, will not be strong enough to hold its own and will crumble with mild perturbation. This is not a desirable property and the hardness of control cake from wheat flour should be taken as a reference here. The closer the cake's hardness is to this value, the better the quality of the cake (Burešová et al., 2016; Sangpring et al., 2015; Schober et al., 2005). With this in mind, Q0.1E and Q0.2E samples yielded the best cakes. So addition of QSE and coupling it with an emulsifier as lecithin was successful in giving a tougher texture to the batter network. Large QSE molecules helped in formation of a more extensively bonded network, whereas egg yolk phospholipids positioned themselves on the oil-water interface and eased dispersion of fat into the batter (Burešová et al., 2016; Sangpring et al., 2015; Schober et al., 2005).

3.7 Sensory Analysis

Sensory analysis results can be seen in Table 5. The overall sensorial acceptance of the products was relatively good. Mean scores ranged between 2.8-4.1. This indicates that all formulations were acceptable in terms of taste, color, texture and odor. However, considering the data it is not possible to comment on specific differences on sensorial properties between different samples. The standard deviation of scores was too large so the differences for most attributes was not statistically significant. There are a few things to mention here. Color of whole egg containing samples (Q0.1E, Q0.2E) were found to be significantly more preferred by panelists compared to other samples. Upon visual inspection, it was possible to see a more yellowish hue in these samples, which could be reflected to the sensory analysis results as a higher preference. Again for Q0.1E and Q0.2E, texture was also more preferred. These samples were softer and mushier in texture possibly due to the higher fat content coming from egg yolk. The higher fat content was also identified by a shinier outer surface compared to other samples. Therefore, these results show that it was possible to improve the consumer acceptance of gluten free cakes in terms of texture and appearance.

Table 5
Sensory analysis results

	Taste	Color	Texture	Odor
Control	2.8±0.4^{a}	3.6±0.4^{b}	2.9±0.3^{b}	3.5±0.2^{a}
Control GF	3.1±0.5^{a}	3.3±0.3^{b}	3.5±0.5^{ab}	3.3±0.2^{a}
Q0.1	3.5±0.4^{a}	3.3±0.3^{b}	3.3±0.4^{b}	3.7±0.2^{a}
Q0.2	3.2±0.3^{a}	3.2±0.2^{b}	3.5±0.3^{ab}	3.5±0.3^{a}
Q0.1E	3.2±0.5^{a}	4.1±0.3^{a}	3.9±0.2^{a}	3.4±0.2^{a}
Q0.2E	3.4±0.4^{a}	4.1±0.3^{a}	3.8±0.2^{a}	3.6±0.3^{a}

4. Conclusion

This work concentrated on improving the quality and consumer acceptance of gluten-free cakes made out of rice flour by using a new hydrocolloids source, quince seed extract. Numerous researchers have used non-adsorbing hydrocolloids to increase the strength of the cake batter network and simulate the role of gluten in batter. These hydrocolloids yielded even more successful results when used in combination with emulsifiers that show surface adsorption capabilities. Quince seed extract is a unique hydrocolloid that also has emulsification properties. Hence, we wanted to see how it would function as a gluten replacement in cake batter.

The study yielded promising results. In terms of water activities, which is an indicator of water binding capacity of the batter ingredients. There was no significant difference between formulations. An increase in QSE concentration is normally expected to decrease water activities by hydrogen bonding with water molecules. However, the presence of starch-fat network dispersed in water seemed to prevent QSE-water interactions. Emulsion stability results indicated an excellent improvement of physical stability of batter emulsions by addition of QSE and lecithin, which was identified with no visible phase separation in samples Q0.1E and Q0.2E. QSE seemed to function better in presence of egg yolk lecithin and fat, this was particularly evident from porosity results that shows that the porosity of Q0.1E and Q0.2E samples were similar to porosity of control wheat flour sample.

All cake batters displayed a pseudoplastic flow behavior with apparent viscosities and shear thinning behavior increasing substantially with increasing QSE concentrations. Hardness values gathered from texture profile analysis implied that best cake texture was obtained via QSE and lecithin incorporation. Sensory analysis results also supported the same result in that, samples with egg yolk and QSE both, yielded a more preferable appearance and texture.

Therefore, with this study, it was possible to observe the effect of QSE on cake batter and baked cake properties. The results were promising in that some quality attributes of cake samples were improved with QSE addition.

Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

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