CHEMICAL AND PHYSICAL PROPERTIES OF MUFFIN PREPARED FROM DIFFERENT LEVELS OF MANGO (*Mangifera indica*) VARIETY CHOKANAN PULP FLOUR

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Muffins were prepared with 0-20% mango pulp flour (MPF) and were evaluated for physico-chemical properties. Increased in substitution of MPF showed an increased ($p<0.05$) in moisture, fat, crude fibre and ash content. The 20% MPF muffin differ significantly with the others in terms of mineral content such as copper, zinc, sodium, potassium and calcium. The resistant starch content of the muffins were unaffected by the substitution of MPF. Muffin substituted with 20% MPF has the highest ($p<0.05$) value of dietary fibres. However, muffins with substitution of MPF has smaller ($p<0.05$) volume and lower ($p<0.05$) in height. Muffins with MPF had lower scores of L and a value than the control muffins. Based on the observation of the physical and chemical results, the matured green 'Chokanan' variety mango pulp is suitable to be processed into flour as fibre ingredient with potential health benefits.

Keywords: Mango (Mangifera), mango flour, muffin, physico-chemical

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ABSTRACT

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INTRODUCTION

Mangoes, unlike other fruits, differ not only in physical appearance but also in their aroma and flavour. The intensity of such characteristics varies widely amongst varieties upon ripening (Ueda *et al.*, 2001). Mango is mainly consumed in ripe state and is scarcely commercialized, when compared to the quantity produced due to the difficulties in post harvest management in the producing countries (Giraldo *et al.*, 2003). Hence, agricultural produce is lost every year due to lack of adequate storage facilities (Vazquez-Salinas and Lakshminarayana, 1985). Thus, mango processing that maintains the product freshness characteristics and stabilizes the product, which lengthens its shelf life in the market, would be very convenient to increase commercialization in the non-producing countries (Giraldo *et al.*, 2003). Mango consist a fair amount of insoluble dietary fibre and soluble dietary fibre (Ramulu and Rao, 2003). According to Figuerola *et al.* (2005), fruit fibre are better quality as source of confectionary dietary fibre than cereal grains due to higher fibre content, ability of higher water and oil holding capacity as well as lower caloric value. More ever, fruit fibres are able to minimize losses of nutrient compounds which will exert higher health promoting effects (Larrauri, 1999). Extensive studies in developing mango products concentrated in juice, chutney, jam, dried mango slices (Cooke *et al.*, 1976; Mitra and Baldwin, 1997; Giraldo *et al.*, 2003). Production in powder or flour form has great economical potential, offers convenience, reduced bulk weight and storage stability. The importance of flour is further strengthen when the Food and Agriculture Organization of the United Nations (FAO) has launched a 'Composite Flour Program' to seek new possibilities for the raw materials other than the wheat for bread, biscuits, pastas and similar flour base production (De Ruiter, 1978). Muffins, just like bread and cookies are peoples favourite as it is ready and convenient to consume yet contains good nutritive value. Muffin can be enriched with various types of functional additives as well as new types of raw material which are able to enhance the quality of muffin. High fibre carbohydrate-rich breakfast has been shown to augment satiety and reduce daily energy consumption as compared with fat-rich breakfast (Cho *et al.*, 2003; Mattes, 2002; Holt *et al.*, 1999; Ruxton and Kirk, 1997).

Although Chokanan variety is found abundant in Malaysia and Thailand, less research has been done concerning this variety. Hence, in this investigation, mango pulp flour (MPF) is processed from Chokanan variety and the flour is incorporated into muffin at different percentage levels (5%, 10%, 15% and 20%). The effects of mango pulp flour substitute for wheat flour on the physico-chemical properties were evaluated.

MATERIAL AND METHOD

Preparation Mango Pulp Flour

Fully matured green mangoes were obtained from local market. Undamaged mango fruit free from infection were selected for this investigation. The fruit were washed and sliced using a peeler and dipped into 0.1% (w/v) potassium metabisulphite solution. The slices were rinsed under running water to remove excess potassium metabisulphite. The slices were placed on aluminium trays and dried in conventional hot air dryer (Afos, Model Mini, No. CK 80520 England) at $60^{o}C$ to a constant weight. The dried slices were then grind into flour with a bench-top grinder (retch Micro Universal, 0.05µm, 14000rpm, Germany) and later the flour samples was kept refrigerated in air-tight container until usage.

Muffin Ingredients

Ingredients used for the preparation of muffin include Blue Key self raising flour, egg, sugar, margarine, milk powder and sugar ester were obtained from Sunshine Trading Company in Siam Road, Penang. Distilled water was used for preparation of muffin.

Preparation of Mango Muffin

Muffin was prepared according to Campbell *et al.* (1979) method where dry and wet ingredients were separated in the early stage of mixing. Heavy duty mixer (Kitchen Aid-KSM 900, USA) was used throughout the mixing procedure. The muffins was prepared with different percentage of mango pulp flour were baked as shown in Table 1. Margarine, sugar ester and brown sugar were first mixed together and followed by egg and water. Self raising flour, mango pulp flour, milk powder and mango flakes were added later and were mixed well at low speed to deter trapping air. The prepared batter was then transferred into paper cup cakes and weighing about 65g. The batter was then baked using Salva Modular oven for 20 minutes at 190° Celsius. The cooked muffins were cooled for an hour at ambient temperature prior to analyses.

Chemical Analyses

Proximate analysis of moisture (Method 925.40), crude fat (Method 920.39), crude fibre (Method 7.504), ash (Method 923.03), crude protein (Nx6.25) (Method 955.04) was determined according to AOAC (1990) standard method. Carbohydrate content was determined by subtracting 100% with the total percentage of the above proximate. Minerals contents were determined by using AA Spectrophotometer Flame Perkin Elmer. Resistant starch content was evaluated according to Goni *et al.* (1996) method. All chemical analyses were carried out in triplicate. The insoluble and soluble dietary fibre was carried out following a slight modification of procedure from SIGMA Total Dietary Fibre Assay Kit and AOAC, 1997 (Method 991.43).

Physical analyses

The volume, specific volume, weight and height of the muffins were carried out according to AACC Method 55-50 (2000). Samples were analyzed in triplicate. The muffin was weighed 1 hour after removal from the oven. The volume (ml) was determined using rapeseed displacement method and specific volume (cm^3/g) was obtained from divided volume with loaf weight. Colour was measured by using the Minolta 3500d Osaka, Japan. Six replicates were used in the measurement. Each muffin was cut into slices, of sizes 2x2x2 cm. Each replication was presented by 4 measurements taken from each sample. The samples were measured for L*, a*, b* and hue value.

Statistical Analysis

The experimental data were analyzed statically by analysis of variance with statistical significance ($p=0.05$) using Duncan's Multiple Range Test. Result obtained from triplicate samples (unless stated) are given as means and standard deviations and inferences were reported at appropriate place.

RESULT AND DISCUSSION

Results showed in Table 2 are the proximate composition of muffin substituted with different levels of MPF. The increase substitution of MPF resulted in significantly higher ($p<0.05$) moisture content in the muffins. This might be attributed to the presence of fibre in flour which will enhance the water absorption capacity. High water absorption was expected due to the hydroxyl groups in the fibre structure, which allows more water interaction through hydrogen bonding (Rosell *et al.*, 2001). This was further confirmed when Mansour *et al.* (1999) reported that the addition of pumpkin and canola proteins to wheat flour attributed to an increase in water absorption.

The substitution of MPF in muffins also resulted in significantly higher ($p<0.05$) fat content. However, the fat content of MPF substituted muffins in this study (14.95-16.33%) can be considered low as compared to other baked products reported in past studies. Macaroons baked with 25% of coconut flour contents 33.50% of fat while carrot cake with 20% coconut flour consist 19.30% fat (Trinidad *et al.*, 2006). With almost similar substituted flour amount, macaroons and carrot cake that contained coconut flour contents much higher fat content when compared to muffins substituted with 20% MPF in this study. Dhingra and Jood (2001) reported wheat flour bread that contains 5.44% fat had increase with significant ($p<0.05$) when full fat soy flour was blended into the bread.

Table 1: Mango muffin formulation prepared with different substituted percentage of mango pulp flour (MPF)

Ingredients	Control	5% MPF	10% MPF	15% MPF	20% MPF
Self raising flour (g)	25.00	23.75	22.50	21.25	20.00
Mango flour (g)	-	1.25	2.50	3.75	5.00
Water (ml)	12.80	15.25	17.30	20.20	21.00
Mango flakes (g)	-	2.00	2.00	2.00	2.00
Egg (g)	10.00	10.00	10.00	10.00	10.00
Brown sugar (g)	6.50	6.50	6.50	6.50	6.50
Margarine (g)	4.00	4.00	4.00	4.00	4.00
Milk powder (g)	4.00	4.00	4.00	4.00	4.00
Sugar ester (g)	3.00	3.00	3.00	3.00	3.00

Table 2: Proximate composition of muffin with different levels of mango pulp flour.(MPF)

Composition %	Control	5% MPF	10% MPF	15% MPF	20% MPF
Moisture	30.35 ± 0.68^{a}	34.62 ± 0.43^{b}	37.01 ± 0.37^{c}	38.76 ± 0.14^{d}	39.45 ± 0.46^{d}
Fat	14.95 ± 0.81^{a}	15.40 ± 0.53^{ab}	15.81 ± 0.13^{ab}	16.18 ± 0.36^{b}	16.33 ± 0.21^{b}
Crude fibre	3.04 ± 0.07^{a}	3.54 ± 0.13^{ab}	4.11 ± 0.15^{bc}	4.62 ± 0.55^{c}	5.68 ± 0.40^{d}
Protein	6.86 ± 0.20^{a}	6.40 ± 0.07^{b}	6.01 ± 0.08^{c}	5.92 ± 0.11^{c}	5.81 ± 0.03^{c}
Ash	1.37 ± 0.05^{a}	1.48 ± 0.04^{b}	1.55 ± 0.11^{bc}	1.56 ± 0.06^{bc}	1.61 ± 0.02^{c}
Carbohydrate	43.19 ± 1.32^{a}	38.48 ± 0.81^{b}	35.58 ± 0.64^{c}	33.15 ± 0.55^{d}	31.18 ± 0.80^{e}
Calorie (kcal/100g)	334.77 ± 1.72^{a}	318.17 ± 2.46^{b}	308.65 ± 1.22^{c}	301.90 ± 3.01^{d}	294.89 ± 1.55^{e}

Mean within the same row with different alphabet are significantly ($p<0.05$) different.
Values are the Means±SD with n=3 for each group.

The increase was due to higher fat content of full fat soy flour. Fat content has technological and nutritional implications due to the amylase-lipid complex formed during processing, which can produce resistant starch (Asp and Bjorck, 1992).

Muffin substituted with 20% MPF had the highest content of crude fibre. This shows that increment in incorporation of MPF resulted higher fibre content in the muffins. It is world-wide recommendation to increase cereal intake which is a source of dietary fibres and the development of enriched baked products with higher dietary fibre content should be the best way to increase the fibre intake.

Ash composition in muffins gradually increased with significant ($p<0.05$) corresponding to the higher MPF used for substitution of self raising flour. However, this result is in contrast with the observation reported by Dhingra and Jood (2001) whereby the wheat flour bread consist 2.10% ash and had remained almost the same in various flour supplementation at all levels. High content of crude fiber reduced the calorie value and high ash composition indicates good minerals composition.

However, the crude protein, carbohydrate and calorie content in muffins with MPF showed significantly ($p<0.05$) lower values than the control muffin. According to the observation reported by Paul and Southgate (1978), the chemical composition of self raising flour is high in protein (9.3%) and carbohydrate (77.5%) with caloric value of 339 kcal/100 g. These explain the decrement in protein and carbohydrate content when more amount of MPF was used to substitute self raising flour. The muffins substituted with MPF has lower protein content as compared to the research reported by Trinidad *et al.* (2006) on white bread (7.30%), hotcake substituted with 15% of coconut flour (9.50%) and multigrain loaf baked with 10% of coconut flour (9.80%). Dhingra and Jood (2001) found that wheat flour bread contain 11.50% protein which decreased gradually when barley flour was substituted.

Results indicated in Table 3 are the mineral composition of muffins with different levels of MPF. As for mineral content, higher level of mango pulp flour indicated increment in content except for sodium, iron and calcium. Mattoo and Modi (1969) reported that in their investigation, the main minerals in mango were potassium and magnesium. The muffin substituted with 20% MPF were the best source of potassium, magnesium and zinc.

In a study done by Trinidad *et al.* (2006), analysis of mineral elements such as iron, zinc and calcium contents were done on a variety of breads. The muffins in this study were compared with the variety of breads observed by Trinidad *et al.* (2006) whereby the white bread consist 1.70 mg/100 g iron, 4.40 mg/100 g zinc and 4.30 mg/100 g calcium. Multigrain loaf substituted with 10% of coconut flour has 4.70 mg/100 g iron, 5.30 mg/100 g zinc and 53.4 mg/100 g calcium. Hotcake made from 15% of coconut flour gives a reading of 2.40 mg/100 g iron, 5.5 mg/100 g zinc and 24.10 mg/100 g calcium. From the comparison as stated above, control and MPF substituted muffins had higher amount of iron and calcium content.

Mango pulp flour has no significant effect on the resistant starches (Table 4). Selvaraj *et al.* (1989) demonstrated that unripe mature mangoes consists high starch level and reduced considerably from harvest maturity to eating ripe stage. Bread, breakfast cereals and cookies which is cereal-based foods can contain appreciable amounts of resistant starch (Wen *et al.*, 1996). Liljeberg *et al.* (1996) did a research on bread made from wholemeal rye flour; white wheat flour (70:30) revealed 3.00% RS content. The

Table 3: Minerals content of muffins with different percentage of mango pulp flour (MPF).

Mineral mg/100g	Control	5% MPF	10% MPF	15% MPF	20% MPF
Copper	0.82±0.00^{a}	0.81±0.00^{a}	0.81±0.00^{a}	0.81±0.00^{a}	1.16±0.08^{b}
Iron	31.41±0.01^{a}	27.25±2.64^{a}	28.56±2.62^{a}	26.45±0.55^{a}	26.39±3.20^{a}
Zinc	1.71±0.00^{a}	1.79±0.09^{a}	1.89±0.04^{a}	2.11±0.00^{b}	2.32±0.12^{c}
Sodium	4682.56±1.70^{a}	4544.72±6.17^{b}	4431.48±4.06^{c}	3531.35±6.97^{d}	3455.47±11.60^{e}
Potassium	4323.18±17.73^{a}	4431.47±12.74^{b}	4976.01±6.48^{c}	5281.33±6.02^{d}	5318.92±15.66^{e}
Magnesium	225.32±6.07^{a}	237.14±0.17^{a}	244.56±11.92^{a}	253.67±25.06^{a}	254.64±0.04^{a}
Calcium	921.41±72.66^{a}	913.91±71.81^{a}	814.35±3.72^{ab}	789.07±5.06^{b}	777.83±17.82^{b}

Mean within the same row with different alphabet are significantly ($p<0.05$) different.
Values are the Means±SD with n=3 for each group.

Table 4: Mean values of resistant starch of muffins with different levels of mango pulp flour (MPF).

Control	5% MPF	10% MPF	15% MPF	20% MPF
1.89±0.10[a]	2.00±0.46[a]	2.22±0.13[a]	2.39±0.53[a]	2.51±0.03[a]

Mean within the same row with different alphabet are significantly ($p<0.05$) different.
Values are the Means±SD with n=3 for each group.

Table 5:Mean value of insoluble, soluble and total dietary fibre of muffins with different level of mango pulp flour(MPF).

Parameter	Control	5% MPF	10% MPF	15% MPF	20% MPF
Insoluble	3.69±0.19[a]	3.93±0.22[a]	4.28±0.06[b]	4.45±0.09[b]	4.91±0.07[c]
Soluble	1.24±0.15[a]	1.53±0.23[a]	1.65±0.17[ab]	2.05±0.10[bc]	2.28±0.32[c]
Total	4.93±0.34[a]	5.46±0.09[ab]	5.93±0.22[bc]	6.50±0.19[c]	7.19±0.39[d]

Mean within the same row with different alphabet are significantly ($p<0.05$) different.
Values are the Means±SD with n=2 for each group.

70% rye flour bread is considered to be low in RS (3.00%) when compared with the present study of muffin substituted with 20% of MPF (2.51% of RS).

Mango is known as a fibrous fruit. Hence, the total dietary fibre in mango muffin results a significant climb with a higher value in insoluble fibre compared to soluble fibre (Table 5). The value of total dietary fibre (TDF) from control muffin to 20% MPF substituted muffin had increased with significant ($p<0.05$). It was observed that with every additional of 10% of MPF substitution into muffin, both IDF and SDF content will increase with significant ($p<0.05$). Trinidad *et al.* (2006) confirmed the white bread to have 3.10% of TDF. Trinidad *et al.* (2006) also reported that foods substituted with coconut flour are higher in TDF as compared to the white bread. Similar observation was found in the present study whereby muffins substituted with MPF have better TDF content than the control muffin.

Table 6 shows the value of weight, volume, specific volume of muffins substituted with different levels of mango pulp flour. Increasing levels of mango pulp flour dramatically increased the weight of 5% sample as compared to the control. This may be due to the higher water absorption capacity of mango pulp flour. Rosell *et al.* (2001) observed that the presence of fibre in flour will enhance the water absorption capacity. However, the weight difference among 5%, 10%, 15% and 20% substituted MPF muffins is not significant ($p>0.05$). This suggests excess water in the dough is readily evaporated during baking since larger amount of water was used with the increased level of mango pulp flour. Borrelli *et al.* (2003) stated that when heat treatment is given, water percentage on the dough surface dramatically decreases.

Table 6:Mean values of weight, volume, specific volume of muffins incorporated with different levels of mango pulp flour(MPF).

Parameter	Control	5% MPF	10% MPF	15% MPF	20% MPF
Weight (g)	55.39±2.92[a]	61.25±1.64[b]	60.89±0.40[b]	59.31±0.08[b]	58.95±0.57[b]
Volume (ml)	161.39±7.87[ab]	165.00±4.33[a]	156.67±2.89[abc]	154.17±3.82[bc]	150.00±2.50[c]
Specific volume (cm)	2.92±0.12[a]	2.69±0.14[b]	2.57±0.05[b]	2.60±0.07[b]	2.54±0.04[b]
Height (cm)	5.17±0.06[a]	4.97±0.06[b]	4.80±0.10[c]	4.57±0.06[d]	4.33±0.12[e]

Mean within the same row with different alphabet are significantly ($p<0.05$) different.
Values are the Means±SD with n=3for each group.

The 5% sample had the highest loaf volume and specific volume as compared to other samples. Ptitchkina *et al.* (1998) reported similar result whereby 5% of pumpkin powder bread sample had the highest loaf volume and specific volume. The addition of high starch and high protein non-wheat flours to wheat flours results in poorer baking performance. The proportion and type of non-wheat component plays a great difference in baking characteristics existed among flours (De Ruiter, 1978). Thus explains the drop value of volume loaf and height of samples.

When more MPF was substituted, darker coloured muffin was produced (as shown in Table 7 with the decreasing L* value in crumb and crust). Higher a* value indicated a progress of browning (Aldemo *et al.*, 1993). The a* value had increased in both crust and crumb with significant ($p<0.05$) from control muffin to 20% MPF muffin. Hence, browning reaction occurred when higher amount of MPF was substituted into muffins. Similar observation was reported by Dhingra and Jood (2001) whereby the crust colour of breads had changed from creamy white to brown colour when the level of barley and soy flour mixture was increased. However, the crust colour was only reported to be significant when more than more than 10% of the non-wheat flours were used (Dhingra and Jood, 2001).

Addition of sulphur compound during food processing is known to effectively improve colour of product and able to reduce the rate of deterioration during storage (Copley *et al.*, 1956). Copley *et al.* (1956) also reported that a slight but visible non-enzymatic browning occurred in both sulphited and non-sulphited samples. This further elaborates the browning occurrence when mango pulp flour was substituted into muffins.

Table 7: Mean colour values of the crumb and crust of muffins with different levels of mango pulp flour (MPF).

Parameter	Control	5% MPF	10% MPF	15% MPF	20% MPF
Crumb					
L	71.27±1.79^{a}	62.59±1.11^{b}	60.61±0.48^{c}	58.41±0.77^{d}	54.95±1.76^{e}
a	0.87±0.21^{a}	5.07±0.61^{b}	6.13±0.52^{c}	6.11±0.23^{c}	7.57±0.38^{d}
b	24.54±0.71^{a}	25.29±1.87^{a}	24.73±1.02^{a}	25.46±0.89^{a}	28.18±0.55^{b}
c	24.62±0.63^{a}	25.80±1.91^{ab}	25.36±1.13^{ab}	26.16±0.92^{b}	28.95±0.61^{c}
Hue	88.03±0.51^{a}	78.69±1.06^{b}	76.02±0.57^{c}	76.55±0.22^{c}	74.89±0.59^{d}
Crust					
L	69.53±1.46^{a}	62.65±1.92^{b}	60.18±1.26^{c}	56.24±0.84^{d}	50.42±1.31^{e}
a	7.76±1.26^{a}	10.24±0.36^{b}	11.59±0.23^{c}	12.57±0.19^{d}	14.10±0.43^{e}
b	39.26±1.60^{a}	37.52±1.71^{b}	35.08±1.89^{c}	33.64±0.44^{c}	34.30±1.01^{c}
c	40.04±1.80^{a}	39.18±2.14^{a}	36.84±2.07^{b}	35.51±0.47^{b}	36.96±1.21^{b}
Hue	78.87±1.35^{a}	73.39±1.70^{b}	72.23±0.88^{bc}	71.50±0.34^{c}	68.14±0.92^{d}

Mean within the same row with different alphabet are significantly ($p<0.05$) different.
Values are the Means±SD with n=6 for each group.

Furthermore, high temperature and long heating time will also contribute to the rapid colour change as reported by Lau *et al.* (2000).

Maillard reaction is another factor that caused browning since this reaction is the main chemical event occurs in bakery products during cooking. This is a reaction between proteins and carbohydrate and is responsible for the brown colour and organoleptic properties of bread and bakery products. When heat treatment is given, water percentage on the dough surface dramatically decreases thus providing an optimum condition for the formation of Maillard reaction which gives the intense brown colour (Borrelli *et al.*, 2003). This resulted darker colored crust compared to crumb. Thorvaldson and Kjoledbrand (1998) also observed darker coloured crust than the crumb in bread.

CONCLUSION

Based on the observation of the physical and chemical results, the processed mango pulp flour from matured green 'Chokanan' variety was found suitable to be substituted into muffins. Incorporation of MPF into muffins will attribute to the nutritional value of the muffins as proximate and mineral analysis showed a general significance ($p<0.05$) increase correlating with the amount of mango pulp flour used. The same trend also happens in dietary fibre where the soluble (SDF), insoluble (IDF) and total (TDF) dietary fibre had increased ($p<0.05$). However, MPF did not show significance ($p>0.05$) in increasing the resistant starch of the muffins. More ever, darker coloured muffin was produced with higher level of substituted MPF. Additional amount of MPF also resulted in drop value of volume loaf and height of samples.

Acknowledgement

The authors would like to thanks the financial assistance granted by the Escience Fund under the Ministry of Science Technology and Innovation and Universiti Sains Malaysia.

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