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Effects of Various Food Components on the Expansion, Oil Absorption, and Crispiness of Fried Rice Dough

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ABSTRAK

Ciri-ciri fisikal do goreng telah dikaji menggunakan sistem contoh berasaskan tepung beras. Do goreng yang paling rangup dan yang paling kurang menyerap minyak didapati daripada campuran tepung beras : pulut dalam nisbah 75:25 (nisbah amylos:amylopektin = 9:69). Perkembangan isipadu hasilan goreng didapati mempunyai hubungan rapat dengan kandungan amylopektin dan penyerapan minyak mempunyai hubungan songsang dengan kandungan amylos dalam tepung (r^2 = 0.98 dan 0.96 masing-masing). Garisan yang paling baik untuk menentukan perkembangan isipadu dan penyerapan minyak do goreng adalah y = 120.6 + 7.16x dan y = 23.4 + 0.15x masing-masing, di mana x adalah kandungan amylopektin/amylos dalam keseluruhan tepung. Amylos didapati meningkatkan kekerasan dan mengurangkan penyerapan minyak dalam hasilan goreng. Kerangupan hasilan goreng dapat ditingkatkan lagi dengan menambah sedikit putih telur, minyak, kapur ($CaCO_3$) dan tepung beras terprajel. Walaupun tepung terprajel meningkatkan kerangupan, ia juga meningkatkan penyerapan minyak. Penyerapan minyak dapat dikurangkan dengan penambahan 2.5 - 5.5% minyak dan 4 - 12% putih telur ke dalam tepung.

ABSTRACT

The physical characteristics of fried dough were studied using model systems based on rice flours. Fried dough of maximum crispiness and minimum oil absorption were obtained from flour mixtures containing rice : glutinous rice in the ratio of 75:25 (amylose:amylopectin ratio = 9:69). Volume expansion and oil absorption of the finished product were found to be directly proportional to the amylopectin content and inversely proportional to the amylose content of the flour (r^2 = 0.98 and 0.96 respectively). The best fitted lines for predicting the volume expansion and oil absorption of fried dough are y = 120.6 + 7.16x and y = 23.4 + 0.15x respectively, where x is the amylopectin/amylose content of the whole flour. Amylose was found to increase hardness and reduce oil absorption of the fried product. Crispiness of the fried product was further improved by the addition of a little egg albumin, oil, $CaCO_3$ and pregelatinised rice flour. Although pregelatinised rice flour improved crispiness, it increased oil absorption. Oil absorption was reduced by the addition of 2.5 –5.5% oil and 4 –12% egg albumin to the flour.

INTRODUCTION

A number of snacks and dishes all over the world has fried dough as a constituent. Fried dough is defined here as a flour-water mixture which is deep fried in hot oil. The constituents in the flour affect the characteristics of starch-based products. Moisture, protein content, amylose and amylopectin components were found to correlate with the elasticity, linear expansion, oil absorption, and crunchiness of fried crackers or keropok (Mohamed *et al.* 1989). Moisture, protein, oil, sugar, salt, grain size and barrel screw speed have been found to affect extrusion characteristics of starch-based products (Mohamed 1990). Studies have shown that amylopectin/amylose content determine the expansion characteristics of extruded products (Feldberg 1969; Mercier and Feillet 1975). This work was conducted to investigate factors affecting the physical characteristics such as expansion, oil absorption and crispiness of fried dough using model systems based on rice (*Oryza sativa*) flours. Factors studied include moisture, amylose/amylopectin content, protein, oil, calcium and effect of pregelatinisation

This study will enable us to understand the kind of flour/starch one should choose or modify to produce crispy, puffy of low oil-absorbing fried starch-based dough products.

MATERIALS AND METHODS

Weighed rice flour (Maju Perak Rice Flour Co. Ltd) and glutinous rice flour (Cho Heng Rice Vermicelli Fac., Co. Ltd.) were kneaded into dough with the addition of measured amounts of water. It was then rolled and cut into 0.2x2x2 cm cubes and fried in RBD (refined, bleached and deodorised) palm olein (Labour Brand) for 15 to 20 min. at 170°C. Effects of amylopectin content, pregelatinisation, and the addition of various concentrations of oil, $CaCO_3$, and powdered egg white on the expansion, hardness (the higher the force the less crispy is the product) and oil absorption of the fried dough were determined.

Pregelatinised flour was prepared using a drum drier (3 bar steam pressure ~ 133.5°C; 0.1mm gap; at 2 rpm) on the rice flour slurry (7:3 water:flour). A 7:3 water:flour ratio was found to be the optimum concentration to produce a good homogenous pregelatinised rice flour, which did not stick to the drum and did not retrograde on cooling. Protein and fat contents were determined using the micro kjeldahl and soxhlet extraction methods respectively. Proximate analysis was done using AOAC (1980) methods. Starch content was determined by hydrolysing the starch and determining the reducing sugar content (Osborne and Voogt 1978; Southgate 1976). Sugar was first removed from the starch using hot 80% ethanol. Excess protein and fat were then extracted using hot alcoholic KOH. The extracted starch from 0.2g of flour, were gelatinised and hydrolysed with 0.2ml (82 units) amyloglucosidase in the presence of 0.1M Na acetate buffer, pH 4.5. The amount of glucose released was determined by the Nelson-Somogyi method and multiplied by a factor of 0.9 to give the total starch content in the sample (Southgate 1976).

Amylose was determined by the reaction with $KI-I_2$ (Morrison and Laignelet 1983). The amylopectin content of the starch was calculated by difference and the amylopectin content of the whole flour (%) can be calculated using the formula:

$$1 - = \% \text{ amylopectin content in starch} \times \frac{\% \text{ starch content in flour}}{100}$$

Volume expansion was determined by height × length × width of the rolled, cut dough before and after frying.

The % volume expansion was determined from the formula $[100\ (V_2 - V_1) / V_1]$ where V1= Volume before frying; and V2 = Volume after frying.

Hardness was determined using an 8 mm Magnus Taylor probe attached to the Instron Universal testing machine compressing at a crosshead speed of 5cm/min. All measurements were done on at least 6 samples.

RESULTS AND DISCUSSION

Proximate analysis showed that both the rice flour (R) and the glutinous rice flour (GR) were similar in composition (Table 1), except in their amylose/amylopectin content; this accounts for their different functional properties.

TABLE 1
Proximate composition of rice / glutinous rice flour

% in flour[1]	glutinous rice flour	rice flour
Moisture	11.89±0.24	11.14±0.01
Protein[2]	6.62±0.07	6.29±0.10
Fat	0.57±0.05	0.45±0.02
Ash	0.25±0.01	0.24±0.01
Crude fiber	0.09±0.01	0.06±0.01
Carbohydrate[3]	92.47	92.96
Total starch	91.91±0.19	91.20±0.66
Amylose	0.56	13.78±0.34
Amylopectin[3]	91.91	77.42
*Hot paste viscosity	high	low
*Resistance to shear	low	medium
*Stability to retrograde	high	low
*Clarity	clear	cloudy
*Freeze-thaw stability	medium	low
Oil absorption after frying	high	low
Texture after frying	hard	crispy
Expansion after frying	high	v. low

1 % w/w based on dry matter,
2 Protein = N x 5.95 for glutinous rice and rice,
3 By difference
* Pomeranz (1985)

Volume Expansion

Table 2 clearly shows that the % volume expansion highly correlates with the amylopectin content and is inversely related to the amylose content ($r^2 = 0.98$) regardless of their moisture con-

tent. The best fitted line for predicting the expansion for fried rice dough is:

% volume expansion =

$$120.6 + 7.16 \left(\frac{\text{amylopectin content in flour}}{\text{amylose content in flour}}\right)$$

Similar results were found for the correlationship of % linear expansion to amylopectin content of the flour ($r^2 = 0.99$) in precooked fried crisps 'keropok' (Mohamed *et al.* 1989).

The presence of oil, $CaCO_3$, and egg albumin reduced expansion probably by reducing the amylopectin content in the whole flour. The presence of pregelatinised GR flour reduced the expansion of GR dough probably due to the same

TABLE 2

Volume increase of fried rice pastries containing different % of amylose, amylopectin, fat, $CaCO_3$, protein (egg albumin) and pregelatinised component

% in flour amylose	amylopectin	rice:glut rice	water	% Expansion 70%	75%	80%	85%
0.56	91.91	0:100		$^{A}1225^{a}$	$^{A}1288^{a}$	$^{A}1188^{a}$	$^{B}738^{a}$
3.46	88.27	25:75		$^{B}288^{b}$	$^{B}338^{b}$	$^{A}475^{b}$	$^{B}312^{b}$
6.92	84.64	50:50		$^{A}250^{b}$	$^{A}300^{b}$	$^{AB}194^{c}$	$^{B}125^{c}$
10.35	80.98	75:25		$^{A}117^{c}$	$^{A}125^{c}$	$^{A}100^{d}$	$^{A}75^{c}$
13.78	77.42	100:0		$^{B}88^{c}$	$^{B}94^{c}$	$^{A}141^{cd}$	$^{C}62^{c}$

	% Expansion Glutinous Rice				% Expansion Rice			
% Water	70	75	80	85	65	70	75	80
% Oil added								
0	$^{A}1225^{a}$	$^{A}1288^{a}$	$^{A}1188^{a}$	-	-	$^{A}88^{a}$	$^{A}94^{a}$	-
2.5	$^{A}690^{b}$	$^{A}660^{b}$	$^{A}653^{b}$	-	-	$^{A}70^{a}$	$^{A}50^{b}$	-
5.5	$^{A}758^{b}$	$^{A}650^{b}$	$^{A}610^{b}$	-	-	$^{B}0^{b}$	$^{A}30^{c}$	-
10	$^{A}768^{b}$	$^{A}739^{b}$	$^{A}618^{b}$	-	-	$^{A}0^{b}$	$^{A}0^{d}$	-
% CaCO added								
0	-	$^{A}1288^{a}$	$^{A}1188^{a}$	$^{A}738^{a}$	-	$^{B}88^{a}$	$^{B}94^{a}$	$^{B}141^{a}$
4	-	$^{B}530^{b}$	$^{AB}550^{c}$	$^{A}610^{b}$	-	$^{B}0^{c}$	$^{B}0^{c}$	$^{B}0^{d}$
8	-	$^{A}550^{b}$	$^{A}580^{bc}$	$^{A}620^{b}$	-	$^{B}35^{b}$	$^{BC}25^{b}$	$^{C}20^{c}$
12	-	$^{A}610^{b}$	$^{A}620^{b}$	$^{A}620^{b}$	-	$^{C}25^{b}$	$^{BC}25^{b}$	$^{B}50^{b}$
Protein (egg albumin)								
0	$^{A}1225^{a}$	$^{A}1288^{a}$	$^{A}1188^{a}$	-	-	$^{B}88^{a}$	$^{B}94^{a}$	-
1	$^{A}570^{b}$	$^{A}590^{b}$	$^{A}600^{b}$	-	$^{B}0^{c}$	$^{B}0^{d}$	$^{B}0^{c}$	-
2	$^{A}580^{b}$	$^{A}610^{b}$	$^{A}620^{b}$	-	$^{B}0^{c}$	$^{B}0^{d}$	$^{B}0^{c}$	-
4	$^{A}405^{c}$	$^{AB}390^{c}$	$^{B}340^{c}$	-	$^{C}150^{a}$	$^{D}100^{b}$	$^{E}50^{c}$	-
8	$^{A}410^{c}$	$^{B}355^{c}$	$^{B}330^{c}$	-	$^{B}50^{b}$	$^{B}50^{c}$	$^{B}50^{b}$	-
12	$^{A}395^{c}$	$^{B}345^{c}$	$^{C}210^{d}$	-	$^{B}50^{b}$	$^{B}50^{c}$	$^{B}50^{b}$	-

Pregelatinisation (Pre = Pregelatinised flour)

	% Expansion Glutinous Rice				% Expansion Rice		
Pre:GR \water	55%	60%	65%	Pre:rice\water	110%	115%	120%
10:90	$^{A}604^{ab}$	$^{A}610^{a}$	$^{A}670^{a}$	15:85	$^{A}0^{c}$	$^{A}0^{c}$	$^{A}0^{b}$
15:85	$^{A}650^{a}$	$^{B}568^{a}$	$^{A}620^{b}$	25:75	$^{B}0^{c}$	$^{A}90^{a}$	$^{A}90^{a}$
20:80	$^{B}604^{ab}$	$^{B}614^{a}$	$^{A}680^{a}$	35:65	$^{B}50^{a}$	$^{A}90^{a}$	$^{A}90^{a}$
25:75	$^{B}544^{b}$	$^{AB}604^{a}$	$^{A}620^{b}$	45:55	$^{A}50^{a}$	$^{A}70^{ab}$	$^{A}70^{a}$
				50:50	$^{A}47^{b}$	$^{B}57^{b}$	$^{B}60^{a}$

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reason. On the other hand, pregelatinised rice flour increased the expansion of fried rice dough probably by reducing the % amylose present.

Oil Absorption of Fried Dough

Table 3 also shows that there is a high correlation between oil absorption and amylopectin/amylose content of the flour regardless of the amount of water used ($r^2 = 0.96$). The best fitted line for predicting oil absorption of fried rice dough based on amylopectin/amylose content is:

% oil absorption =
23.4 + 0.15 (amylopectin/amylose content in flour)

In precooked fried crisps (keropok) the oil absorption was found to be dependent only on amylopectin content ($r^2 = 0.97$) (Mohamed *et al.* 1989).

TABLE 3

% Oil absorption of fried rice dough containing different % of amylose, amylopectin, fat, $CaCO_3$, protein (egg albumin) and pregelatinised component

% in Flour				% Oil Absorption			
amylose	amylopectin	rice:glut rice	water	70%	75%	80%	85%
0.56	91.91	0:100		$^{A}46.9^{a}$	$^{A}48.5^{a}$	$^{A}49.2^{a}$	$^{A}48.5^{a}$
3.46	88.27	25:75		$^{A}32.3^{b}$	$^{A}29.8^{b}$	$^{A}31.8^{bc}$	$^{A}33.8^{b}$
6.92	84.64	50:50		$^{AB}32.0^{b}$	$^{B}21.8^{b}$	$^{A}35.1^{b}$	$^{AB}24.7^{bc}$
10.35	80.98	75:25		$^{A}26.4^{b}$	$^{A}25.9^{b}$	$^{B}24.2^{c}$	$^{C}19.3^{c}$
13.78	77.42	100:0		$^{A}23.8^{b}$	$^{A}24.1^{b}$	$^{A}24.4^{bc}$	$^{A}21.6^{bc}$

	% Oil Absorption				% Oil Absorption			
	Glutinous Rice				Rice			
% Water	70	75	80	85	65	70	75	80
% Oil added								
0	$^{A}46.9^{b}$	$^{A}48.5^{c}$	$^{B}49.2^{ab}$	-	-	$^{C}23.8^{a}$	$^{C}24.1^{a}$	-
2.5	$^{A}60^{ab}$	$^{A}57.1^{a}$	$^{B}50.7^{a}$	-	-	$^{C}20.9^{a}$	$^{D}15.5^{b}$	-
5.5	$^{A}63.2^{a}$	$^{B}48.8^{c}$	$^{B}46.7^{b}$	-	-	$^{C}24.8^{a}$	$^{D}14.4^{b}$	-
10	$^{A}66.2^{a}$	$^{B}54.4^{b}$	$^{B}51.4^{a}$	-	-	$^{C}26.2^{a}$	$^{D}20^{ab}$	-
% $CaCO_3$ added								
0		$^{A}48.5^{c}$	$^{A}49.2^{a}$	$^{A}48.5^{a}$	-	$^{C}23.8^{a}$	$^{C}24.1^{a}$	$^{C}24.4^{a}$
4		$^{A}51.6^{b}$	$^{B}56.5^{b}$	$^{B}57.3^{a}$	-	$^{C}25.9^{a}$	$^{C}27.9^{a}$	$^{C}27.2^{a}$
8		$^{B}54.9^{a}$	$^{A}57^{b}$	$^{A}58.6^{a}$	-	$^{C}24.4^{a}$	$^{C}24.8^{a}$	$^{C}25.4^{a}$
12		$^{A}56.1^{a}$	$^{A}57.5^{b}$	$^{A}59.1^{a}$	-	$^{C}22.4^{a}$	$^{C}24.7^{a}$	$^{C}25^{a}$
Protein (egg albumin)								
0	$^{A}46.9^{a}$	$^{A}48.5^{a}$	$^{A}49.2^{a}$		-	$^{B}23.8^{a}$	$^{B}24.1^{ab}$	
1	$^{A}46.9^{a}$	$^{A}44.8^{b}$	$^{A}44.2^{b}$		$^{B}24.3^{b}$	$^{B}25.6^{a}$	$^{B}26.2^{a}$	
2	$^{A}45.2^{ab}$	$^{B}43.4^{c}$	$^{B}43.6^{b}$		$^{C}27.4^{a}$	$^{C}27.1^{a}$	$^{C}26.4^{a}$	
4	$^{A}36.5^{bc}$	$^{B}31.5^{d}$	$^{C}29.0^{c}$		$^{D}25.0^{b}$	$^{D}24.8^{a}$	$^{D}21.85^{abc}$	
8	$^{A}26.5^{d}$	$^{A}25.2^{e}$	$^{B}21.7^{d}$		$^{A}23.4^{c}$	$^{A}23.1^{a}$	$^{B}19.0^{c}$	
12	$^{A}22.1^{d}$	$^{A}20.0^{f}$	$^{A}21.1^{d}$		$^{A}23.4^{c}$	$^{A}23.1^{a}$	$^{B}19.0^{c}$	

Pregelatinisation (Pre = Pregelatinised flour)

	% Oil Absorption				% Oil Absorption		
	Glutinous Rice				Rice		
Pre:GR \Water	55%	60%	65%	Pre:Rice\water	110%	115%	120%
10:90	$^{C}44.2^{b}$	$^{C}48.1^{c}$	$^{C}51^{b}$	15:85	$^{B}37.1^{a}$	$^{B}37.5^{a}$	$^{A}40.4^{a}$
15:85	$^{C}51.3^{a}$	$^{C}52.1^{b}$	$^{D}47^{b}$	25:75	$^{B}32.6^{b}$	$^{A}37^{a}$	$^{A}37.4^{b}$
20:80	$^{D}52.5^{a}$	$^{CD}54.2^{a}$	$^{C}57^{a}$	35:65	$^{B}33.4^{b}$	$^{B}34^{b}$	$^{A}35.7^{c}$
25:75	$^{C}43.9^{b}$	$^{C}45.4^{d}$	$^{C}46^{b}$	45:55	$^{B}30.7^{c}$	$^{A}34^{b}$	$^{A}34.8^{d}$
				50:50	$^{A}36.3^{a}$	$^{A}37^{a}$	$^{A}37.5^{b}$

(Similar capital letters indicate insignificant difference within rows at 5% level; similar small letters indicate insignificant difference within columns at 5% level)

TABLE 4

Hardness of fried rice pastries containing different % of amylose, amylopectin, fat, $CaCO_3$, protein (egg albumin) and pregelatinised component.

% in Flour amylose	amylopectin	rice:Glut Rice	Water	Hardness (kg) 70%	75%	80%	85%
0.56	91.91	0:100		$^{A}1.86^{b}$	$^{A}1.65^{b}$	$^{A}1.6^{b}$	$^{A}1.59^{b}$
3.46	88.27	25:75		$^{A}4.54^{a}$	$^{A}4.72^{a}$	$^{A}4.8^{a}$	$^{A}4.98^{a}$
6.92	84.64	50:50		$^{B}0.584^{d}$	$^{B}0.528^{d}$	$^{B}0.46^{c}$	$^{A}1.008^{d}$
10.35	80.98	75:25		$^{A}0.404^{d}$	$^{A}0.372^{d}$	$^{AB}0.356^{c}$	$^{B}0.304^{c}$
13.78	77.42	100:0		$^{A}1.128^{c}$	$^{A}1.148^{b}$	$^{A}1.204^{b}$	$^{A}1.256^{c}$

	Hardness (KG) Glutinous Rice				Hardness (KG) Rice		
% Water	70	75	80	85	65	70	75	80
% Oil added								
0	$^{A}1.86^{a}$	$^{A}1.65^{a}$	$^{A}1.6^{a}$	-	-	$^{B}1.128^{a}$	$^{B}1.148^{a}$	
2.5	$^{B}1.104^{b}$	$^{A}1.424^{a}$	$^{C}0.812^{b}$	-	-	$^{D}0.744^{b}$	$^{C}0.9^{a}$	
5.5	$^{A}1.148^{b}$	$^{A}1.572^{a}$	$^{A}1.54^{a}$	-	-	$^{C}0.428^{b}$	$^{B}1.0^{a}$	
10	$^{B}1.18^{b}$	$^{A}1.620^{a}$	$^{A}1.772^{a}$	-	-	$^{D}0.576^{b}$	$^{C}1.008^{a}$	
% $CaCO_3$ added								
0		$^{A}1.65^{a}$	$^{A}1.6^{a}$	$^{A}1.59^{a}$	-	$^{C}1.128^{a}$	$^{C}1.148^{a}$	$^{C}1.204^{a}$
4		$^{A}1.354^{ab}$	$^{A}1.7^{a}$	$^{A}2.08^{a}$	-	$^{D}0.45^{b}$	$^{D}0.494^{b}$	$^{C}0.604^{b}$
8		$^{B}1.14^{b}$	$^{AB}1.64^{a}$	$^{A}2.04^{a}$	-	$^{D}0.396^{bc}$	$^{D}0.456^{b}$	$^{C}0.594^{b}$
12		$^{B}1.1^{b}$	$^{B}1.42^{a}$	$^{A}1.86^{a}$	-	$^{C}0.350^{c}$	$^{C}0.408^{b}$	$^{C}0.434^{c}$
Protein (egg albumin)								
0	$^{A}1.86^{b}$	$^{A}1.65^{c}$	$^{A}1.6^{c}$		-	$^{B}1.128^{a}$	$^{B}1.86^{a}$	
1	$^{B}1.07^{c}$	$^{A}1.93^{c}$	$^{A}2.06^{c}$		$^{D}0.264^{d}$	$^{CD}0.344^{d}$	$^{C}0.386^{b}$	
2	$^{B}0.75^{c}$	$^{A}1.88^{c}$	$^{A}1.72^{c}$		$^{D}0.222^{d}$	$^{D}0.242^{c}$	$^{C}0.370^{b}$	
4	$^{B}0.7^{c}$	$^{B}0.78^{d}$	$^{A}1.36^{c}$		$^{C}0.388^{c}$	$^{C}0.430^{d}$	$^{C}0.444^{b}$	
8	$^{B}1.89^{b}$	$^{A}3.29^{b}$	$^{A}3.82^{b}$		$^{D}0.570^{b}$	$^{D}0.680^{c}$	$^{C}1.69^{a}$	
12	$^{A}6.44^{a}$	$^{A}6.6^{a}$	$^{A}6.84^{a}$		$^{D}0.656^{a}$	$^{C}1.02^{b}$	$^{B}1.98^{a}$	

Pregelatinisation (Pre = Pregelatinised flour)

	Hardness (kg) Glutinous Rice				Hardness (KG) Rice		
Pre:GR \Water	55%	60%	65%	Pre:Rice\water	110%	115%	120%
10:90	$^{A}4.36^{a}$	$^{B}2.58^{c}$	$^{B}1.88^{c}$	15:85	$^{D}0.195^{b}$	$^{E}0.123^{b}$	$^{E}0.092^{c}$
15:85	$^{A}4.84^{a}$	$^{B}1.78^{c}$	$^{B}1.36^{c}$	25:75	$^{D}0.398^{a}$	$^{DE}0.328^{a}$	$^{E}0.178^{bc}$
20:80	$^{C}4.2^{a}$	$^{B}6.96^{a}$	$^{A}11.096^{a}$	35:65	$^{D}0.444^{a}$	$^{D}0.358^{a}$	$^{D}0.27^{ab}$
25:75	$^{C}1.92^{b}$	$^{B}4.24^{b}$	$^{A}5.92^{b}$	45:55	$^{D}0.534^{a}$	$^{DE}0.458^{a}$	$^{E}0.356^{a}$
				50:50	$^{D}0.538^{a}$	$^{D}0.462^{a}$	$^{D}0.362^{a}$

(Similar capital letters indicate insignificant difference within rows at 5% level; similar small letters indicate insignificant difference within columns at 5% level)

However, there seemed to be no clear correlation between moisture content (within the range studied) and oil absorption. Oil absorption seemed to be minimal at a 75:25 R:GR ratio or amylopectin:amylose ratio of 69:9 at a moisture content of 85%.

A good correlationship was found between oil absorption and volume expansion ($r^2 = 0.83$) and this could be explained by the fact that more oil is trapped in the surface layer of the bigger air cells when expansion occurs.

The addition of 2.5 to 5.5% oil to the dough decreased the oil absorption of the fried rice flour dough (13.78% amylose) to about 15%. However, addition of oil to the high amylopectin GR dough increased its oil absorption during frying. Again the high moisture dough seemed to result in less oil absorption than the low moisture dough. Calcium carbonate seemed to have no significant effect on oil absorption.

Pregelatinisation did not significantly affect the oil absorption of high amylopectin GR dough but significantly increased the oil absorption of 13.78% amylose rice dough. This is probably because the presence of amylose which inhibits oil absorption was reduced by the addition of pregelatinised components. Egg white was effective in reducing the oil absorption of the fried dough. In the absence of amylose, oil absorption negatively correlated ($r^2 = 0.93$) with egg white content, with $y = 59.8-2.36x$ (x = egg white content) as the line for prediction of oil absorbed.

Crispiness

It was found that the lower the force required to break the fried dough the crispier was the product. Flour having a amylose:amylopectin ratio of 9:69 (25% GR and 75% rice) required the lowest breaking force (~0.3kg) while flour with 1:21 ratio had the highest breaking force (~5kg) (Table 4). Addition of oil improved crispiness slightly under low moisture content. Pregelatinisation does not improve the crispiness of fried high amylopectin GR dough but significantly improved the crispiness of fried 100% rice dough from approximately 1.2Kg to 0.09kg (Table 4). The addition of $CaCO_3$ too did not improve the crispiness of fried GR dough but improved the texture of fried rice dough. The addition of egg albumin to rice dough at an optimum level of 1 to 2%, reduced hardness to 0.2Kg, while in GR dough the best egg albumin level for texture improvement was at 2 to 4% level with 70% moisture.

Hardness of the fried dough could probably be explained by the degree of polysaccharide-polysaccharide interaction. In high amylopectin flours, the interaction may be higher than in flours containing amylose. The addition of oil, protein or pregelatinised components may reduce the polysaccharide-polysaccharide interaction. Calcium may play a role in binding with pectin or proteins making them more brittle and by interfering with the starch-starch interaction.

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