Effect of Soya flour, Carrageenan and Glycerol Monostearate as Egg Replacers on Cake Quality

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Background

Egg plays many functional roles in cakes during the different stages of the cake making process. These functions are mainly foaming and emulsification during the batter preparation and heat coagulation which is vital during baking stage (Hui and Corke, 2006). Soya flour (SF) can form fragile and soft gels (Riaz, 2006) and has almost the same stabilising and foaming capacity of egg white, and it was used successfully to replace 25% of the egg almost the same volume and texture as the control with no egg replacement in muffins (Gilbertson and Porter, 2001). The aim of this study was to study the effect of a combination of soya flour with a gum (Carrageenan CG), and emulsifier (Glycerol Monostearate GMS) on Madeira cake quality based on results of Ashwini et al., (2009) and Arozarena et al., (2001).

Methods

Several cake formulations were prepared to investigate the effect of varied degrees of egg replacement on the quality of cake (table 1), cakes were weighed after baking to calculate baking loss and specific weight. After that cakes were left 24 hours at 21 ^{o}C, then height and volume were measured using VolScan. Texture measurements were taken 1 day after baking and a week after the first measurement using the Texture Analyser, where 3 samples were tested each day for each formula. Scans of the middle slice of cakes from each formula were taken using an hp scanner to compare appearance and crumb structure.

Table 1: Cake batter formulas investigated (g).

Ingredients	Flour	Sugar	Margarine	Whit Shortening	Baking Powder	Whole Egg	SF	Water	CG	GMS
C	500	400	200	200	7	500	-	-	-	-
P25%	500	400	200	200	7	375	13	95	0.63	0.63
P50%	500	400	200	200	7	250	25	190	1.25	1.25
P75%	500	400	200	200	7	125	38	285	1.88	1.88
E100%	500	400	200	200	7	-	50	380	2.5	2.5

Results and Discussion

The increase in egg replacement caused a decrease in cake volume, specific volume and height. Volume and specific volume were the most dependant cake properties (table 2) and they decreased significantly ($p<0.05$) with each increase in egg-replacement. Cake height is not proportional to its volume since the cake shape is conical and because cake from some formulas shrunk after being removed from the oven. In terms of height, only cake with 25% egg replacement showed no significant difference ($p<0.05$) compared to standard cake, this is similar to what has been achieved by (Gilbertson and Porter, 2001) in muffins, however Madeira cake recipe used in this study has higher fat content than muffin recipe which puts more pressure on cake structure and suggest that this formula achieved better results.

Table 2: Mean values for cake parameters ± standard deviation in each cake formula and their significant differences ($p< 0.05$).

Formula	Baking Loss % in Round Cakes	Volume (cm^3)/200 g of batter	Specific Volume (cm^3/g)	Height of the middle slice (mm)
C	10.15 ± 0.42 a	373.93 ± 31.73 a	2.08±0.17 a	37.85 ± 5.08 a
P25%	9.72 ± 0.65 a	338.88 ± 30.21 b	1.87±0.15 b	34.3 ± 2.21 a,b
P50%	9.86 ± 0.64 a	313.25 ± 3.88 c	1.74±0.03 c	31.38 ± 0.95 b,c
P75%	11.37 ± 0.7 b	273.78 ± 4.79 d	1.54±0.02 d	27.5 ± 0.62 d,e
E100%	12.02 ± 0.43 b,c	234.75 ± 3.74 e	1.33±0.02 e	26 ± 1.37 e

The cake structure, which is built on the solidified batter foam, seems to be weakened by the gradual removal of egg protein which has the property of remaining flexible and allowing for further volume expansion during the baking in oven and then shaping the cake structure alongside with starch gelatinisation (Pernell et al., 2002); the difference in heat-set properties between egg white and soya flour proteins could be the factor leading to the volume loss (figure 1).

There was a significant increase ($p<0.05$) in baking loss for formulas with 75% and 100% egg replacement which could be attributed to a reduction in water holding capacity due to the egg replacement and the added water which is easier to evaporate than water bound to egg components in the control (Puhr and D'Appolonia, 1992).

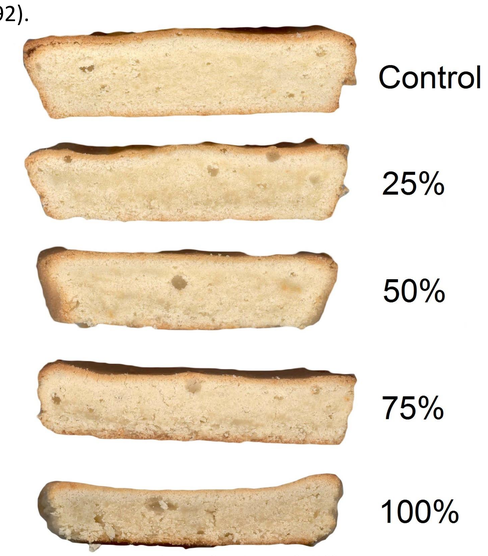

Figure 1: Cross section of cakes of different egg replacement ratios (25%, 50%, 75%, 100%) compared to the control.

In day 1 after baking, cake firmness slightly (but not significantly) decreased with the increase in egg replacement compared to the control. However, Ambient storage for a week led to a significant increase ($p<0.05$) in firmness of all experimental samples compared to firmness in day 1 (Table 3).

In day 8, the control and P25% formulas had significantly ($p<0.05$) higher firmness compared to the rest of formulas which contained 50% egg replacer or more. This result can be explained by the combined effects of “CG, GMS and SF” and the initial firmness values in Day 1. Soya flour gives a softer crumb and slows starch retrogradation process due to its content of soybean-soluble polysaccharides and soybean 7S globulin which are known to retard starch retrogradation by competing with starch for water (Wang et al., 2015).

Soya lecithin has been found to successfully slow wheat starch crystallisation due to the effect of its high content of lysophospholipids which retards amylopectin crystallisation (Gómez et al., 2004).

Table 3: Means of firmness ± standard deviation of cakes made with different formulas and tested on days 1 and 8 and their significant differences.

Formula	Firmness (g) at Day 1	Firmness (g) at Day 8	Significance between Day 1 & Day 8
C	1071.2 ± 155.7 a,b	2365 ± 333.4 a	**
P25%	1030 ± 124.1 a,b,c	2561.4 ± 223 a	**
P50%	1151.5 ± 16.4 a	1726.9 ± 307.5 b	**
P75%	899.2 ± 19.4 c,d	1396.1 ± 91.6 b,c	**
E100%	959.9 ± 55.9 b,c,d	1219.4 ± 98.1 c,d	*

Conclusion

Formula 25% had the best quality attributes compared to the control and it was not significantly different in terms of height, however, it had significantly less volume ($p<0.05$). The use of SF in combination with CG and GMS seems to give better results than SF on its own. Soya flour seems to have a softening effect on the cake structure and reduces firmness rate with storage. Further research is required to improve the volume and texture of egg-replaced Madeira cake.

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