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Research paper

Effects of Par-Frying and Calcium Propionate on the Quality of Frozen Curry Puff

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Abstract

This study proves that the application of par-frying method and addition of calcium propionate able to prolong the shelf life and preserve the quality of frozen pastry curry puff during distribution and storage after exposure to fluctuating temperature. Par-fried curry puff added with 0.1% calcium propionate produce lower moisture content, oil uptake and weight loss than non-par fried puff. In addition, par fried curry puff was capable of preventing any visible black spots (after 4 weeks storage) which are related to the quality defect. No sensorial changes detected during sensory evaluation in terms of texture, appearance, taste and overall acceptability after addition of calcium propionate. There is a high possibility of frozen curry puff to be commercialized internationally without any deterioration.

Keywords: *Par-frying, Calcium Propionate, Frozen Pastry, Sensory, Curry Puff*

1. Introduction

The global demand and consumption of frozen food market are predicted to increase at a compound annual growth rate (CAGR) of 4% by 2019 [1]. Due to the change in lifestyle, consumers prefer more convenience foods for on-the-go consumption rather than preparing everything from the scratch. Preferences for pastries consumptions are also increasing in the current lifestyle, thus creating the interest for the food manufacturers to manufacture more ready-to-bake frozen pastries to supply in the food service industry and to be sold in the market [2].

Curry puff is a traditional Malaysian pastry and is consumed after deep-frying. It is widely sold in supermarkets and the food service industry. However, it is easily spoiled due to its soft texture during thawing. Kasetsart [3] stated that fluctuations of temperature (-18°C, -13°C, and -8°C) may reduce its shelf life, thus affecting its end product quality. Black spots may be detected on the curry puff surface, further reducing the product quality. Bakery products are prone to spoilage which includes physical, chemical, and microbial spoilage [4]. Temperature fluctuation in bakery products due to poor handling during storage may lead to loss of dough strength, thus reducing the quality in the final product [3]. Guynot et al. [5] stated that 1% to 5% of bakery products are spoiled, depending on the product type and its processing method.

According to the European Food Safety Authority (EFSA) [6], calcium propionate (CP) is defined as organic salt with molecular formula $C_6H_{10}O_4Ca$. Belz et al. [7] and Khaldun et al. [8] stated that CP, propionic acid, and propionates are usually used in bakery products due to their antimicrobial effects. Kirbaslar et al. [9] reported that propionic salts are listed as "generally recognized as safe (GRAS)" food additives. Apart from adding preservatives, pre-drying and par-frying the food is one of the methods to reduce the moisture content to prolong the shelf life of the food. According to Lonn et al. [10], pre-drying, which includes a par-frying step, improves texture and reduces oil uptake. Raj et al. [11] define par-frying as a process where the product is partially fried, followed by storage in a freezer until it reaches the end consumers or restaurants. Many street food vendors in Malaysia use frying process for cooking which includes the frying of curry puffs. Hence, the addition of preservatives and par-frying process are believed to reduce the presence of black spots on curry puff skin after frozen storage at -18°C. Thus, the objective of this study to focus on the effect of par-frying and permitted preservative towards the physicochemical properties and sensory attributes of the frozen curry puff.

2. Materials and methods

2.1. Materials

Bleached wheat flour, margarine, fat, cooking oil, and curry puff filling were supplied by Doana Frozen Food from Kota Tinggi, Johor, Malaysia. Salt and monosodium glutamate were purchased from Tesco, IOI City Mall Putrajaya, Malaysia.

2.2. Preparation of curry puff

The curry puff skin was prepared according to the recipe provided by Doana Frozen Food. Two types of dough were formulated: the addition of 0.1% CP and without the addition of CP (control). The ingredients were mixed using a mixer (Aikosha, China) and kept at room temperature (25°C) before resting for 15 min. Next, the dough was rolled using a sheeter (Ampia Brevettata, Italy) and cut into square pieces using a knife followed by moulding using curry puff moulder and later, filled with potato curry filling (provided by Doana Frozen Food, Johor, Malaysia). The two formulated dough for the curry puff skin was further analyzed as par-fried (PF) and non-par-fried (NPF). The samples were par-fried in the deep fryer (Philux, China) using palm cooking oil (Tiara, Felda Global Venture, Malaysia). The different par-frying duration (1 min, 2 min and 3 min) for PF_1 (par-fried curry puff without the incorporation of CP) and PF_2 (par-fried curry puff with the addition of 0.1% CP) were carried out to determine the optimal frying time. Melito and Farkas (2013) used a total of 64 s duration time to par-fry four doughnuts. A slight modification was done by frying the PF curry puffs in hot oil at 180°C for 2 min. All formulations were labelled accordingly as NPF_1: non-par-fried/control, NPF_2: non-par-fried with 0.1% CP, PF_1: par-fried/control, and PF_2: par-fried with 0.1% CP. The curry puff samples were stored in a freezer at -18°C for further analysis.

2.3. Frying the curry puffs

The NPF and PF curry puffs were thawed before frying. Both PF and NPF curry puffs were fried at 180°C using a deep fryer (Philux, China). Preliminary studies were also conducted at this stage to determine the optimal frying time (after frozen) for both PF (2.0 min, 2.5 min, 3.0 min) and NPF (4 min, 5 min, 6 min) curry puffs. Based on the preliminary studies, NPF curry puff was fried for 5 min. and PF curry puff was fried for 2 min

2.4. Moisture

Moisture of both PF and NPF curry puffs were determined by referring to AOAC [13] (Method 925.40) via oven drying (Binder, Germany).

2.5. Crude fat and oil uptake

Crude fat content and oil uptake were determined according to AOAC [13] (Method 920.39) by Soxhlet method to compare between the NPF and PF curry puffs.

2.6. Total polar compound (TPC)

Total polar compounds in oil used for par-frying the curry puff (PF1) was measured with Testo 265 (Testo Inc., Germany) according to Lemos et al. [14] to determine the limits. TPC was analyzed during the fifteenth time of par-frying.

2.7. Colour

Colour parameters (L, a, b) were measured with a colourimeter (Konica Minolta, Japan) according to Ferreira et al. [15].

2.8. Weight loss and image analysis

Weight loss analysis was performed to observe the weight changes during frozen storage. Both PF and NPF curry puffs were subjected to temperature fluctuation based on Ding et al. [16] method with some modifications (25 ± 2°C, 25 ± 4°C, 25 ± 6°C, 25 ± 8°C, and 25 ± 10°C). Image analysis was done using a microscope with 40× magnification (Meiji, Japan) concurrently with the weight loss analysis. The images of thawed curry puffs were observed weekly for 4 cycles to detect the presence of black spot on the surface of both NPF and PF curry puffs.

2.9. Sensory evaluation

The sensory analysis was conducted using 50 untrained panellists which consisted of university students and staffs from Universiti Putra Malaysia. The curry puffs were produced 2 days earlier and kept at -18°C. Panellists were asked to evaluate a 9-point hedonic scale (1=extremely dislike; 9=extremely like) as described by Melito & Farkas [12]. The panellists had to score the curry puffs in terms of appearance, texture, taste, and overall acceptability.

2.10. Statistical analysis

Each type of analysis was performed in triplicates. Statistical analysis and comparison of means were carried out using the Minitab 16.0 (2014) (Minitab Inc., USA). The data collected were examined by one-way ANOVA. The Tukey's test was used to compare the means and the differences were considered significant at the level of $p<0.05$.

3. Results and discussion

3.1. Moisture, crude fat and oil uptake

Table 1 shows that the NPF_1 curry puff had significantly the highest percentage of moisture ($p<0.05$) compared to PF_1 curry puff after frying. Moisture contents in NPF_1 and NPF_2 curry puffs before frying were significantly high ($p<0.05$) compared to NPF_1 and NPF_2 curry puffs after frying. During par-frying, most of the moisture in curry puffs evaporated into the oil and were further removed during frozen storage [11]. According to Mohamed et al. [17], moisture content shows a significant effect on the product crispiness. Sanz et al. [18] stated that par-frying causes the moisture to be reduced inside French fries, hence making the product crispier than the non-par-fried products. They also stated that the NPF French fries needed longer frying time in order to remove moisture from the dough to become crispy. Therefore, lower moisture content in the curry puff after frying is more desirable as it produced crispier texture for PF curry puff compared to the NPF curry puff.

Table 1: Comparison of the moisture content of NPF and PF curry puffs

Type of sample	Moisture (%) (before frying)	Moisture (%) (after frying)	Moisture loss (%) (before frying − after frying)
NPF_1	19.32 ± 0.21^a	13.49 ± 0.067^a	5.83
NPF_2	17.92 ± 1.01^c	11.66 ± 0.36^c	6.26
PF_1	11.67 ± 0.08^b	7.61 ± 0.065^b	4.06
PF_2	10.57 ± 0.16^b	7.64 ± 0.25^b	2.93

NPF_1: non par-fried (control), NPF_2: non par-fried with 0.1% CP,
PF_1: par-fried (control), PF_2: par-fried with 0.1% CP
$^{a-c}$ Different alphabets within the same column are significantly different by Tukey's test ($p<0.05$).
Values are mean ± SD of triplicates.

Table 2 shows that the crude fat content was significantly the lowest ($p<0.05$) in fried NPF_1 curry puff compared to PF_2 curry puff. In addition, NPF_1 curry puff had significantly the lowest crude fat content in un-fried curry puff (before frying) compared to PF_2 curry puff. Table 2 also shows a significant difference ($p<0.05$) of oil uptake between NPF and PF curry puffs after frying. The NPF_1 and NPF_2 curry puffs showed higher oil uptake than PF_1 and PF_2 curry puffs. Melito and Farkas [12] stated that deep frying took a shorter time (32 s) at 182°C, leading to lesser oil uptake in French fries. From this study, longer time (5 min) was required to fry NPF curry puffs until fully cooked compared to the PF curry puffs that required only 2 min to be completely cooked before serving.
Moisture content plays a major role in how much oil in the food product is absorbed during the frying process. The moisture needs to be sufficient for the vapour to be carried out to the crust continuously, thus leaving the exposed area void for the fat to enter when frying. This might be related to moisture content and oil uptake of the NPF_1 curry puff which was the highest compared to other types of the sample during frying. In addition, an increase in moisture loss contributes to the high-fat uptake of the product [19]. In this study, high moisture content in NPF_1 and NPF_2 curry

puffs led to a higher percentage of moisture loss in non-par-fried than par-fried samples. Therefore, the high moisture content resulted in higher oil uptake during frying in NPF curry puffs compared to the PF curry puffs.

Table 2: Crude fat and oil uptake analysis of NPF and PF curry puffs during and after frying

Type of sample	Crude Fat (before frying)	Crude Fat (after frying)	Oil Uptake (during frying)
NPF_1	6.44 ± 0.04^d	14.03 ± 0.02^d	39.24 ± 0.15^b
NPF_2	10.59 ± 0.29^c	15.28 ± 0.02^c	37.41 ± 0.39^b
PF_1	13.65 ± 1.09^a	16.13 ± 0.01^b	26.29 ± 0.49^a
PF_2	14.41 ± 0.29^b	18.80 ± 0.07^a	28.91 ± 6.76^a

NPF_1: non par-fried (control), NPF_2: non par-fried with 0.1% CP,
PF_1: par-fried (control), PF_2: par-fried with 0.1% CP
$^{a-d}$ Different alphabets within the same column are significantly different by Tukey's test ($p<0.05$).
Values are mean ± SD of triplicates.

3.2. Total polar compounds (TPC)

Table 3 shows a significant difference ($p<0.05$) in TPC between the fresh oil and the oil at the tenth and fifteenth frying of the par-fried curry puff (PF_1). The percentage of TPC in the fresh oil increased until the fifteenth time of par-frying. TPC was found to increase with the repeated frying using the same oil [20].

Table 3: Total polar content (TPC) during frying of PF_1 curry puff (fresh oil until 15th time)

Frying	TPC (%)
Fresh oil	12.43 ± 0.90^a
5th time	13.63 ± 0.51^a
10th time	18.00 ± 0.50^b
15th time	21.00 ± 0.50^c

$^{a-c}$ Different alphabets within the same column are significantly different by Tukey's test ($p<0.05$).
Values are mean ± SD of triplicates.

According to Chatzilazarao et al. [21], a total polar compound in oil has a linear relationship with the repeated usage of frying oil. They also stated that there was a high amount of polar compound present in the hot oil when frying the French fries. Chen et al. [22] stated that during frying of pork chop, French fries, and chicken leg fillet, thermal reaction and oxidation of oil occur and produce polar compounds. Oil is degraded due to the release of water and fat into the frying oil during the frying process [23]. Therefore, the frying condition should be controlled since the frying oil is easily degraded by the presence of food in the frying oil [22]. Deora et al. [20] stated that polar compound determination in used oils is a well-accepted method due to its accuracy and reproducibility. TPC measures the extent of deterioration in frying oil in most situations [24]. Aladedunye and Przybylski [25] stated that TPC is more polar than triacylglycerol and considered as the non-volatile compound that resulted from thermal, hydrolytic, and oxidative alteration. According to Weisshaar [26], the TPC value should be less than 25% for the assessment of used frying oils. However, in this study, the oil used to par-fry the curry puff (PF_1) was still at an acceptable level (less than 25%) even after the 15th time of par-frying. Chen et al. [22] reported that after 48 h of frying pork chop, chicken fillet, and French fries using palm oil, the TPC value increased from 11.3% to almost 30% which was found to exceed the maximum TPC limit (exceeding 25 %) set by the Taiwan regulation. Melck et al. [27] also reported that the TPC value was 31.8% from the palm oil which was collected from restaurants after six days of frying. The TPC value exceeded the 24% limit based on the German regulations.

3.3. Colour

Effect of frying the NPF and PF curry puffs were analyzed using the colour analyzer. Table 4 shows b* (yellow to blue) values with no significant difference ($p>0.05$) between the NPF and PF samples. However, for a* (red to green) and L* (lightness) value, the only PF_2 sample showed a significant difference ($p<0.05$) compared to other samples.

Table 4: Comparison of the colour of PF and NPF curry puff skin

Types of Sample	Color index			
	L*	a*	b*	ΔE
NPF_1	60.2 ± 0.6^b	11.9 ± 0.8^a	30.5 ± 1.4^a	-
NPF_2	60.9 ± 2.1^b	10.2 ± 2.3^{ab}	31.7 ± 2.2^{ab}	3.7
PF_1	61.5 ± 0.3^b	12.5 ± 0.9^a	31.5 ± 0.8^a	4.8
PF_2	64.9 ± 0.4^a	7.3 ± 1.3^b	30.8 ± 0.7^a	6.8

NPF_1: non par-fried (control), NPF_2: non par-fried with 0.1% CP,
PF_1: par-fried (control), PF_2: par-fried with 0.1% CP
^{a,b} Different alphabets within the same column are significantly different by Tukey's test ($p<0.05$).
Values are mean ± SD of triplicates.

Colour is an important quality attribute to curry puffs. According to Melito and Farkas [12], a dark-coloured crust was due to the high heat flux on the surface of curry puffs during frying. Thus, Maillard reaction occurred and produced darker-coloured crumb. In addition, the oil colour turns darker with repeated frying due to the chemical reactions that resulted from oxidation and browning of pigment when frying the potatoes [25]. Thus, the used oil needs to be discarded in order to maintain the end-product quality.

3.4. Weight loss and image analysis

Weight loss of curry puffs was observed in four consecutive weeks. Ice crystals started to develop on the surfaces of curry puffs after freezing at -18°C. During the storage, the weight loss rate was fairly constant with time. According to Table 5, there were significant differences ($p<0.05$) of weight loss between the PF and NPF samples during the 4-week cycle.

Table 5: Weight loss of frozen curry puff during 4 weeks of storage at -18°C

Types of Sample	Weight Loss (%)			
	Week 1	Week 2	Week 3	Week 4
NPF_1	0.2 ± 0.0^{aC}	0.4 ± 0.0^{aB}	0.4 ± 0.0^{aAB}	0.5 ± 0.0^{aA}
NPF_2	0.2 ± 0.0^{aC}	0.4 ± 0.0^{aB}	0.4 ± 0.0^{aAB}	0.5 ± 0.0^{aA}
PF_1	0.1 ± 0.0^{bB}	0.2 ± 0.04^{bA}	0.2 ± 0.0^{bA}	0.3 ± 0.0^{bA}
PF_2	0.1 ± 0.0^{bC}	0.2 ± 0.0^{bB}	0.2 ±0.0^{bAB}	0.3 ± 0.0^{bA}

NPF_1: non par-fried (control), NPF_2: non par-fried with 0.1% CP,
PF_1: par-fried (control), PF_2: par-fried with 0.1 % CP
^{a,b} Different small alphabets within the same column are significantly different by Tukey's test ($p<0.05$).
$^{A-C}$ Different capital letters within the same row are significantly different by Tukey's test ($p<0.05$).
Values are mean ± SD of triplicates.

On the fourth week, NPF_1 and NPF_2 samples lost a high percentage of weight compared to both PF_1 and PF_2 samples, with a weight loss of only 0.3% each. Insignificant weight loss ($p>0.05$) between NPF_1 and NPF_2 samples were observed from week one till four. However, PF_1 and PF_2 samples showed significant weight loss during week one till three. Phimolsiripol et al. [28] stated that freezing and thawing will lead to structural changes and damage to the gluten network of dough. The freeze-thaw procedure was also reported to damage the crumb texture and gluten fibril [29]. In addition, a high number of freeze-thaw cycles may coarsen the gluten of baked bread prepared from the frozen dough [30], thus contributing to undesirable texture for consumption. Park et al. [31] stated that the increase in storage time may result in decreased moisture content due to the removal of water during the frozen stage. The significant weight loss ($p<0.05$) between the NPF and PF samples might be due to a dissimilar rate of heat transfer caused by the differences of a mass transfer medium on each sample surface [32]. All curry puffs were exposed to temperature fluctuation for four weeks and the image was monitored weekly via a microscope to observe the formation of black spots on the surface of curry puffs. Figure 1 shows the observation of curry puffs on the first and fourth week of the freeze-thaw cycle. Dark spots were detected on the surface of NPF_1 curry puff dough after the fourth cycle. However, no dark spot was detected on NPF_2, PF_1, and PF_2 curry puffs during the 4-week cycle.

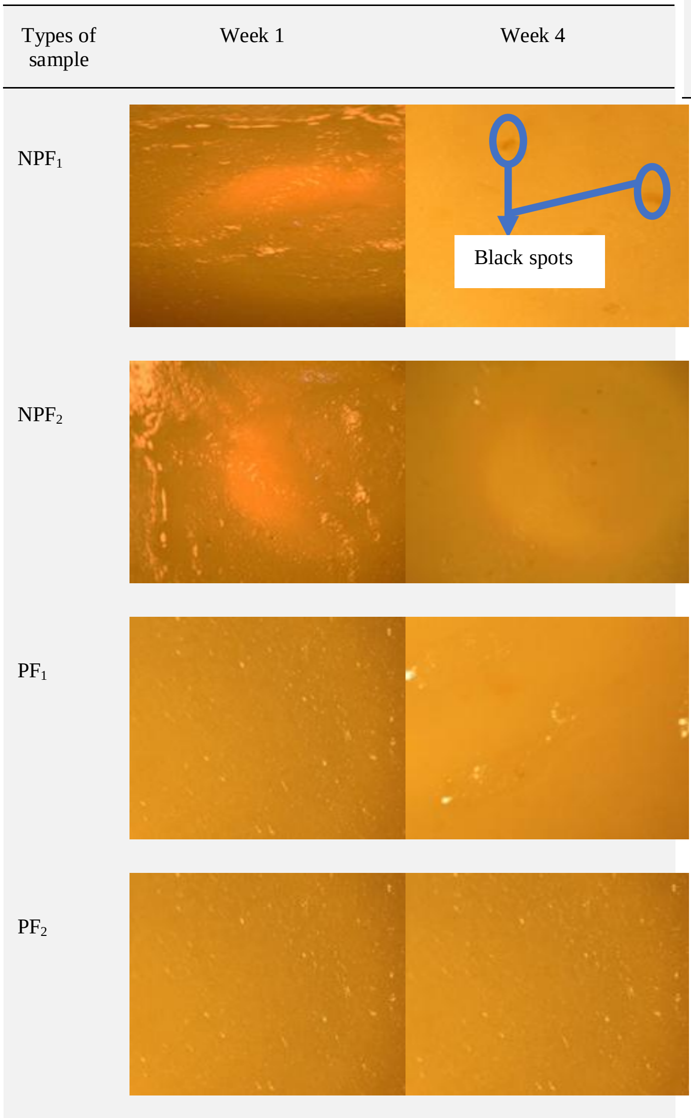

Fig. 1: Observation of black spot via a microscope (40×) during freeze-thaw stage

3.5. Sensory Evaluation by Consumer Panellists

The evaluation was conducted by 50 untrained consumer panellists who consisted of 50% working adults and 50% of students. Approximately 70% Malay, 14% Chinese, 10% Indians, and 6% foreigners were selected to be the panellists. Table 6 shows no significant difference (p>0.05) of scores for all tested attributes (colour, texture, taste, overall acceptability) between NPF and PF samples. This finding (colour attribute) was similar to colour evaluation by an instrument of b value (yellowness index) with no significant difference found (p>0.05) as in Table 4. Both instrument and panellists were not able to detect any colour differences between NPF and PF curry puffs. Both NPF and PF samples had a distinct surface texture after the frying process. The panellists commented the fried PF has a smoother surface than NPF curry puff. Therefore, it can be concluded that consumers were unable to detect the differences in taste, and overall acceptability (with and without the addition of calcium propionate) between NPF and PF curry puffs. All the samples were fairly accepted by this group of consumers. Results indicate that there is a possibility to commercialize par-fried curry puff locally and internationally.

Table 6: Sensorial characteristics of NPF and PF curry puffs

Type of sample	Colour	Texture	Taste	Overall Acceptability
NPF_1	6.5 ± 1.3^a	6.4 ± 1.6^a	6.9 ± 1.1^a	6.7 ± 1.0^a
NPF_2	6.8 ± 1.2^a	6.6 ± 1.9^a	7.0 ± 1.3^a	6.9 ± 1.4^a
PF_1	6.9 ± 1.3^a	7.0 ± 1.4^a	7.0 ± 1.2^a	7.1 ± 1.3^a
PF_2	6.6 ± 1.4^a	6.8 ± 1.3^a	6.7 ± 1.2^a	6.8 ± 1.0^a

NPF_1: non par-fried (control), NPF_2: non par-fried with 0.1% CP, PF_1: par-fried (control), PF_2: par-fried with 0.1 % CP
Similar alphabets within the same column show the insignificant difference by Tukey's test (p>0.05).
Values are mean ± SD of triplicates.

4. Conclusion

The moisture content in uncooked NPF_1 curry puff was significantly the highest (p<0.05) compared to NPF_2, PF_1, and PF_2 curry puffs. Meanwhile, oil uptake shows significant differences (p<0.05) between NPF and PF curry puffs. The NPF_1 and NPF_2 curry puffs had higher oil uptake compared to PF_1 and PF_2 curry puffs. Total polar content (TPC) in fried oil shows linear relationship upon repeated frying. The TPC in oil from the first time of frying until the 15th time frying increased significantly but was still at an acceptable level. There was a significant difference in weight loss (p<0.05) between the uncooked NPF and PF curry puffs on the fourth week of the freeze-thaw cycle. Uncooked NPF_1 and NPF_2 curry puffs had significantly higher weight loss than PF_1 and PF_2 curry puffs. Image analysis showed black spots on the uncooked NPF_1 curry puff on the fourth-week cycle. The colour of the curry puff surface was analyzed via colourimeter and sensorial evaluation. Both consumers and instrument showed no significant difference in the colour attributes of fried curry puff. Consumers were not able to detect the differences between NPF and PF curry puffs in terms of texture, appearance, taste, and overall acceptability. Thus, par-frying with the addition of CP may be adapted for the production of frozen curry puff to maintain its quality and preserve the product during distribution and frozen storage.

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