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Effect of Sugar Beet Pectin on Oil Uptake in Fried Banana and its Acceptability

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ABSTRACT

Fried banana is one of the popular local snacks in Malaysia. However, tremendous interest in healthy food has risen among consumers and producers resulting in a rising demand for low-fat foods. Thus, oil uptake needs to be considered during frying since it also affects the flavour, odour and general organoleptic properties of the food. The main objective of this study is to determine the effect of different concentrations of sugar beet pectin in the frying batter of fried banana and introduce the new usage of sugar beet pectin as one of the ingredients in the frying batter. Three different formulations of frying batter were prepared using 1%, 1.5% and 2% of sugar beet pectin (SBP) together with other ingredients including rice flour, water, plain flour, baking powder and salt. The addition of sugar beet pectin improved the characteristic of the batter as well as the fried banana crust. The moisture content of the crust increased about 7.6% when 1.5% SBP (F2) was used in the formulation thereby reducing the oil absorption by 8.5%. The crust crispiness also increased by 16.7% when 1.5% SBP (F2) was added to the frying batter formulation. Batter pick-up value was found highest in F1 (1% SBP) with 8.84% increment as compared to batter with no added hydrocolloids. Addition of SBP in batter formulations significantly increased the batter pick-up value. In terms of acceptability, F1 (1% SBP) was the most preferred by the panellist which was due to the appearance and colour of the fried bananas. All formulations obtained attributes scores higher than six thus were accepted by the panellists.

Keywords: *sugar beet pectin, banana coating, frying batter, fried banana.*

1. INTRODUCTION

Most of the world's edible bananas are from the species *Musa acuminata* or the naturally occurring hybrid between *Musa acuminata* and *Musa balbisiana*. In Malaysia, the most important species of bananas include 'Mas', 'Berangan', 'Awak', 'Nangka', 'Raja and 'Nipah (also known as 'Abu' in Peninsular Malaysia" [1]. Bananas are normally consumed in either as raw, boiled or fried forms. Fried banana is commonly consumed as a tea-time snack in South East Asia thus it was used as a carrier in this study. Despite its appealing characteristics, fried banana relatively contains high oil uptake ranging between 33 to 38% and this is discordant with recent trends towards consuming low fat and healthier food. Oil uptake needs to be considered as some important parameters in fried food especially when deep frying is involved. In general, the fat content will affect the flavour, odour and general organoleptic properties of food. There have been many efforts to reduce oil absorption including the use of hydrocolloids

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such as pectin, carboxyl methylcellulose (CMC) and xanthan gum in the batter preparation of fried food. Batter which is defined as liquid dough, consists of flour and water. The food is dipped in the batter before deep frying. Batter covers the surface of the food products to form the crust during deep frying and provides crisper texture, golden yellow colour and act as a barrier against the loss of moisture by protecting the natural juices of foods. Therefore, the fried products have tender and juicy interior food and crisper crusts [2]. Deep frying can be defined as the process of drying and cooking food through contact with hot oil. Deep frying involves the immersion of food pieces into hot oil with temperatures between 170 to 180°C. This immersion causes several physical and chemical changes in both the frying oil and the food, resulting in changes that define the quality of the fried product [3]. During frying, moisture which consists of vapour and water, migrates to the surface and creates a porous system within the food. This porous system allows the water in the crust to evaporate while the oil penetrates the food. The vapour escape path becomes an access for fat invasion thus, ingredients used in batter preparation plays an important role in the determination of oil absorption and the quality of the fried product. Moreover, the use of high frying oil temperature leads to oil degradation and oxidation of fatty acids as well as further reactions with protein, carbohydrates and other product decompositions. Hence, the aim of this study is to determine the effect of different sugar beet pectin (SBP) concentrations on the oil uptake of fried banana *Musa acuminata* variety and its acceptability.

2. MATERIALS AND METHOD

2.1 Materials

Bunches of bananas from the *Musa acuminata variety* were purchased from suppliers of bananas around Shah Alam, Selangor. Plain flour (Brand: Faiza), rice flour (Brand: Rose), baking powder (Brand: Nona) and salt were purchased from the local market. Sugar beet pectin was purchased at a local bakery store that is located in Shah Alam, Selangor.

2.2 Preparation of batters

Four batter formulations including control were prepared. Details of the batter formulations are shown in Table 1.

Table 1 Batter formulation with different percentage of sugar beet pectin (SBP)

Ingredients (%)	Control (%)	F1 (1%)	F2 (1.5%)	F3 (2%)
Rice Flour	40.00	39.00	38.50	38.00
SBP	0	1	1.5	2
Water	54.83	54.83	54.83	54.83
Plain Flour	4.46	4.46	4.46	4.46
Baking Powder	1.25	1.25	1.25	1.25
Salt	0.31	0.31	0.31	0.31

**SBP: sugar beet pectin; F: formulations*

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The batter consisted of rice, plain flour, baking powder, salt and water. The hydrocolloids, sugar beet pectin (SBP) were added based on rice flour dry weight basis at 1.0% for formulation 1, 1.5% for formulation 2, 2% for formulation 3 and 0% for the control formulation. Sugar beet pectin (SBP) and rice flour powder were first dispersed and mixed with 40% of the total amount of water used while the other dry ingredients were mixed with the remaining water. All ingredients were mixed thoroughly until a homogeneous batter was obtained.

2.3 Moisture and oil content
The crust samples were dried in an oven at 105°C for 24 hours until constant weights were achieved, and the oil content was determined using the Soxhlet apparatus [4].

2.4 Batter pick-up value
Batter pick-up value was expressed as the differences in battered and initial weight divided by the initial weight, times 100. In batter-coated products, the term ‘pick-up’ is generally used to denote the amount of batter that adhered to the piece of food; the yield and the quality of the final product depended on it. Therefore, the amount of batter adhering to a fried banana was considered the batter pick-up value, calculated as:

$$\text{Batter pick-up (\%)} = \frac{B}{(B+S)} \times 100$$

Where:

B is the mass of batter coating the food item after cooking
S is the mass of the food item, excluding the batter (‘peeled’), after cooking.

2.5 Viscosity
Flow behaviour of the batters was investigated at 25°C using a parallel plate rotational viscometer (Brookfield Model CV20, Karlsruhe, Germany). The batter was allowed to equilibrate for 5 min and was tested using spindle number six. The speed used was 100 rpm.

2.6 Texture analysis
Texture analysis of the fried banana from each formulation was conducted to obtain mechanical data. A TA-XT2i plus Texture Analyser (Stable Micro Systems, Godalming, UK) was used to measure crust crispiness and adhesiveness of the crust towards banana using a 10 kg load weight. The crispiness of the crust was measured using a 2 mm needle probe (P/2N) while the adhesiveness of the crust was measured using a cylinder probe with a diameter of 5 mm (P/5). The peeled off from the banana crust and the inner side of the crust that sticks to the banana was used to measure the adhesiveness of the crust.

2.7 Colorimetric measurements
The crust sample colour with triplicates was measured using a Chromameter (CR400, Konica Minolta, Japan) and standardized against a calibration white tile. The L*, a*, and b* readings were recorded. A standard white calibration plate was used to calibrate the equipment.

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2.8 Sensory evaluation

Sensory evaluation was performed by 30 panellists, on samples that had been fried using four formulations. The preference/acceptance tests with a nine-point hedonic scale were conducted to distinguish the levels of several sensory parameters. The parameters evaluated were colour, flavour, crispiness, texture and overall acceptability. The following hedonic scale was used for scoring these attributes: 1. Dislike extremely, 2. Dislike very much, 3. Dislike moderately, 4. Dislike slightly, 5. Neither like nor dislike, 6. Like slightly, 7. Like moderately, 8. Like very much, 9. Like extremely.

2.9 Statistical analysis

The data obtained in this study were analysed using analysis of variance (ANOVA) to determine the interaction between batter formulation with oil and moisture content, viscosity and batter pick-up value, texture profile, colour and sensory evaluation. Tukey's honest significant difference (HSD) test was conducted to determine the significant level of mean values for each variable. The analysis was performed using SPSS for Windows Version 12 (SPSS Inc., USA) in triplicates.

3. RESULTS AND DISCUSSION

3.1 Oil and moisture content

Table 2 shows the oil and moisture content in the crust of fried banana with different formulations. There was no significant ($p>0.05$) difference seen in the oil content between formulations. The lowest percentage of oil in the crust was 27.1% for F2 formulation (1.5% SBP) followed by 26.3% for F3 formulation (2% SBP).

Table 2 Oil and moisture content in the crust of fried banana with different formulations

Formulation	Oil Uptake (%)	Moisture Content (%)
C 0% SBP	35.6 ±0.88^{a}	14.1±3.14^{b}
F1 (1% SBP)	36.4 ±0.88^{a}	17.0±1.19^{b}
F2 (1.5% SBP)	27.1 ±1.75^{b}	20.2±3.27^{ab}
F3 (2% SBP)	26.3 ±1.31^{b}	21.7±0.18^{a}

SBP: sugar beet pectin
Note: Values are expected as mean ± standard deviation.
^{a} Means with different small letters within a column indicate significantly different using Duncan's multiple ranges test ($p<0.05$).

The addition of SBP significantly decreased the oil uptake and this is supported by Norizzah *et al.* who reported that hydrocolloid treatment may alter the water-holding capacity and consequently affect oil uptake. Norizzah *et al.* reported a significant reduction ($p<0.05$) in oil content of banana fritters dipped in batter containing xanthan gum compared to carrageenan and control [5]. Arantzazu *et al.* explained the reason for lower oil uptake when hydrocolloids

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were added into the batter formulation is due to hydrogen bonding between water molecules in the batter and hydrocolloids which promote moisture retention [6]. In another study by Sahin *et al.*, batter formulation for fried chicken nuggets with hydroxypropyl methylcellulose (HPMC) and xanthan gums also exhibit a significant reduction in oil absorption [7]. An inverse relationship between moisture loss and oil uptake was also observed in this study. The F3 (2% SBP) crust was significantly different ($p<0.05$) from F1 (1% SBP) and control (0% SBP) however, F2 (1.5%) and F3 (2%) were reported to have no significant differences. This is supported by Zainun *et al.* in her study on fried breaded banana that obtained relatively lower moisture and higher fat content [8].

During deep frying, water starts evaporating as soon as the raw material is in contact with oil. Water evaporation through heat transfer during a frying process creates void spaces within the crust which then is filled with oil, thus increasing the oil content in some of the formulations [8,9]. The previous study reported moisture increases due to the hydrocolloids coating and was proportional to the increase in the concentration of the films, indicating greater moisture retention by thicker films [10]. Furthermore, a high amount of SBP in F3 (2% SBP) causes thermal gelation or crosslinking properties of hydrocolloids, which resulted in less oil entrance to the pores. Moreover, hydrocolloids were able to form edible films and coatings with good oxygen, carbon dioxide and lipid barriers, which gives them the potential to reduce oil absorption in deep-fat-fried products [11].

3.2 Viscosity and batter pick-up value

Table 3 shows the viscosity and batter pick-up value of the frying batter with different SBP formulations. An increase in viscosity is seen with the increase of SBP percentage. All the formulations were significantly different from the F3 (2% SBP) frying batter obtaining the highest viscosity at 1765 cP. Higher viscosity in F3 (2% SBP) is due to the amount of sugar beet pectin whereby the interaction between pectin from SBP and protein occurred and resulted in higher water binding capacities. This finding was in accordance with Arantzazu *et al.* who confirmed the addition of different starch and gum species to batter was found to be effective for both viscosity development and quality attributes of deep-fat fried chicken nuggets. In addition, Cunningham and Tiede (1981) also reported that coating pickup was found to be directly proportional to batter viscosity however, results obtained from this study contradicts with Cunningham *et al.* findings whereby the batter pick-up values decreased as the viscosity increased [12].

Table 3 Batter pick up value in different formulation of frying batter

Formulation	Viscosity (cP)	Batter pick-up value (%)
C 0% SBP	$250±14.44^{d}$	$36.2±1.05^{c}$
F1 (1% SBP)	$510±14.14^{c}$	$45.0±0.93^{a}$
F2 (1.5% SBP)	$980±14.04^{b}$	$43.0±0.58^{b}$
F3 (2% SBP)	$1765±7.07^{a}$	$42.7±1.70^{b}$

SBP: sugar beet pectin
Note: Values are expected as mean ± standard deviation.
$^{a-b}$ Means with different small letters within a column indicate significant difference using Duncan's multiple ranges test ($p<0.05$). this box overlaps the text

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As shown in Table 3, increasing the amount of SBP in the batter formulations resulted in an increase in viscosity and a decrease in batter pick-up value. The highest batter pick-up value was found in F1 (1% SBP) at 45% and there was no significant difference observed between the F2 (1.5% SBP) and F3 (2% SBP) formulations. The higher proportion of protein content (7 to 9 %) of rice flour in F1 (1% SBP) may contribute to the highest batter pick-up value in this study. The addition of hydrocolloids to batter formulation increases surface adherence and influences the coating ability by enhancing water retention in fried foods. Hence, the addition of SBP in batter formulations was found to be significantly effective for batter pick-up value on the fried banana. The increment of SBP amount comma however comma did not significantly increases batter pick-up as seen in F2 (1.5% SBP) and F3 (2% SBP) batter formulation.

According to Salvador *et al.*, the addition of hydrocolloids is generally effective at levels as low as 1% or less of the dry weight formulation because many hydrocolloids are highly hydrophilic, so the formulation needs an adjustment to the solids–water proportion, modifying the characteristics of the entire system. This is supported by Altunakar, *et al.* who reported viscosity development within the batter may be explained by the water binding capacities of the dry ingredients. If the hydrocolloid binds a significant amount of moisture, it will provide a consistency for batter pick-up value.

Conferring to Fiszman *et al.* and Altunakar *et al.*, the use of hydrocolloids is primarily based on their ability to retain water and their effect on controlling viscosity, which normally translates into an improvement in the characteristics of adhesion to the food substrate and an increase in the degree of coating. The effectiveness of hydrocolloids in improving adhesion has mainly been linked to their gel-forming properties. The gelled films provide strength and integrity towards effective adhesion. Incorporation of pectin in batter formulation reduces batter detachment and fall-off into the oil, as well as maintaining adhesion in final frying stages [16].

3.3 Texture Profile Analysis

3.3.1 Adhesiveness

The adhesiveness of the frying batter was measured on the fried banana crust after frying. The results in Table 4 shows the adhesiveness and hardness of the fried bananas at different formulations. A significant difference in adhesiveness was seen between each formulation and F3 (2% SBP) obtained the highest adhesiveness at 318 g which believed contributed to 2% SBP used in the batter formulations. The adhesiveness of the crust is important to ensure the batter does not fall off from the substrate during frying and is still intact after frying. The effectiveness of gums in improving adhesion has mainly been linked to their gel-forming properties. The gelled films formed to provide strength and integrity and have a positive effect on adhesion, preventing blow-off and pillowing. The gelling of gum, pectin, carrageenan and alginates in the presence of ionic salts has been associated with improved adhesion [16].

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Table 4 Texture profile analysis of the adhesiveness and hardness (crispiness) of fried banana between formulations

Formulation	Adhesiveness (g)	Hardness (N)
C 0% SBP	7.03±0.44^{d}	-20.12±1.41^{c}
F1 (1% SBP)	69.98±9.13^{b}	-4.87±2.22^{b}
F2 (1.5% SBP)	30.78±1.22^{c}	-24.17±0.93^{c}
F3 (2% SBP)	318.03±1.70^{a}	105.61±0.87^{a}

SBP: sugar beet pectin
Note: Values are expected as mean ± standard deviation.
$^{a-b}$ Means with different small letters within a column indicate significantly different using Duncan's multiple ranges test ($p<0.05$).

3.3.2 Crispiness

The crispiness of the final fried crust is an important index in battered, fried food. Some of the texture changes happened when moisture was removed from the crust during frying. The breaking force or hardness (N) is an indicator of the extent of crispness. A lower hardness value corresponds with a higher crispness [17]. In Table 4, the lowest hardness or breaking force was found in F2 (1.5% SBP) at -24.17 N and F2 formulation also obtained the highest crispness. There were no significant differences ($p>0.05$) seen F2 (1.5% SBP) and ~~to~~ control samples that have no additional hydrocolloids. However, when the amount of SBP was increased to 2% in the formulation, the hardness was promptly increased. This result was similar to the findings of Norizzah *et al*. (2016) who reported the addition of gum in the batter formulation had increased the hardness of the coating due to the viscosity properties in the gum itself. Thus, the additional minimum amount of hydrocolloids in batter formulations is crucial to retain the crispness of the final product.

The fried crusts containing too much hydrocolloids had softer and elasticity texture, because hydrocolloids gel absorbs water molecules in the crusts resulting in poor crispness and increased elasticity of the crust [18]. This can be observed in F3 batter formulation. This finding is supported by Sothornvit *et al.* who reported that vacuum fried banana chips coated with guar gum had lower crispness compared with control samples [11]. The crust containing hydrocolloids was differentiated by presenting greater visual sponginess as a result of the higher gas retention produced by the leavening agent [13]. Adding hydrocolloids also improved their gelling properties, thereby ensuring a final product that is tender and juicy on the inside and crisp on the outside simultaneously [20]. In addition, the use of baking powder resulted in a spongy structure, promotes aeration during frying, contributes to the crispness of the food product and facilitates vapour release during the pre-frying and final frying procedures [16].

According to Primo-Martín *et al*., the crispness of the crust formed during deep frying of battered products is a key driving factor for consumer preference [20]. The usage of hydrocolloids as one of the ingredients in the batter can influence the adhesiveness of a batter coated product because of their ability to give viscosity. According to Varela *et al.*, the body

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and integrity conferred by gums enhance batter performance before, during and after the frying operation, leading to improved batter adhesion. The effectiveness of gums in improving adhesion has mainly been linked to their gel-forming properties. Gums play two main roles in fried food development. When they are added to the batter among the other ingredients, they can avoid oil absorption, improve adhesion, and help to retain the crispness of the battered. A large number of hydrocolloids have been found to serve as adhesives, whereby one of them includes pectin. Sugar beet pectin is reported to increases the coating adhesiveness and its emulsifying activities which is influenced by the protein, ferulic acid groups, proportion of ester group and molecular mass distribution of the fraction (2). In this study, a few formulations with different concentration of sugar beet pectin (SBP) were used as a batter for fried bananas using deep frying technique. Pectin present in the sugar-beet pulp contains high methoxyl groups and have more than 50% of methoxylated residues. Pectin gels at low pH values and in the presence of a high concentration of soluble solids [21].

3.4 Colour analysis

Colour is another important quality attribute of fried battered food. The ideal colour is a light golden brown which is normally due to the browning reaction when frying. L* is an approximate measurement of lightness, a* takes positive values for reddish colours and negative values for greenish ones, whereas b* takes positive values for yellowish colours and negative values for bluish ones [33]. Table 5 shows that the value of L* was only different in control formulation (0% SBP) whereby an additional amount of SBP does not influences the L value in batter formulations. As for the redness (a*) and yellowness (b*) the study shows no significant difference at $p>0.05$ even though concentration of SBP varied. The colour of the fried banana does not have a significant difference ($p < 0.05$) with each other as the addition of SBP does not influence the development of the colour of the fried product.

Table 5 Results of the colour of fried banana with different frying batter formulation

Formulation	L*	a*	b*
C 0% SBP	63.09±2.31^a	6.00±3.17^a	33.49±5.85^a
F1 (1% SBP)	55.62±1.05^b	6.17±0.85^a	28.21±1.06^a
F2 (1.5% SBP)	59.23±2.44^b	6.14±0.94^a	34.28±4.69^a
F3 (2% SBP)	59.23±1.11^b	55.06±0.42^a	28.30±0.62^a

SBP: sugar beet pectin
Note: Values are expected as mean ± standard deviation.
$^{a-b}$ Means with different small letters within a column indicate significantly different using Duncan's multiple ranges test ($p<0.05$).

3.5 Sensory evaluation

The appearance, colour, crispness, adhesiveness and overall acceptability scores for fried banana are presented in Table 6. There was no significant difference ($p > 0.05$) reported in the appearance and colour of different batter formulations in fried banana. Sensory panellists prefer

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the crispness and adhesiveness of the control fried banana that contain no SBP in formulations. In overall acceptability, panellists prefer the control fried banana as compared to fried banana with added SBP in the formulations. Addition of SBP in batter formulations were not significantly different between F1 (1% SBP) and F2 (1.5% SBP) as well as F2 (1.5% SBP) and F3 (2% SBP). However, the scores for all attributes were higher than 5, indicating that all formulations were acceptable. In terms of appearance and colour of the fried banana, the usage of SBP in the formulations was still highly acceptable by the panellist.

Table 6 Sensory evaluation of fried banana of different formulation of frying batter.

Formulation	Appearance	Colour	Crispness	Adhesiveness	Overall
C 0% SBP	6.77±1.67^{a}	6.87±1.50^{a}	8.03±0.72^{a}	7.6±0.89^{a}	8.20±0.66^{a}
F1 (1% SBP)	7.20±1.16^{a}	7.20±1.19^{a}	7.17±1.44^{b}	6.67±1.44^{b}	7.40±1.45^{b}
F2 (1.5% SBP)	6.83±1.29^{a}	6.77±128^{a}	6.90±1.52^{b}	6.57±1.50^{b}	6.90±1.49^{bc}
F3 (2% SBP)	6.77±1.36^{a}	6.53±1.72^{a}	5.93±1.86^{c}	6.20±1.47^{b}	6.63±1.38^{c}

SBP: sugar beet pectin
Note: Values are expected as mean ± standard deviation.
$^{a-b}$ Means with different small letters within a column indicate significantly different using Duncan's multiple ranges test ($p<0.05$).

The finding in this study is in accordance with Norizzah *et al.* that reported no significant differences ($p>0.05$) in terms of overall acceptance between treated and untreated sample with hydrocolloids [5]. Hence, the addition of SBP in this study was effective in reducing oil absorption of fried banana without affecting the overall sensory acceptability.

4. CONCLUSION

The addition of sugar beet pectin (SBP) in the modification of frying batter formulation by using banana as the carrier improved certain quality of the fried products. The oil content of the crust of fried banana was reduced by 8.46% with the addition of 1.5% SBP (F2). The addition of hydrocolloids such as sugar beet pectin can address the concern related to the consuming fried products. The moisture content of batter with 1.5% of SBP had an inverse relationship with the oil content. As the moisture content was high, with 7.55% difference from control, the oil content was low in the crust. The addition of SBP in formulation could effectively hinder the oil absorption as hydrocolloids tend to absorb moisture. However, the addition of 1% and 2% SBP does not effectively reduce the oil intake even though their moisture content was high.

The pick-up value of the batter was the highest at 1% SBP (F1) with an increment of 8.84% from control. The highest viscosity was found in F3 (2% SBP) at 1765 cps. Thus, the usage of SBP in the formulations proves that SBP has the ability to retain water and control the viscosity which improves the characterisation of adhesiveness toward food substrate and increase the degree of coating. Addition of sugar beet pectin in frying batter only improves the texture of

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the crust when used in certain concentrations. The crispiness of the fried banana crust increased by 16.8% when 1.5% SBP (F2) was used in the formulation.

The sensory evaluation shows that the panellists can accept the addition of SBP in the fried product as there were no big differences in all the attributes. Noticeably, the addition of 1.5% amount of SBP in the batter formulation significantly improves the crunchiness and sensory properties of the products, suggesting its prospect as promising ingredients to produce fried banana with lower oil content. In addition, further studies on the relation of formulations with the frying time and frying oil temperature should be conducted since both factors also affect the overall results.

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