

Interactive effect of carboxymethyl cellulose and sodium bicarbonate on moisture and oil migration in fried banana

(Kesan interaksi karboksimetil selulosa dan natrium bikarbonat terhadap perpindahan lembapan dan minyak di dalam pisang goreng)

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Key words: carboxymethyl cellulose, sodium bicarbonate, moisture, oil, migration, fried banana

Abstract

Carboxymethyl cellulose (CMC) and sodium bicarbonate (SB), though commonly used, exert contradicting effects in coating systems towards mass migration. Thus, a study was done to determine the interactive effect of CMC and SB on moisture and oil migration in fried, coated banana. Results showed no significant interaction existed between CMC and SB for moisture content in both coating and banana portions of the samples. SB also did not have a significant effect on moisture content in both the coating and banana portions. However, CMC showed significant barrier effect towards moisture migration in both the coating and banana portions. For fat content, a significant interaction was observed between CMC and SB for the coating and banana portions. At 0% CMC, increase in SB produced an increase in fat content in the coating portion. However, at 3% CMC, increasing SB resulted in a decreased fat content in the banana portion.

Introduction

Frying is one of the oldest food processing methods being practised today (Varela et al. 1988). In Malaysia, fried foods are a staple of the Malaysian diet. Ranging from starchy foods such as sweetpotato and banana to protein-based foods such as *keropok*. Fried foods are consumed mostly, but not limited to, during breakfast and evening tea. Coatings are commonly applied to fried foods to enhance palatability and value (Rawle 1987; Hurni and Loewe 1990). Among the most important coating characteristics is crispiness (Loewe 1993).

Crispiness, which provides an appealing sensation during eating, is produced by the repeated resistance and

collapse of the coating's structure. Roudaut et al. (1998) reported that, commonly, crispy products have a low density cellular structure. As a result, they are brittle and generate a loud and high pitched sound when fractured. Sodium bicarbonate is commonly used to increase crispiness by increasing the porosity of the coating. However, an increase in porosity would result in an increase in fat absorption (Pinthus et al. 1995). Efforts have been made to control oil absorption in fried foods due to the consumer's higher awareness on the setbacks of high oil consumption towards health. Previous research has reported on the ability of carboxymethyl cellulose (CMC) in reducing oil absorption

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during frying. Priya et al. (1996) reported that the addition of 2% CMC resulted in 26.2% oil content reduction in deep-fat fried boondis.

The study was conducted to determine the interactive effect of using both sodium bicarbonate and CMC on the migration of moisture and oil in fried foods, using banana as the substrate due to the contrasting effects of sodium bicarbonate and CMC on the oil absorption in fried products.

Materials and methods

Sample preparation

Banana (*Musa sapientum*) of the Nipah variety was purchased from a local store in Bandar Baru Bangi, Selangor, Malaysia and used in this study. The fruits were peeled and cut into halves longitudinally. Dry batter mix was prepared by mixing rice flour with carboxymethyl cellulose (CMC) and sodium bicarbonate (SB), which were also purchased locally. Three levels of CMC and SB each at 0, 1.5 and 3% relative to the weight of the rice flour, were prepared using a 3 x 3 factorial design. Batter solution was prepared by mixing the dry batter mix with water at a ratio of 1:1.5 (dry mix:water) using a hand-held mixer (Black & Decker, USA).

Frying

The banana halves were then immersed in the batter for 5 s, drained for 15 s and deep-fat fried at 190 °C for 7 min using an electric fryer (GRAES, Graes Appliances Sdn Bhd, Selangor). Each treated sample (approximately 35 g) was fried in 1.5 litres of palm olein as the frying medium. After frying, the coating portion of the fried bananas was immediately separated from the banana portion and the coating and banana were analysed separately. Three replications were carried out for each treatment.

Analysis

Moisture content was determined using the oven drying method (AOAC 1995). Fat content of the samples was determined using the Soxhlet apparatus with hexane as the

solvent (AOAC 1995). All analyses were done in triplicates.

Statistical analysis

Statistical analysis was done using ANOVA and Duncan multiple means comparison test. If the interaction between CMC and SB was significant, analysis of the effect of CMC and SB was done in combination. However, if the interaction between CMC and SB was not significant ($p > 0.05$), analysis of the effect of CMC and SB was done separately as according to Montgomery (1991). In all analyses, the probability level used was $p = 0.05$ and analysed using a statistical software (SAS Inst. 1988).

Results and discussion

Moisture content

The effect of sodium bicarbonate (SB) and carboxymethyl cellulose (CMC) on moisture content of the coating and banana portions is shown in *Table 1*. No significant interaction between SB and CMC for both the coating and banana portions. Increasing the level of SB did not result in any significant change in the moisture content of the coating and banana portions. These results suggest that the effect of SB did not have a significant effect on the migration of moisture from the banana into the coating portion and also

Table 1. Moisture content in the coating and banana portions as affected by different levels of sodium bicarbonate (SB) and of carboxymethyl cellulose (CMC)

	Moisture content (%)	
	Coating portion	Banana portion
SB (%)		
0	21.39a	58.20a
1.5	22.62a	57.96a
3.0	23.27a	57.68a
CMC (%)		
0	19.05c	55.11c
1.5	21.94b	58.14b
3.0	26.28a	60.59a

Means in the same column followed by the same letter are not significantly different ($p > 0.05$)

evaporation of moisture from the coating portion into the frying oil.

However, increasing the level of CMC produced significant ($p < 0.05$) changes in the moisture content of both the coating and banana portions (*Table 1*). In both portions, moisture content increased with increasing level of CMC. The increase in moisture content in the coating portion may be due to CMC water binding property. CMC has been shown to have the ability to bind moisture. As a result, it is used as water binders in food systems (Keller 1986; Da Ponte et al. 1987). Increased CMC level in the product will increase its water binding capability and thus will increase the moisture content of the product.

Moisture content in the banana portion increased with increasing level of CMC. This observation may also be attributed to the water binding ability of CMC. During frying, the moisture at the surface of the product is evaporated due to heat supplied by the frying oil. The evaporation of moisture at the surface of the product will cause moisture to migrate from the inner layers of the product towards the surface due to the existence of concentration and pressure gradients (Gamble et al. 1987; Levine 1990). The increased binding of moisture within the coating portion with increasing CMC level would result in a decreased concentration gradient for moisture migration within the banana portion. As a result, increasing the level of CMC produced a higher retention of moisture within the banana portion. It is also possible that the increasing moisture content

in the banana portion may be due to the physical ability of CMC as a barrier towards moisture migration (Priya et al. 1996).

Fat content

There was significant ($p < 0.05$) interaction between SB and CMC for fat content in the coating portion (*Table 2*). It can be observed that the absence of CMC and increasing level of SB up to 3%, resulted in an increase in fat content in the coating portion. This seemed that there was an increase in oil migration from the frying media into the product. This observation may be due to the effect of SB on the coating structure. During frying, heat is supplied to the product and this causes the SB to produce carbon dioxide gas, which will create pores within the coating portion. A higher percentage of SB would possibly produce a higher degree of porosity. An increase in porosity would allow more oil from the frying medium to migrate into the coating portion (Pinthus et al. 1995), resulting in the increase of fat content in the product.

Adding 1.5% CMC did not produce any significant differences in the fat content of the coating portion although the level of SB was increased. However, contrary to the fat content results of 0% CMC, coating samples with 3% CMC showed a reduction in oil content with increasing SB level. These observations suggest that the effect of SB on fat content is significantly affected by the presence of CMC.

An overall trend of decreasing fat content with increasing CMC level can be observed at all levels of SB (*Table 1*).

Table 2. Fat content (%) in the coating portion at different levels of sodium bicarbonate and carboxymethyl cellulose

		Carboxymethyl cellulose (%)		
		0	1.5	3.0
Sodium bicarbonate (%)	0	18.67bc	16.97c	15.11cd
	1.5	21.92ab	16.54c	11.62de
	3.0	25.12a	19.19bc	10.28e

Means with different letters within any row or column indicate significant difference ($p < 0.05$)

Table 3. Fat content in the banana portion at different levels of sodium bicarbonate (SB) and carboxymethyl cellulose (CMC)

Level (%)	Fat content (%)	
	SB	CMC
1	1.89a	2.49a
1.5	2.47a	2.21ab
3.0	2.04a	1.70b

Means with different letters within the same column indicate significant difference ($p < 0.05$)

The decreasing trend of fat content may be attributed to the barrier effect of CMC on oil migration (Keller 1986; Priya et al. 1996). When the fat content of the product containing 0–3% CMC was compared, it could be seen that with increasing SB level, the degree of fat content reduction was also increased. The reduction of fat content for 0, 1.5 and 3% SB was 19.1, 47.0 and 59.1%, respectively. Thus, it can be concluded that SB interacts with CMC to further reduce oil absorption during frying.

As the level of SB increased, larger pores were formed, thus increasing oil absorption during frying and subsequently resulting in the increased fat content as was observed at 0% CMC. However, with the presence of CMC, increasing the level of SB may have allowed the CMC to be interspersed within the microstructure of the coating and producing a higher degree of barrier towards oil migration. However, further studies should be carried out to determine the microstructure of the coatings in order to ascertain this possibility.

There was no significant interaction between SB and CMC on banana portion (Table 3). SB has no significant effect on the fat content of the banana portion. However, increasing the CMC level up to 3% reduced the fat content of the banana portion. This may be due to the barrier property of CMC towards oil migration.

Conclusion

Both sodium bicarbonate (SB) and carboxymethyl cellulose (CMC) was found to have an influence on the migration of oil and moisture within both the coating and banana portions of coated fried bananas. However, the extent of the influence by SB and CMC on these migration properties of the samples varied between oil and moisture and also between different portions (coating and banana portion).

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Abstrak

Karboksimetil selulosa (CMC) dan natrium bikarbonat (SB), walaupun kerap digunakan, memberikan kesan yang berlawanan terhadap perpindahan jisim dalam sistem salutan. Dengan itu, kajian telah dijalankan untuk menentukan kesan interaksi CMC dan SB terhadap perpindahan lembapan dan minyak bagi pisang salut bergoreng. Hasil kajian menunjukkan tiada interaksi yang ketara wujud antara CMC dengan SB untuk kandungan lembapan bagi bahagian salutan dan pisang. SB juga tidak memberikan kesan yang ketara terhadap kandungan lembapan bagi bahagian salutan dan pisang. CMC pula memberi kesan rintangan yang ketara terhadap perpindahan lembapan bagi bahagian salutan dan pisang. CMC dan SB memberi interaksi yang ketara untuk kandungan lemak bahagian salutan dan pisang. Pada kadar 0% CMC, peningkatan kadar SB menghasilkan peningkatan kandungan lemak bahagian salutan. Tetapi, pada kadar 3% CMC, peningkatan kadar SB menghasilkan pengurangan kandungan lemak pada bahagian pisang.