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Effect of Coating on Doughnut Cake Preference using R-index

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ABSTRACT

Signal detection has been used to explain the underlying basis of difference testing from control and produces accurate different values on consumer acceptance. The number of samples presented in signal detection rating test was much lower than that of the instrumental method of limit test, which would require less time and cost for preparation by the experimenter. Signal detection on the preference of coated doughnut cake with different coatings from blend polymer between chitosan (CH) and methylcellulose (MC) at different ratios of CH: MC (1.00:0.00, 0.00:1.00, 0.75:1.25, 1.00:1.00 and 1.25:0.75) were conducted by R-index method. Instrumental measurement on coated doughnut cake were also determined. Results showed that the instrumental method was highly correlated with R-index method. Coating solution of CH:MC at 1.00:0.00 and 1.25:0.75 showed the difference of instrumental measurement on brownish color, odor, hardness and oil content higher than that of the control. The optimum coatings at CH:MC of 0.00:1.00 (MC) and 0.75:1.25 (CM1) significantly reduced oil uptake without any effect on overall liking.

Key words: R-index, consumer, preference, biopolymer coating, doughnut cake

INTRODUCTION

Deep fat frying is widely used in industrial or institutional preparation of food (Pinthus *et al*.,1992). Some fried food products, fat and oil may improve overall food palatability, mouthfeel, or flavor, but high fat diet are discouraged because of potential diet related diseases. Thus, oil uptake in fried foods has become a health concern. High consumption of lipids has been related to obesity and other health problems like coronary heart disease. Edible coating at the surface of the food comprises another possibility, but this technique has not been studied extensively. Williams and Mittal (1999) reported that methylcellulose (MC) film showed the best barrier property, because it reduced fat uptake more than hydroxypropylmethylcellulose (HPMC) for a pastry mix. It was reported that the cellulose derivatives were used to reduce oil absorption in fried products (Meyers, 1990). However, food coatings may become a good alternative to solve this problem. The effectiveness of a coating must be determined by its mechanical and barrier properties.

Signal detection theory has been used to explain the underlying basis of difference testing, but implementation of signal detection procedures is rather time consuming. Therefore, short-cut signal detection procedures were developed allowing R-indice to be calculated from either rating or ranking data on a variety of food products

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(O'Mahony *et al*., 1985).

Hedonic or 'liking' measurements have generally used category scales (5, 7, or 9 points) and uni- or bipolar magnitude estimation scales to give numerical estimations of liking (Pearce *et al.*, 1986). More recently, signal detection procedures have been modified for hedonic evaluation, allowing the calculation of an R-index that gives the probability of preferring a test product over the control rather than the degree of difference from the control. Vie *et al*.(1991) used rating and ranking data collection procedures to calculate R-indice for potato chip preference and to determine the likelihood-to-buy. Swanson and Lewis (1992) used ranked data to calculate an R-index indicating honey preferences and a willingness-to-buy.

Cliff *et al*.(2000) modified this index to develop a bipolar R-index. This allows for the 'signal' samples to have both lower and higher intensities than the control sample. A further modification by the same authors provided a 'weighted-bipolar' R-index. This addressed the bias associated with overestimation of the sample size. However, R-index is a probability rather than a relative preference score. It provides to the food researcher with an alternate interpretation for market research, which will ultimately save time and cost during development of food products.

This research was intended to examine in term of probability on difference of coated doughnut cake from uncoated doughnut cake (control) and usefulness of the R-index to produce accurate different values with less preparation and correlation of rating data collection procedures with instrumental measurements for consumer preference, which would ultimately save time and costs.

MATERIALS AND METHODS

1. Preparation of coating solutions

Two types of biopolymer were used in this study (chitosan, CH: DE>94.68; Thai Union Co. Ltd, Thailand and methylcellulose, MC: methoxyl group 27.5-32.0%; Fluka, Switzerland). Coating solution blending at different ratios of CH: MC was studied (1.00:0.00, 0.00:1.00, 0.75:1.25, 1.00:1.00, 1.25:0.75 named CH, MC, CM1, CM2, and CM3, respectively) and the concentration in the solutions was prepared at 1% (w/w). Coating solution was first dissolved thoroughly in 1% (w/w) formic acid solution (99% concentrate, BHD Co., England). After added with 0.1% polyethyleneglycol (No.400 Fluka, Switzerland) and stirred by agitator mixer (Cole Co., Ltd., Illinois) for 20 minutes, the solution was then filtered with silk filter at 120 mesh. Coating solutions were used in doughnut cake development.

2. Doughnut cake preparation

Six treatments of doughnut cake produced by coating with different biopolymer solution as ratios of chitosan: methylcellulose (1.00:0.00, 0.00:1.00, 0.75:1.25, 1.00:1.00 and 1.25:0.75 w/v) were used in the tasting. All of doughnut cakes were prepared by compressing with mold to obtain 50 mm × 10 mm height dimension. One was uncoated sample (hereafter referred to as the control) and the other doughnut cakes were then dipped in coating solutions for 10 second and allowed to dry at 45°C for 15 minutes with tray drier (Model BWS, B.W.S. trading Ltd, Thailand). Frying of doughnut cake was carried out at 165°C for 2.0 minute (Pinthus, 1995).

Prior to sensory evaluation, the six doughnut cakes were transferred into polyethylene bags. Each of doughnut cake was presented as one piece labeled with a three digit random order. They were evaluated using one or two scorecards, rating or ranking, which were randomly assigned to the bags.

3. Physicochemical properties

3.1 Oil content

Oil content (OC) of fried products was determined (by dried samples) using combined technique of successive batch and continuous fat extraction (Soxtec Avanti-2050, USA), with petroleum ether (AOAC, 1995).

3.2 Colorimetric measurements

Experiments were carried out with a Minolta spectrophotometer (CM-3500d series, Japan) calibrated with a standard. The Hunter scale was used, lightness (L*) and chromaticity parameters a*(red-green), b*(yellow-blue) and overall difference of color (ΔE*) was measured. Sampling five points of surface sample were measured and they were analyzed in triplicate, recording three measurements for each sample.

3.3 Texture analysis

Samples were measured by compression test using a texture analyzer Lloyd TA-500 (USA). Samples (specimen) were compressed with a 5 kg cell at speed of 0.5 mm/s with a cylinder compressive shape (10 cm diameter). Texture profile analysis was determined on hardness property. At least 10 samples were measured in each experiment. Samples were allowed to reach room temperature before performing the tests (Garcia *et al.,* 2002).

4. Sensory evaluation

The consumer evaluation consisted of 40 panelists, 20 males and 20 females, with age range of 15 to 55 years. Panelists were given a presentation on the basics of sensory evaluation, specifically the R-index method, in order to familiarize them with the type of test being used. Panelists were advised no bias in preference of doughnut cake. After the evaluation, comments were collected on their preferences.

Panelists were splitted equally into two gender balanced groups for the different and acceptance tests. R-index was used for different test and all attributes of color (brownish), odor, texture (hardness) and oily sheen were obtained, panelists tested the six samples and scored samples 'least liked' (left) to 'most liked' (right). For acceptability, 9 point hedonic scale was used. Panelists tested the products according to a randomized design and checked the appropriated box according to their degree of liking from 'extremely dislike' to 'extremely like' (Vie *et al.,* 1991).

5. Statistical analysis

The R-index measures the degree of difference between a 'control' sample and a 'signal' or treatment sample, in terms of the probability of distinguishing sample paired comparison. The experiment selected with a chance value more than 0.5 indicated samples to be distinguished. Values of the traditional R-index are ranged between 0.5 and 1.0 (50-100%), with higher values indicating better discrimination (Harker *et al.,* 2002).

The weighted-bipolar with R-indice was calculated following the method of Chiff *et al*. (2000). The weighting values were described in terms of propability in paired comparison and the significant signal and noise of samples with randomization were calculated using tables provided by O'Mahony *et al.* (1995).

RESULTS AND DISSCUSSION

1. Instrumental measurement

Oil content, hardness, and color measurement of uncoated (control) and coated sample are shown in Table 1

1.1 Oil content

Blending of chitosan and methylcellulose at the given ratios (CH, MC, CM1, CM2, and CM3) were studied in doughnut cakes coating compared with the uncoated samples (control). The results showed that coating solution

significantly reduced oil content in doughnut cake ($p \leq 0.05$) described by a mechanism and natural barrier properties of coating solution, which depended on small porous size in microstructure of product (Debeaufort and Voilley, 1997). It also demonstrated that coating could reduce oil content in doughnut cake. Comparing between coating treatments, coating with only MC (0.00:1.00) showed the most effective on oil reduction, because of MC exhibited thermo-gelation, consequence as the best barrier properties of oil and moisture during frying (Grover, 1993).

1.2 Color properties

Coating affected color of fried doughnut cake significantly ($p \leq 0.05$). The lowest value of ΔE was observed in the control sample and MC (0.00:1.00) due to yellow color of fried product. The highest differences of color in CH (1.00:0.00) and CM3 (1.25:0.75) were observed. When chitosan content in coating solutions increased, the brownish color increased in coated samples. These may be due to browning reaction of polysaccharide with protein complex when it was heated at high temperature (Muzzareli *et al.*, 1985).

1.3 Texture properties

Texture analysis was performed on hardness property of doughnut cake. These profiles showed that texture attributes related with total fat content. Uncoated sample had higher hardness values than coated samples. These differences of hardness occurred due to the differences of water retention and oil uptake, which depended on lower values of moisture loss and oil absorption than that of uncoated sample (Garcia *et al.*, 2002).

2. Preference on coated doughnut cake

R-index was calculated by the R-index response matrix method (O'Mahony, 1992) for all samples and panelists. The values of difference from the control sample by R-index method shown in Table 2. The result was explained in terms of the degree of difference, the value higher than 0.5 (50%) indicating high probability of difference from control (Harker *et al.*, 2002). R-index measurement of color, odor and hardness values were significant different from the control ($p \leq 0.05$) in CH (1.00:0.00) and CM3 (1.25:0.75) respectively. High ratio of chitosan in coating solution affected brownish color, odor and hardness of fried doughnut cake due to occur the thickness of crust or case hardening in fried product (Pinthus and Saguy, 1994). Oily sheen of MC was not significantly different ($p > 0.05$) at 0.00:1.00 as MC formed the best barrier of water loss and oil absorption (Garcia *et al.*, 2002), which protected the evaporation of water from the food and absorption of oil by the food during frying (Krokida *et al.*, 2000b).

Table 1 The values of physicochemical in fried doughnut cake.

Treatments (Chitosan : Methylcellulose)	Oil content (% wb.)	Hardness (N)	L*	a*	b*	ΔE*
Uncoated (Control)	19.61± 2.03^{a}	186.96^{a}	64.31±0.23^{a}	13.44±0.28^{d}	40.08±0.30^{b}	1.48±0.82^{d}
0.00 : 1.00 (MC)	13.31± 1.52^{d}	113.06^{b}	61.74±0.88^{a}	12.45±0.30^{e}	39.96±0.48^{b}	2.46±0.67^{d}
1.00 : 0.00 (CH)	16.46± 2.55^{b}	115.14^{b}	51.18±0.74^{c}	18.34±0.33^{a}	38.64±0.58^{c}	13.05±0.90^{a}
0.75 : 1.25 (CM1)	14.96± 2.04^{c}	114.22^{b}	58.44±1.42^{b}	14.64±0.94^{c}	41.33±0.61^{a}	5.26±1.75^{c}
1.00 : 1.00 (CM2)	15.36± 2.15^{c}	115.04^{b}	57.75±0.59^{b}	16.61±0.25^{b}	41.59±0.22^{a}	7.14±0.65^{b}
1.25 : 0.75 (CM3)	15.39± 2.53^{c}	116.29^{b}	53.79±1.67^{c}	16.04±0.75^{b}	40.58±0.51^{b}	7.97±1.82^{b}

^{abcd} Mean in the same column with different letters are significantly different ($p \leq 0.05$)

Table 2 R-index measures of characteristics on doughnut cake.

Treatments (Chitosan : Methylcellulose)	Weight-Bipolar (brownish color)		Weight-Bipolar (odor)		Weight-Bipolar (hardness)		Weight-Bipolar (oily sheen)	
	R-index more	R-index less	R-index more	R-index less	R-index more	R-index less	R-index more	R-index less
0.00 : 0.00 (Control)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00 : 1.00 (MC)	nc	0.64	0.58	nc	0.62	nc	nc	0.53
1.00 : 0.00 (CH)	0.81*	nc	0.69*	nc	0.70*	nc	0.72*	nc
0.75 : 1.25 (CM1)	0.70*	nc	0.59	nc	0.63	nc	nc	0.39
1.00 : 1.00 (CM2)	0.74*	nc	0.63	nc	0.64	nc	0.63	nc
1.25 : 0.75 (CM3)	0.75*	nc	0.69*	nc	0.68*	nc	nc	0.43

R-index followed by * are significant at $p \leq 0.05$

[nc] , R-index not calculated (not significant at $p > 0.05$)

The relationship between instrumental method and R-index of hardness, oil content and brownish color were determined (Figure 1-3). Results showed that the instrumental method was correlated with R-index method, the distribution of the instrumental method was slightly shifted to the relatively right with the R-index distribution. This demonstrated that R-index method could be used as a tool to determine the qualities of product with less number of sample compared to the instrumental method (the number of sample for instrumental method was 108 and for signal detection rating test was 40). It was confirmed by Cliff *et al.* (2000) who mentioned that R-index method could be a measurement of magnitude and direction in the partition of the same-unsure responses. It required less time and cost for preparation by the experimenter. The optimum coating were MC (0.00:1.00) and CM1 (0.75:1.25) whose oil content were lower than the control. As a consequence, it could be used to reduce oil uptake in doughnut cake. It was related with Williams and Mittal (1999) who reported that methylcellulose (MC) films showed the best barrier properties, to reduced fat uptake in pastry mix.

3. Overall liking

The sensory scores of doughnut cake are shown in Table 3. The high score of overall liking of MC (0.00:1.00) and CM1 (0.75:1.25) coatings were not significantly different from the control ($p > 0.05$). This result agreed with R-index measurement on odor, hardness and oily sheen, where those samples were not significantly different from the control.

CONCLUSION

This study demonstrated that R-index method could be used to evaluate the degree of difference from the control in doughnut cake. The results showed that preference of consumer were affected by different coating solutions. However, optimum coating could be obtained and used to reduce oil uptake with non significant effect on overall liking.

Table 3 Overall liking in doughnut cake with 9 points hedonic scale.

Treatments	Mean ± SD
Control (Uncoated)	6.02 ± 1.80ab
0.00 : 1.00 (MC)	7.37 ± 1.74 a
1.00 : 0.00 (CH)	3.90 ± 1.78 c
0.75 : 1.25 (CM1)	6.42 ± 1.97 ab
1.00 : 1.00 (CM2)	4.65 ± 1.99 bc
1.25 : 0.75 (CM3)	4.45 ± 2.09 c

[abc] Mean in the same column with different letters are significantly different ($p \leq 0.05$)

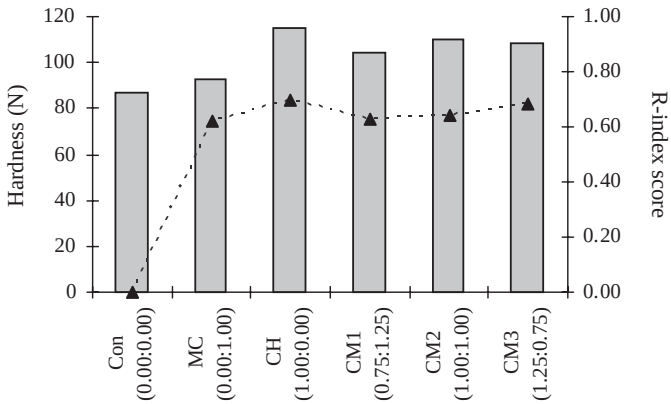

Figure 1 Distribution of hardness detection in coated doughnut cake (■ Instrument method, --▲--R-index method)

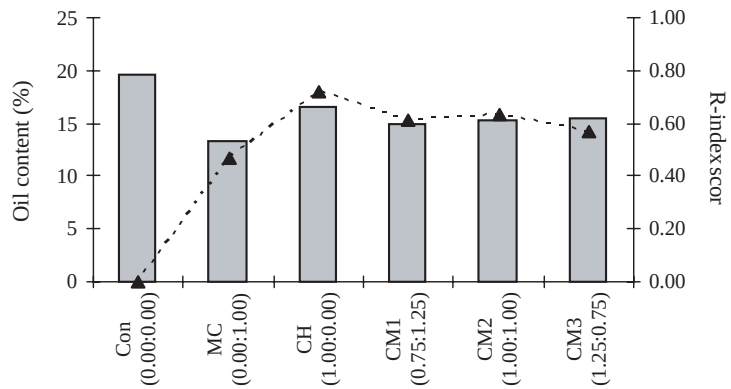

Figure 2 Distribution of oil detection in coated doughnut cake (■ Instrument method, --▲--R-index method)

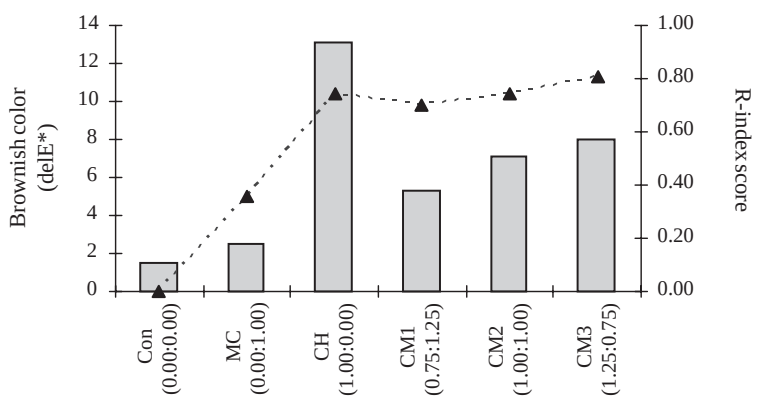

Figure 3 Distribution of color detection in coated doughnut cake (■ Instrument method, --▲--R-index method)

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