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Effect of mixing period, water and sugar on the sesame cracker dough stickiness

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Abstract

Sesame Cracker or *Kuih Bijan* is a popular traditional Malays snack in Malaysia. The simplest formulation of Sesame Cracker dough includes glutinous rice flour, sugar, and water. In order to reduce the negative effect caused by dough stickiness, the effect of mixing period (3 to 7 minutes), water (41.6 to 45.6%) and sugar (1 to 9%) on dough stickiness of sesame cracker dough were studied using Texture Analyzer and Chen-Hoseney methodologies (i.e. Chen-Hoseney Dough Stickiness Cell). The result obtained showing that the increment of mixing time, water and sugar addition, increased the dough stickiness, work of adhesion/adhesiveness and dough strength/cohesiveness. However, overmixing of dough had led to the decrease of these parameters.

Introduction

Sesame Cracker is a popular traditional snack in Malaysia especially amongst the Malays society. It is a deep-fried product of sesame coated dough ball with crispy characteristic and aroma of fried sesame. The main dough ingredients for making this snack consist of glutinous rice flour (GRF), water and sugar. Current production method of this snack is still using manual or handmade. There are five steps involved in manual production of this snack which are preparation of dough, cutting or hand-pinching of dough into small dough fractions, hand-rounding of dough, coating of the dough with sesame and lastly deep-frying. The average diameter of the small dough balls are around 9±1 mm and its diameter can expand to 12±1 mm after deep-frying. Although a lot of efforts had been carried out to mechanizing the production of this snack by sesame cracker entrepreneurs and Malaysia government agency, none of them is success due to the problem caused by sticky nature of the dough that made from glutinous rice flour.

Dough stickiness or adhesion can be defined as the adhesion of dough to the surface that it contacts to (Dobraszczyk, 1996; Hoseney and Smewing, 1999; Adhikari *et al*., 2001; Yildiz *et al*., 2012). Some authors described it in term of combination of cohesion (stickiness between particles) and adhesion (stickiness between particle and wall or surface stickiness) (Adhikari *et al*., 2001). Dough stickiness exists as problems in bakery and confectionary industry since long time ago. Modern bakery and confectionary industry nowadays could only found the ways to reduce the dough stickiness by using dusting flour or oil but not totally eliminate it. The negative impacts brought by dough stickiness are interruption of the production schedule and loss of product quality and profit (Grausgruber *et al*., 2003). Despite the problems caused by the dough stickiness, it has its importance in dough development and has granted a coatable outer dough surface of Sesame Crackers for sesame coating. Other than that, dough stickiness is an environment-sensitive property as it quickly lost when exposure to the air or further manipulation (Cauvain, 2012).

The known factors that resulted in dough stickiness and enhanced the dough stickiness had been reported by several authors. Grausgruber *et al*. (2003) stated factors that caused dough stickiness includes overmixing of dough, over addition of water and uncontrollable intrinsic factors of flour. Sai Manohar and Rao (1997) had found out that increasing of sugar content, increased the stickiness of biscuit dough. Other factors that cause dough stickiness or have enhance effect on dough stickiness had been reported such as flour extraction, amount of water-soluble proteins and pentosans, differences in protein composition, alpha-amylase activity and proteolytic enzyme activity (Grausgruber *et al*., 2003)

For gluten dough, the main culprit of the dough

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stickiness is the glutenin and gliadin fractions of the gluten protein. However, for Sesame Cracker, it uses glutinous rice flour which is a type of non-gluten flour. Glutinous rice flour (GRF), also called as waxy/ sweet/ sticky rice flour is well known with its sticky nature. GRF contains almost 100% of amylopectin and less than 2% of amylose contents (Bor, 1991; NIIR Board of Consultants and Engineers, 2006; Keeratipibul *et al*., 2008). The dough stickiness of Sesame Cracker is mainly caused by the high amylopectin fraction of GRF (Chen *et al*., 1999; Gao *et al*., 2014). The application of glutinous rice or glutinous rice flour is mostly in Asian countries such as Malaysia, Thailand and China in making cuisine, deserts, bakery and confectionery products, snacks and even in sauce production.

For instrumentation measurement of dough stickiness, there is no universal accepted method to measure it. However, texture Analyzer with Chen-Hoseney Cell/Rig and Prespex probe is one of the currently available method for measuring the dough stickiness (Tock *et al*., 2013). The main focus of this paper is to investigate the effect of the mixing time, water and sugar added on the dough stickiness of Sesame Cracker using the Texture Analyzer with Chen-Hoseney Dough Stickiness Cell (A/DSC).

Materials and Methods

Dough preparation

Material for Sesame Cracker dough preparation consisted of glutinous rice flour and coarse sugar that bought for the local market and laboratory distilled water. A preliminary test was conducted to obtain the minimum mixing time and amount of water required to successfully develop the dough based on observation. From the preliminary test, it had been found out that the water addition must be accounted at least 41.60% from the formulation used and mixing time must least 3 minutes, otherwise the mixed ingredients do not form homogeneous dough.

Dough was prepared using 200 g of glutinous rice flour (GRF) (51.28% of dough composition) and 20 g of coarse sugar (5.13% of dough composition) and mixed them in a mixing bowl using a Heavy Duty Mixer (Model 5K5SS, KitchenAid, St. Michigan USA) that equipped with the spiral kneader attachment at speed 1 for 1 minute at room temperature, 23.5±5°C and relative humidity, 60±5%. Next, distilled water with the amount of 170 ml (43.60% of dough composition) was added slowly into mixing bowl and the mixture was mixed at speed 2 for 3 minutes. After mixed, the mixing bowl with the dough was covered with a moist towel in order to prevent the moisture loss. Further study was done on the variation of mixing time, water and sugar added according to Table 1 based on the basic dough formulation.

Table 1. Studied variable and range

Variable	Constant Parameter	Studied Range
Mixing Time (MT)	GRF, Coarse Sugar, Water	3 minutes
		4 minutes
		5 minutes
		6 minutes
		7 minutes
Water Added (WA)	GRF, Coarse Sugar, Mixing Time	41.60%
		42.60%
		43.60%
		44.60%
		45.60%
Sugar Added (WA)	GRF, Water, Mixing Time	1.00%
		3.00%
		5.13%
		7.00%
		9.00%

Dough stickiness test

Dough stickiness test was carried out using the texture analyzer (TA.XT PLUS, Stable Micro Systems, Surrey, U.K.) with a 25 mm perspex cylinder probe (P/25P) and the SMS/Chen-Hoseney dough stickiness rig (A/DSC) under the following setting: Pre-Test Speed: 0.5 mm/s, Test Speed: 0.5 mm/s, Post-Test Speed: 10.0 mm/s, Return Distance: 4 mm, Applied Force: 40 g , Contact Time: 0.1s ,Trigger Type: Auto – 5 g (Chen and Hoseney, 1995). The measurement was performed on triplicate samples from each condition and three measurements were performed on each replicate.

The result obtained from this test was a force versus time curves as shown in **Figure 1**. Three parameters was obtained through the "MACRO" analysis function that available in the Stable Micro Systems software: (a) stickiness (g)-the positive maximum force, (b) work of adhesion (g.s)-the positive area under curve and (c) dough strength/ cohesiveness (mm)-the distance of the dough sample is extended on probe return.

The negative region of the curve when the test commences is a result of 40 g of force being applied for 0.1s to compress the sample slightly. The positive region of the plot, however, is of overall importance. The maximum force reading, i.e. highest positive peak (stickiness), the positive area (work of adhesion) and the distance between the anchors set ('travel') (dough strength/cohesiveness), are all indicators of the stickiness or rheological properties of the dough (Balestra, 2009).

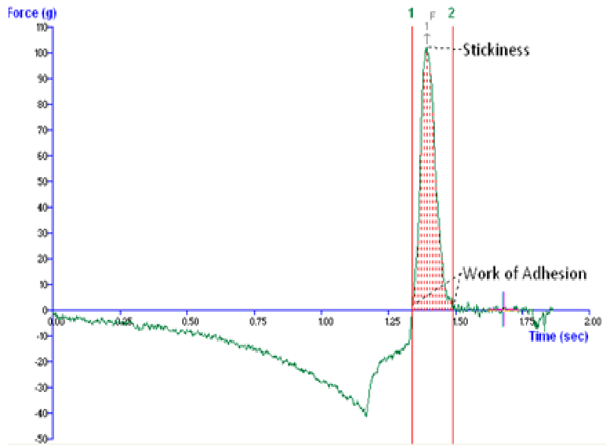

Figure 1. Illustrated force versus time curve for dough stickiness test

Statistical analysis

All the analysis reported in this study was performed in triplicates and data obtained is reported as mean ± standard deviation. One-way ANOVA was used to determine the statistical significance of the results. Duncan means comparison test was applied to determine the difference between the mean values at a significant level of $p<0.05$ using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA).

Results and Discussion

Stickiness

Mixing time, water and sugar added are three parameters that could affect the stickiness of dough. As shown in Figure 2, increasing the mixing time (MT), water added (WA) and sugar added (SA) have an increasing effect on the dough stickiness. From Figure 2A, the average stickiness value was significantly increased ($p<0.05$) from MT 3 to 6 minutes; however the value was dropped at MT 7 minutes. The average stickiness values recorded from MT 3 to 6 minutes were 91.26±1.68 g, 98.29±1.76 g, 113.11±1.85 g, 121.58±1.75 g and dropped to 105.41±1.81 g at MT 7 minutes ($p<0.05$). That drop could be due to the over-mixing of the dough. Chen and Hoseney (1995) found that increasing of mixing time, increased the dough stickiness, however, he stated there was no clear result available whether overmixed dough will decrease in stickiness value or not.

For water added case (Figure 2B), the average stickiness value recorded for water added case was significantly increased ($p<0.05$) from 81.03±1.39, 85.78±1.50, 91.26±1.68, 99.92±1.77 to 114.10±1.72 g for WA 41.6%, 42.6%, 43.6%, 44.6% and 45.6% respectively. Spies (1990) stated that excessive level of free water in dough produces sticky dough. Dhaliwal *et al*. (1990) and Chen and Hoseney (1995) had observed the same increasing trend as the amount of water added increased.

For sugar added case (Figure 2C), it recorded an increasing trend for SA 1% to 9% with average stickiness value from 88.54±1.19, 90.79±1.71, 91.26±1.68, 94.68±1.88 to 99.59±1.46 g. The increment of stickiness value was not significant ($p>0.05$) from sugar content 1.00% to 5.13% but significant increment was observed at SA 7% and SA 9%. This phenomenon might due to the low amount of sugar added is not enough to cause significant increase on the dough stickiness. This trend of increase was supported by a few authors. Indrani *et al*. (2007) and Sumnu and Sahin (2008) found that increased of sugar content, increased the dough stickiness value. Trinh (2013) discovered that dough with higher sugar content was more likely to stick to the probe at the end of dough stickiness test more than the one with the low sugar content.

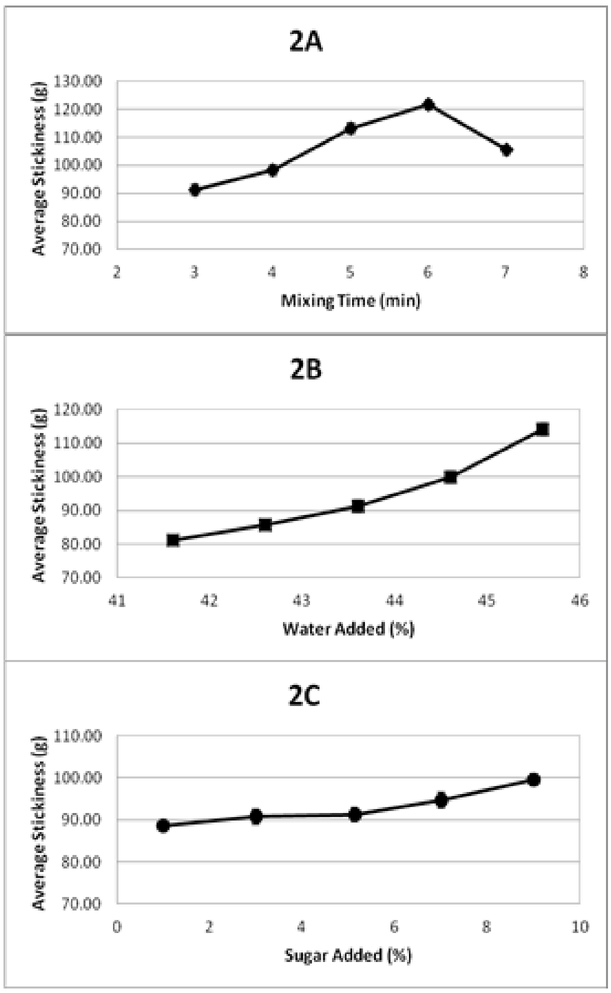

Figure 2. Effect of increment of (a) Mixing time (MT) (b) Water added (WA) (c) Sugar added (SA) on the average stickiness

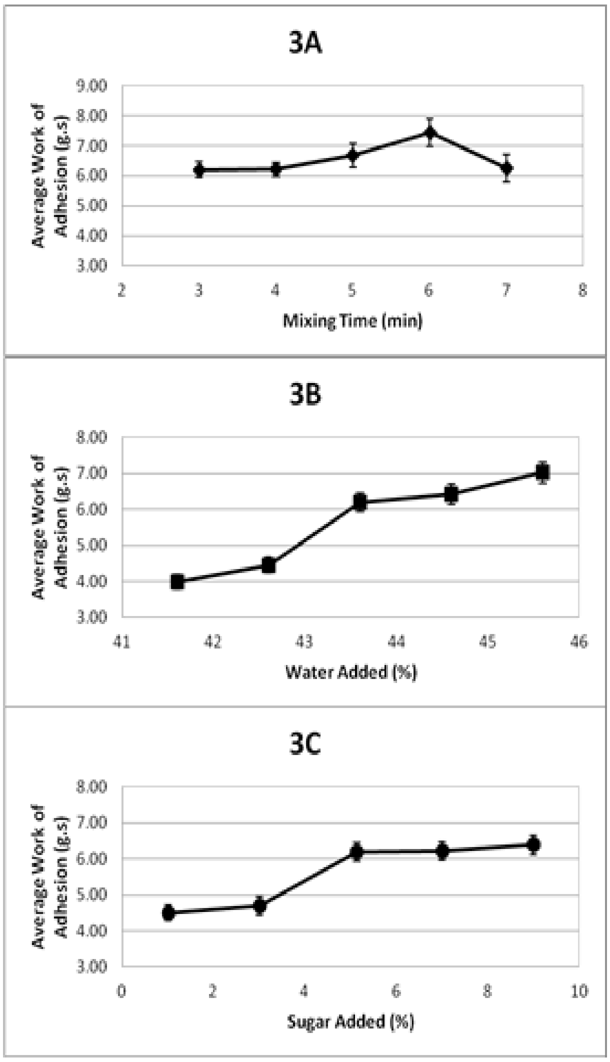

Figure 3. Effect of increment of (a) Mixing time (MT) (b) Water added (WA) (c) Sugar added (SA) on Average work of adhesion

Work of adhesion

Work of adhesion, also called adhesiveness, was defined as work necessary to overcome the attractive forces between the surface of the sample and the surface of the probe used, with which the sample comes in contact with (Szczesniak, 2002). From Figure 3, it can be observed that increment of mixing time, water and sugar added has an increasing effect of the on the work of adhesion as in the stickiness case. The work of adhesion/adhesiveness has a direct relationship with the stickiness since it is the area under the curve at the positive region. Hence, the higher the stickiness value, the greater the work of adhesion is in order to separate the sample from sticking on the probe surface.

For mixing time case (Figure 3A), the average value of work of adhesion recorded was significantly increased ($p<0.05$) from 6.19±0.26, 6.22±0.23, 6.68±0.40 to 7.44±0.45 g.s from MT 3 to 6 minutes respectively and finally dropped to 6.25±0.47 at MT 7 minutes as in stickiness case.

While for water added (WA) case (Figure 3B), the average work of adhesion value was significantly increased ($p<0.05$) from 3.99±0.21, 4.45±0.21, 6.19±0.26, 6.41±0.28 to 7.02±0.28 g.s from WA 41.6% to 45.6% respectively. The same increment trend was also found by (Rezzoug *et al*., 1998). He reported that an increasing of water quantity produced a reduction of consistency but an increase in fluidity and adhesiveness of dough. Sugar added case (Figure 3C) shows an increased ($p>0.05$) of average work of adhesion from SA 1.00% and 9.00% except at SA 5.13%. The work of adhesion increased from 4.50±0.21, 4.70±0.26 6.19±0.26, 6.22±0.25 to 6.39±0.27 g.s.

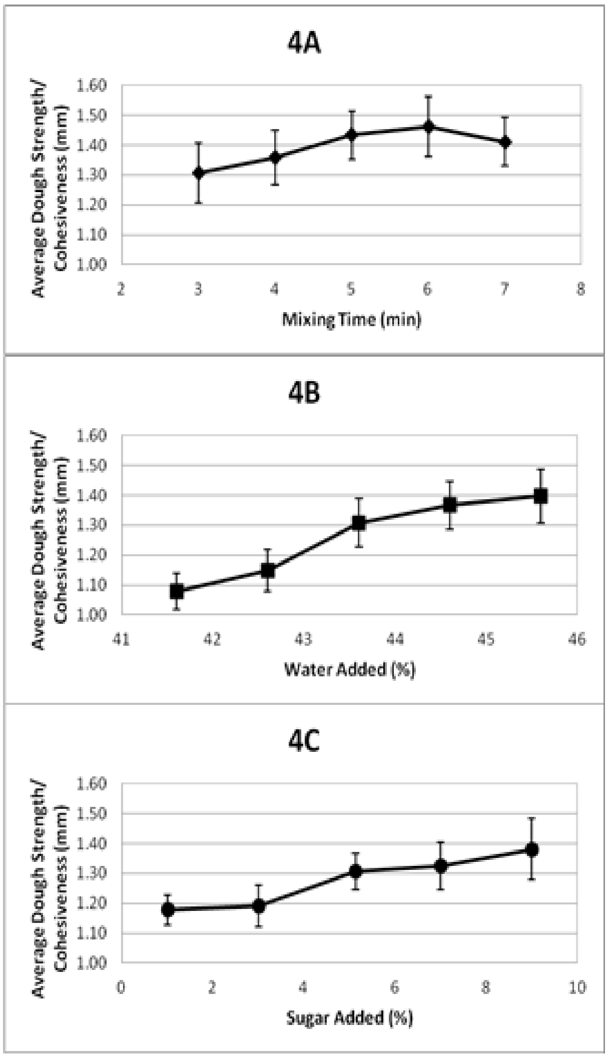

Figure 4. Effect of increment of (a) Mixing time (MT) (b) Water added (WA) (c) Sugar added (SA) on average dough strength/ cohesiveness

Dough strength/cohesiveness

Szczesniak (2002) defined dough strength/ cohesiveness as the extent to the dough can be deformed before it ruptures. While Abdelghafor *et al*. (2011) defined it as the internal strength of the dough samples. By referring to Figure 4A, the average dough strength/cohesiveness value recorded for mixing time case increased insignificantly ($p>0.05$) from MT 3 to 6 minutes. The value was increased from 1.31±0.10, 1.36±0.09, 1.43±0.08 to 1.46±0.10 mm and decreased to 1.41±0.08 mm at MT 7 minutes. The trend showed was similar to the stickiness and work and adhesion cases. This phenomenon may due to longer mixing time enables longer time periods for the amylopectin unit to be broke and aligned into a longer bond and more tightly bound from MT 3 to 6 minutes. However, overmixing produced dough with less elasticity but increasingly softness and extensibility, in another word, decrease in dough strength (Scott Smith *et al*., 2008). According to Rosada (2002) and Suas (2008), the factors that affecting the dough strength include the ingredients such as GRF flour itself and the mixing time. The strong dough tends to elastic rather than extensive while weak dough in opposite way.

While for water added case (Figure 4B), the average dough strength/cohesiveness value was increased from 1.08±0.06, 1.15±0.07, 1.31±0.10, 1.37±0.08 to 1.40±0.09 mm for WA 41.6% to 45.6%. The average dough strength/cohesiveness value recorded for sugar added (Figure 4C) from 1 to 9% was 1.18±0.05 mm, 1.19±0.07 mm, 1.31±0.10 mm, 1.33±0.08 mm and 1.38±0.10 mm. The significant increased ($p<0.05$) only showed at SA 5.13%. This may due to the low amount of sugar (SA<5.13%) is not enough to significantly affect the dough strength/cohesiveness.

Conclusion

As a conclusion, the increased of mixing time, water added and sugar added to Sesame Cracker dough rose up the dough stickiness, work of adhesion/adhesiveness and dough strength/cohesiveness. However, overmixing of dough could lead to a decrease of these three parameters. Based on the results obtained, the dough mixing time (MT), 3 minutes, water added (WA), 41.6%, and sugar added (SA), 1% produces the least sticky dough. This study is important as it affects the performance of machinery processing that involves dough.

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