DEVELOPMENT OF AN INNOVATIVE INGREDIENT FROM JACKFRUITSEED FLOUR IN HEALTH BAKERY PRODUCTS

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OBJECTIVES:

- To develop an innovative functional ingredient from fruit and fruit-based waste of fruit industry for utilization in bakery products.
- Application of innovative functional ingredients from tropical fruits (jackfruit seed) as a new source of dietary fibre in health bread.
- To provide a mean of overcoming waste disposal problems from fruit- based industry.
- To increase the application of tropical fruits in processed products
- To improves the shelf-life of tropical fruits in the form of flour
- To highlight the commercial potential of tropical fruit flour as value-added ingredient in health food

FRUIT FIBRE

- GOOD QUALITY-HIGH TOTAL & SOLUBLE FIBRE
- GOOD FUNCTIONAL PROPERTIES (WATER & OIL HOLDING CAPACITIES)
- GOOD COLONIC FERMENTABILITY & LOW CALORIC CONTENT

BENEFITS OF FRUITS DF IN FOODS

- NUTRITIONAL VALUE
- TECHNOLOGICAL PROPERTIES
- UPGRADE AGRICULTURAL PRODUCTS & BY-PRODUCTS FOR USE AS FOOD INGREDIENTS

TYPES OF DF

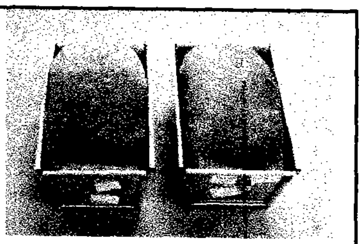
- NEUTRAL FIBRE- OAT,RICE,MAIZE CAN BE ADDED WITHOUT MANY MODIFICATION
- NON-NEUTRAL FIBRES-APPLES, CITRUS CAN PRODUCE COLOURS OR FLAVOURS IN FOOD

INCREASING DEMAND FOR BAKED PRODUCTS FROM CONSUMER

=>LOWER CALORIE & HIGHER DIETARY FIBRE (DF).

HIGHER DF:

DEGRADE SENSORY & BAKING PERFORMANCE



- **Wheat - used in the manufacturing of biscuits, bakery products, noodles, cookies and snack products.**

- **Bread - widely consumed in M'sia, produced by > 1000 bakeries.**

Market Opportunity

- **Consumer research identified public demand for a high fibre bread with the appearance, texture and taste of white bread**
- **Over 50% of mothers prefer to buy wholemeal bread but 80% of children aged 8-15 years prefer the taste and soft texture of white bread**

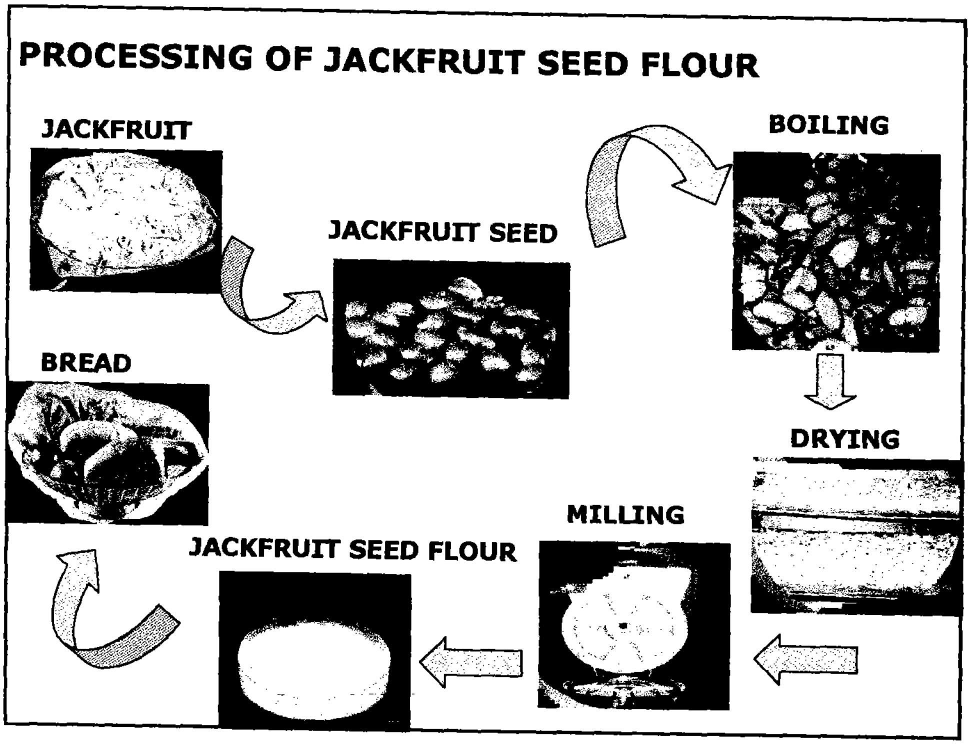
- **Huge and growing market in Malaysia and the region**

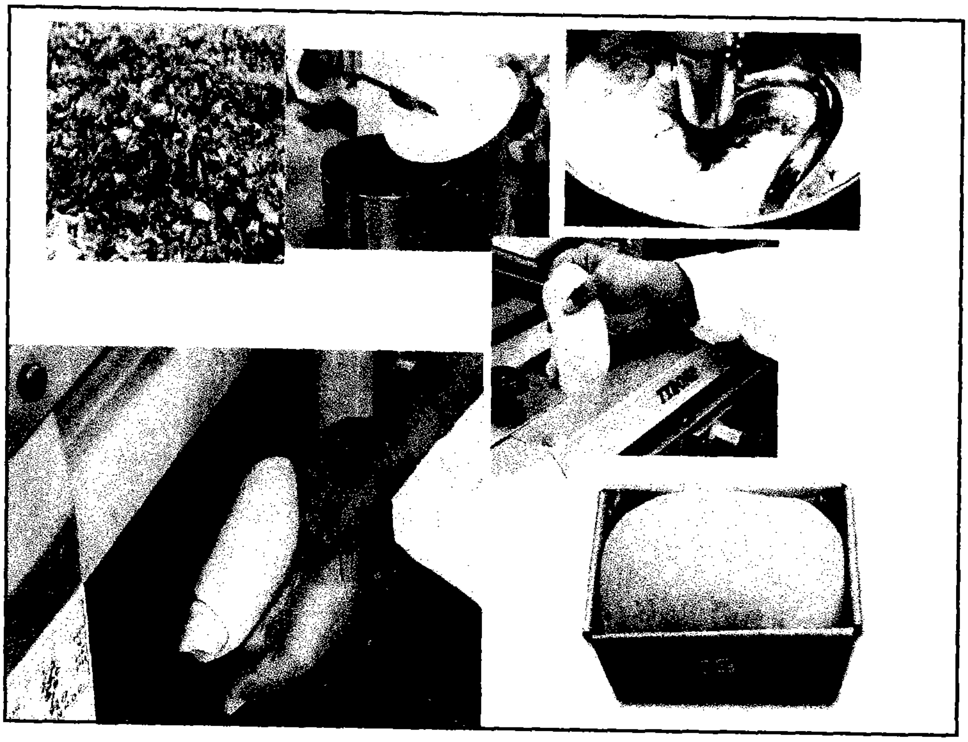
Retail sales recorded in Malaysia alone:

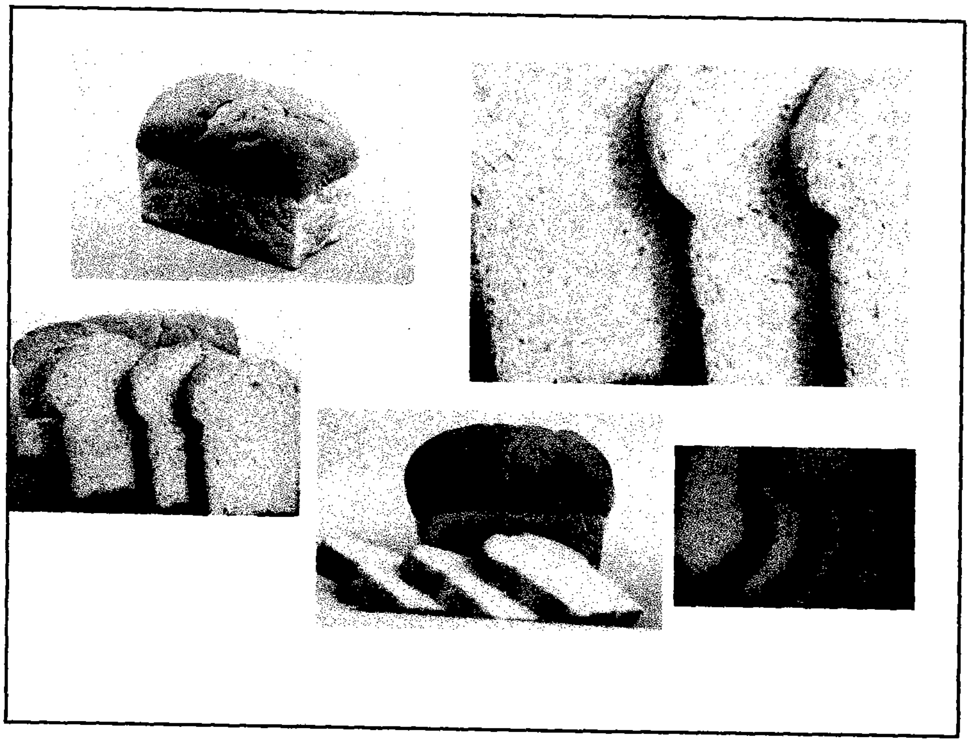
- **2002 - RM 448.48 million**
- **2003 - RM 526.29 million**

M'sian consumer expenditure on bread products:

- **2002 - RM 6.7 billion**
- **2003 - RM 7.0 billion**


PROCESSING OF JACKFRUIT SEED FLOUR
JACKFRUIT
JACKFRUIT SEED
BOILING
DRYING
MILLING
JACKFRUIT SEED FLOUR
BREAD





Technology & Product

- Removal of distinct taste-in jackfruit seed
- Flour contain resistant starch –health benefits
- Unique combination of dietary fibre content which can be added to bread without affecting the sensory properties
- Utilization of flour as an ingredient which does not affect texture and baking performance of bread

Market Opportunity

- High fibre bread is popular among the consumers
- The percentage daily recommended value (DRV) in 50gm serving in 2000 calorie diet is as follows;

	Percentage
Protein	13.73%
Fat	0.91%
Carbohydrate	8.25%
Fibre	18.86%

Technology & Product

- JF seed flour is produced by removing the distinct taste of the seed that renders it unpalatable
- JF seed flour is a natural product from the jackfruit seeds
- It does not contain material from GMO
- It resulted in fibre bread with acceptable taste and texture of white bread

Competitive Analysis

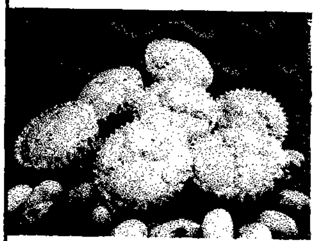
- JF seed flour bread provides higher source of fibre and protein as compared to wholemeal bread.

Composition	JF seed flour	Wholemeal flour
Fat	0.72	2.20
Protein	11.30	12.70
Carbohydrate	75.68	63.90
Total dietary fibre	7.00	8.60
Resistant starch	3.33	0.30

Comparison for 100g of 2 types of flour.

Composition	JF seed flour bread	Wholemeal bread
Fat	1.21	2.50
Protein	13.73	9.20
Carbohydrate	49.50	41.60
Total dietary fibre	9.43	7.40
Resistant starch	3.43	0.70

Comparison for A loaf of bread Using 2 types of flour.



THANK YOU

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Organoleptic and physico-chemical evaluation of breads supplemented with jackfruit seed flour

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Abstract

Jackfruit seed flour (JFS) was supplemented into wheat flour at different levels (10%, 20% and 25%). The physico-chemical and organoleptic characteristics of the supplemented and control breads were determined. Chemical compositions include moisture, protein, fat, ash, crude fibre, total dietary fibre, carbohydrate and caloric value (kcal/100g). The physical characteristics evaluated were loaf and specific volume, oven spring and textural parameters (hardness, cohesiveness, gumminess, chewiness and adhesiveness). Result indicated that increasing level of JFS from 10-25% significantly ($p<0.05$) decreased the protein content (13.81%, 13.73% and 12.89%) respectively as compared to the control bread (14.52%). However the crude fibre (2.49%, 2.78% and 2.98%) and total dietary fibre (6.02%, 9.43% and 11.10%) increased significantly ($p<0.05$). The control bread has fat content decreased from 1.43% to 1.23%, 1.22% and1.22% for bread supplemented with jackfruit seed flour. From this study, it was shown that 25% JFS was the maximum level that can be added to get an acceptable loaf volume and other physical characteristics. Loaf volume was reduce from 870 to 780 ml, oven spring from 1.6 to 0.9cm and specific volume from 3.75 to 3.22g/ml. Supplementation of JFS (10%, 20% and 25%) was shown to increase the cohesiveness and chewiness parameters. Supplementation of 10%, 20% and 25% of jackfruit seed flour to the control bread produced an acceptable breads, which is the ranged in overall acceptability, from 6.3 to 6.8 from sensory evaluation.

Keywords: jackfruit seed flour; bread; organoleptic; physico-chemical characteristics

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1.0 Introduction

Jackfruit is (*Artocarpus heterophyllus*) originated from Western Ghats, India and is now popular throughout South-East Asia. It is a tropical evergreen plant belonging to the family *Moraceae*. It is comparatively cheap, however the fruit is favoured by poor people when the price of staple foods is high (Salunkhe & Kadam, 1995). They are mainly eaten by Indians and Malays but lesser by Chinese (Betty, 1975). Jackfruit attains a great size when fully mature and the large fruits can weigh up to 40 kg (Ramjit Singh, 1969). The ripe fruit consisted 29% pulp, 12% seeds and 54% rind (Berry & Kalra, 1988). The young fruit is cooked as vegetable, pickled or canned in brine or curry; ripe pulp is eaten fresh or made into jam, jelly or paste (Verheij & Coronel, 1991). The seeds are edible and nutritious. It contains 38% carbohydrates, 6.6% protein and 0.4% fats (James, 1993). In general, fresh seeds are considered to be high in starch, low in calcium and iron and good sources of vitamin B_1 and B_2 (Morton, 1987).

The seeds are eaten after boiling or roasting or dried and salted as table nuts or ground to make flour which is blended with wheat flour for baking (Verheij & Coronel, 1991). Due to the high carbohydrate and other nutritional content, jackfruit seed can be added in bakery products such as bread to increase the fibre content. Bread may be an important source of dietary fibre because it is easy to produce, cheap and eaten by all people. White breads have substantially less dietary fibre than mixed bread baked from high fibre flour and wheat flour (Lorenz, 1984). Dietary fibre is important due to its beneficial effects on the reduction of cholesterol levels and the risk of colon cancer (Jinshui, Cristina and Benedeto de Barber, 2002). Only a few studies on the supplementation of jackfruit seed flour on bakery products or other products are carried out. Berry and Kalra (1988) reported that only 25% level of jackfruit seed flour could be supplemented in atta bread. Nutritional studies showed that jackfruit seed have a good nutritional value and a cheap source of raw material. Therefore, supplementation of wheat flour with cheap and nutritious sources helps in improving the nutritional quality of the product in developing country.

The objective of this study was to determine the chemical, physical and organoleptic characteristics of bread supplemented with different levels of jackfruit seed flour.

2.0 Materials and methods

Bread flour, shortening and milk powder were obtained from Sim Company while yeast and improver were obtained from Sunshine Sdn Bhd., Penang.

2.1 Preparation of jackfruit seed flour

Jackfruit was obtained from the local market in Penang. The seeds were removed from the jackfruit and cleaned. Jackfruit seed flour was prepared according to Kuntz *et al.*, (1978) method. The flowchart of the preparation of jackfruit seed flour was shown in Figure 1.

Jackfruit seed
↓
Boiling for 30 minutes, 99°C
↓
Rinsing in water
↓
Removal of skin and hypocotyls
↓
Cut into small pieces and put on tray
↓
Hot air drier for 24 hours, 60°C
(Afos model mini, no CK80520, England)
↓
Grinding of seed and sieving
[Retsch micro universal bench top grinder (0.25 μm, 14000 rpm), German]
↓
Jackfruit seed flour
↓
Storage at 4°C in airtight containers

Figure 1: Processing of jackfruit seed flour (JSF)

2.2 Preparation of bread

Four bread formulations, control, bread I (10% JSF), bread II (20% JSF) and bread III (25% JSF) were prepared according to sponge and dough breadmaking process. The control formula has 400 g flour consisted of milk powder (16 g), salt (5 g), yeast (11 g), brown sugar (60 g), improver (9 g), shortening (28 g). The amount of water required depends on the level of the flour substitutions. The percentage of jackfruit seed flour added is based on the flour weight. The sponge dough paste prepared was fermented for 25 minutes and was later mixed (SPAR mixer, model HL-11010) with the other ingredients optimally mixed in SPAR mixer (model HL-11010) until elastic. The shortening was later added to form uniform dough. The dough was fermented in Bakbar Proofer (model E87, New Zealand) for 30 minutes at 30°C and knocked-back to remove the air. The dough was then weighed into 250g ball and later moulded by the Tyrone roller (type BS-2220, Taiwan). Ball moulded dough was put into an aluminium greased pan and was later proofed for another 30 minutes before baking at 170°C for 20 minutes.

2.3 Chemical analyses

The bread sample was blended prior to analysis. The breads were analyzed for moisture, ash, fat, protein (N x 6.25) and crude fibre according to AACC method (2000). Total dietary fibre was determined using AOAC method (1995). Carbohydrate content was estimated by difference. Caloric value was measured by calculation. The results were triplicated and reported on dry weight basis.

2.4 Physical characteristics

The quality parameters for bread determined include loaf volume (determined by seed displacement), specific volume (g/ml) and oven spring (cm). Texture profile analysis (TPA) was performed using a TA-XT2 version 1.05 (Stable Micro System Ltd.) by using the 25 kg load cell. The sample size was 1 cm x 1 cm and each sample was compressed until 60%. The textural parameters determined include hardness, chewiness, cohesiveness, gumminess and adhesiveness.

2.5 Sensory evaluation

The organoleptic characteristics were determined by a panel of 15 judges comprising of staff members and students of the department. The were evaluated for crust and crumb colour, moistness, softness, aftertaste and overall acceptability using a ninepoint-Hedonic Rating ranging from like extremely (9) to dislike extremely (1).

2.6 Statistical analysis

Statistical analysis of data was performed by one way analysis of variance (ANOVA) at 0.05 of significant levels.

3. Results and discussion

3.1 Chemical composition of jackfruit seed flour

The proximate composition of jackfruit seed flour was shown in Table I. Jackfruit seed flour contains 11.27% protein. This may have resulted from the treatment in the production of the flour and also the type of variety used. The result was lower than the value (16.3%) reported by Singh, Kumar and Singh (1991). The protein content of the jackfruit seed flour is higher than mango seed flour (8.3%) by Giami, Okonkwo and Akusu (1994). The JSF is higher in crude fibre (3.28%), carbohydrate (75.71%), ash (3.66%) and lower in fat (0.72%) content as compared to those reported by Singh *et al.*, (1991).

3.2 Chemical composition of bread

The proximate compositions of bread with different level of JFS were determined (Table II). Significant different ($p<0.05$) was observed in moisture, protein, crude fibre and total dietary fibre content among all samples. Addition of JFS was turned to increase the crude fibre, total dietary fibre and decreased the caloric value of bread samples. The protein content of bread decreased with increase addition level of JFS. The fat content of bread decreased when substituted with 10-25% JFS to range of 1.22% - 1.23% as compared to bread blended with 5-15% barley and soya flour, 5.49% - 6.83% (Dhingra and Jood, 2001). From the results, it showed that JFS is suitable for flour substitution and fibre source in health bread.

3.3 Bread quality

The effect of the JFS supplementation at different level on breads quality was summarized in Table III. Breads supplemented with JFS had smaller loaf volume, specific volume and oven spring than control bread. Similar findings were also reported by Wang, Cristina and de Barber (2002) that addition of carob fibre, inulin and pea fibre decreased the loaf volume and specific volume. Texture profile analysis revealed that addition of JFS increased the cohesiveness and chewiness attributes. The same trend was also shown in hardness, gumminess and adhesiveness but the value was less than the control bread.

Organoleptic evaluation indicated that the bread supplemented with JFS was acceptable (Table III). This result was in agreement with Hallab and Khatchadourian (1974), which showed that the bread supplemented with chickpea and soybean flour was acceptable at ranges between 6.4-7.0. Addition of JFS did not influence the colour of crumb (slightly bright). An increased in moistness, softness, aftertaste was noted on the breads with increased level of JFS added.

4.0 Conclusion

Supplementation of jackfruit seed flour to wheat flour was found to increase the chemical composition especially in crude fibre and total dietary fibre although there was a slightly decreased in protein. The breads were considered acceptable by the sensory panel. Thus, jackfruit seed flour can be added in bread formulas so as to develop high fibre bread and to in order to increase the daily fibre intake.

Acknowledgement

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Table I: Proximate composition of jackfruit seed flour

Composition (%)	Jackfruit seed flour
Moisture	8.64 ± 0.09
Protein	11.27 ± 0.33
Fat	0.72 ± 0.01
Ash	3.66 ± 0.11
Crude fibre	3.28 ± 0.02
Total dietary fibre	6.98 ±0.13
Carbohydrate[f]	75.71

[f]Obtained by difference

*Mean ± standard deviation (n=3)

Table II: Proximate composition of breads with different level of jackfruit seed flour

Composition (%)	Control	Bread I (10%)	Bread II (20%)	Bread III (25%)
Moisture	31.13 ± 0.02[a]	34.09 ± 0.01[a]	34.54 ± 0.07[c]	34.78 ± 0.05[d]
Protein	14.52 ± 0.02[a]	13.81 ± 0.17[b]	13.73 ± 0.14[b]	12.89 ± 0.11[c]
Fat	1.43 ± 0.00[a]	1.23 ± 0.00[b]	1.22 ± 0.00[b]	1.22 ± 0.00[b]
Ash	0.99 ± 0.03[a]	1.02 ± 0.01[a]	1.03 ± 0.01[a]	1.06 ± 0.00[a]
Crude fibre	1.95 ± 0.01[a]	2.49 ± 0.01[b]	2.78 ± 0.02[c]	2.90 ± 0.01[d]
Total dietary fibre	2.83 ± 0.04[a]	6.02 ± 0.00[b]	9.43 ± 0.01[c]	11.10 ± 0.07[d]
Carbohydrate[f]	51.93[a]	49.85[b]	49.48[c]	50.05[d]
Calorie (kcal/100g)	267.35[a]	265.71[b]	263.82[c]	262.74[d]

[f]Obtained by difference

*Mean values in the same row which is not followed by the same letter are significantly different ($p<0.05$). Mean ± standard deviation (n=3)

Table III: Effect of the jackfruit seed flour supplementation on breads

	Control	Bread I (10%)	Bread II (20%)	Bread III (25%)
Loaf volume (ml)	870^{a}	880^{b}	800^{c}	780^{d}
Specific volume (ml/g)	3.66^{a}	3.75^{b}	3.41^{c}	3.32^{d}
Oven spring (cm)	1.60^{a}	1.40^{b}	1.20^{c}	0.90^{d}
TPA parameters				
Hardness	3.57^{a}	2.20^{b}	2.54^{c}	2.57^{d}
Chewiness	8.04^{a}	8.60^{b}	8.66^{c}	10.53^{d}
Cohesiveness	0.41^{a}	0.42^{ab}	0.45^{c}	0.48^{d}
Gumminess	1.47^{a}	0.90^{b}	1.15^{c}	1.33^{d}
Adhesiveness	0.0045^{a}	0.0077^{b}	0.0177^{c}	0.0205^{d}
Sensory analysis				
Crust colour	5.01^{a}	5.01^{ab}	5.02^{c}	5.02^{d}
Crumb colour	4.07^{a}	4.10^{b}	4.19^{c}	4.27^{d}
Moistness	5.40^{a}	5.53^{b}	5.60^{c}	6.13^{d}
Softness	5.87^{a}	5.87^{ab}	6.33^{c}	6.67^{d}
Aftertaste	5.73^{a}	5.60^{b}	5.73^{ac}	6.13^{d}
Overall acceptability	6.60^{a}	6.60^{ab}	6.80^{c}	6.33^{d}

*Mean values (n=3)

MF N 30900

Scanning electron microscopic observations of jackfruit seed, jackfruit seed flour, dough and bread supplemented with jackfruit seed flour (*Artocarpus heterophyllus*)

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1.0 Introduction

Jackfruit (Artocarpus heterophyllus) is originated from Western Ghats, India and now popular throughout South-East Asia. Young fruit is often cooked as vegetable, pickled, canned in brine or curry while ripe fruit is eaten fresh, made into jam, jelly or paste (Verheij & Coronel, 1991). Ripe fruit consist 29% pulp, 12% seeds and 54% rind (Berry & Kalra, 1988). Jackfruit seed contain 38% carbohydrate, 6.6% protein and 0.4% fat (James, 1993) while Bobio *et al.*, (1978) reported that jackfruit contain 38% carbohydrate, 12.3% protein and 0.4% fat. Normally, the seeds are eaten after boiling, roasting or drying (Margaret, 1988; Jacqueline, 1989). It also blended into flour and mixed with wheat flour to produce bakery product (Verheij & Coronel, 1991). There is not much information available on jackfruit, JSF and bread incorporated with JSF. From the previous study, 25% of jackfruit seed flour (JSF) could be added into atta bread (Berry & Kalra, 1988). Recently the information of organoleptic and physico-chemical characteristic of JSF and bread were studied (Hasidah & Noor Aziah, 2003). However, there is no report on the microstructure of JSF and bread to facilitate a better understanding of the baking process of JSF and bread. Different method used to study the microstructure of bread dough have been carried out using light microscopy (Amend & Belitz, 1991; Freeman & Shelton, 1991; Betchel, Pomeranz & de Francisco, 1978) and scanning electron microscopy (SEM) (Aranyi & Hawrylewicz, 1968; Gen *et al.*, 1990; Hyeon-Ju *et al.*, 2003). SEM provides an appropriate means for characterizing the physical properties and textural attributes of food ingredients in a formulated product (Belsie *et al.*, 1993). The advantages that make the SEM an extremely useful investigative tool for examination of the flour-dough transition include its very large depth of focus and the possibility of obtaining three-dimensional images of sample surfaces at relatively low magnifications with minimal preparation (Aranyi & Hawrylewicz, 1969). The aim of the present research was to study the microstructure of starch granules of JSF, dough and bread incorporated with JSF.

2.0 Materials and methods

Bread flour, shortening and milk powder were obtained from Sim Company. Other ingredients were obtained from Sunshine Sdn Bhd., Penang.

2.1 Preparation of jackfruit seed flour

Jackfruit was obtained from the local market in Penang. The seeds were removed from the jackfruit and cleaned. Jackfruit seed flour was prepared according to Kuntz *et al.*, (1978) method.

2.2 Preparation of bread

Four bread formulations, control, bread I (10% JSF), bread II (20% JSF) and bread III (25% JSF) were prepared according to sponge and dough breadmaking process. The control formula has 400 g bread flour, milk powder (16 g), salt (5 g), yeast (11 g), brown sugar (60 g), improver (9 g) and shortening (28 g). The amount of water required depends on the levels of the flour substitution. The percentage of jackfruit seed flour added is based on the flour weight. The sponge dough paste prepared was fermented for 25 minutes and was later mixed (SPAR mixer, model HL-11010) for 10 minutes with the other ingredients until elastic. Finally the shortening was later added to form uniform dough. The mixed dough was then fermented in Bakbar Proofer (model E87, New Zealand) for 30 minutes at 30°C and knocked-back to remove the air. The dough was then weighed into 250g balls and later moulded by the Tyrone roller (type BS-2220, Taiwan). The moulded dough was put into an aluminium-greased pan and was later proofed for another 30 minutes before baking at 170°C for 20 minutes.

2.3 Preparation for Scanning Electron Microscopy (SEM)

Jackfruit seed, jackfruit seed flour, all dough and breads were freezing, followed by freeze-drying using a freeze-dryer (-50°C). The freeze-dried samples were kept in a dessicator until further use.

2.4 Scanning Electron Microscopy

A Leica Cambridge Scanning Electron Microscope Model S-360 was used. The surface of sheeted for all samples was separately placed on the aluminium stub with the help of double-sided scotch tape and sputter coated (Polaron SC515) with gold (30nm thick). Finally, each sample was transferred to the microscope where it was observed at 10 kV.

3.0 Results and Discussion

3.1 Microstructure of jackfruit seed and jackfruit seed flour (JSF)

The images obtained in the SEM of seed and flour is shown in Figure 1 and 2. The SEM observation of jackfruit seed was similar to that reported by Oates and Powell (1996). Granules of jackfruit seed starch were a variety of shapes, many appearing to be compound granules. The size of jackfruit seed starch ranging from 4.2- 48.0 μm (Oates & Powell, 1996). The microstructure of JSF showed gelatinized starch granules. The jackfruit seed starch gelatinised in the temperature ranges 30-120°C. Temperatures of gelatinisation of the seed starches ranked in the order: mango > longan > rambutan > durian > jackfruit (Oates & Powell, 1996).

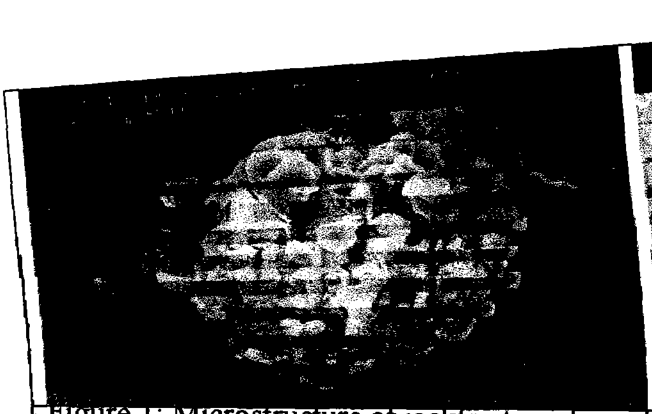

Figure 1: Microstructure of jackfruit seed using SEM with magnification of 1000x

Figure 2: Microstructure of jackfruit seed flour using SEM with magnification of 1000x

3.2 Microstructure of doughs for all samples

The microstructure of dough for all samples was showed in Fig. 3a-6b. The SEM of the dough is quite normal in the gluten matrix, covering most starch granules. Small and large starch granules are densely distributed throughout the formed protein matrix. Addition of different level of JSF increased the small starch granules in the dough. With the protein and gum-like materials, the small starch granules form a strung-out matrix (Parkkonen, Hakaen, & Autio, 1994).

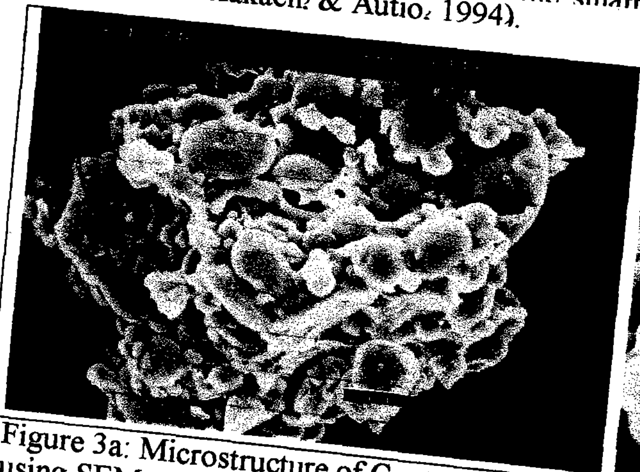

Figure 3a: Microstructure of Control dough using SEM with magnification of 1000x

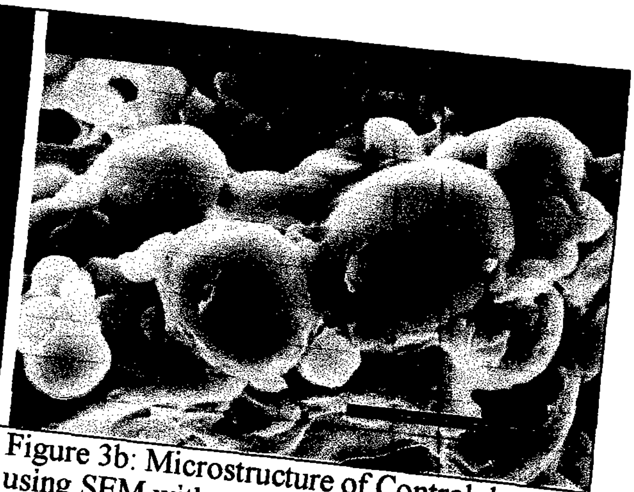

Figure 3b: Microstructure of Control dough using SEM with magnification of 3000x

Figure 4a: Microstructure of dough (10% JSF) using SEM with magnification of 1000x

Figure 4b: Microstructure of dough (10% JSF) using SEM with magnification of 3000x

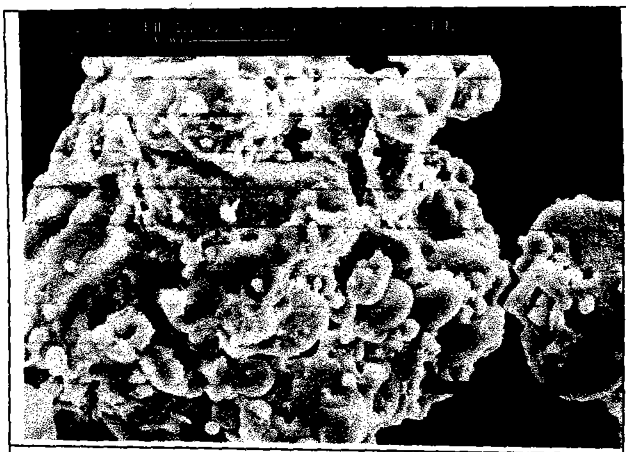

Figure 5a: Microstructure of dough (20% JSF) using SEM with magnification of 1000x

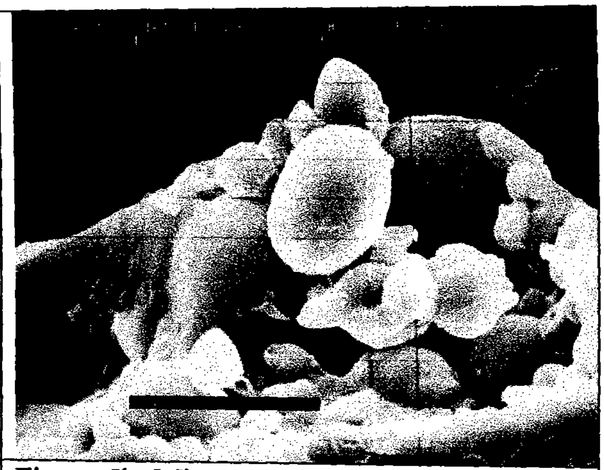

Figure 5b: Microstructure of dough (20% JSF) using SEM with magnification of 3000x

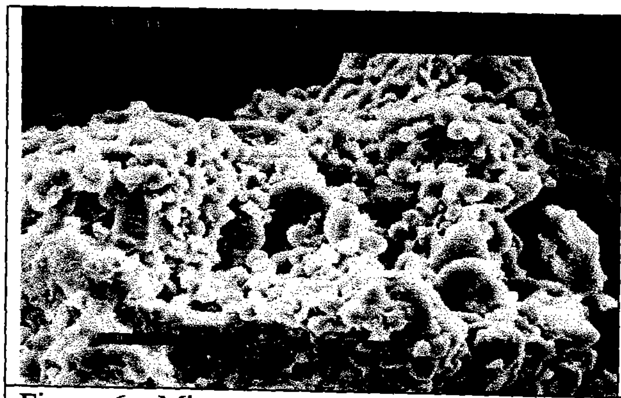

Figure 6a: Microstructure of dough (30% JSF) using SEM with magnification of 1000x

Figure 6b: Microstructure of dough (30% JSF) using SEM with magnification of 3000x

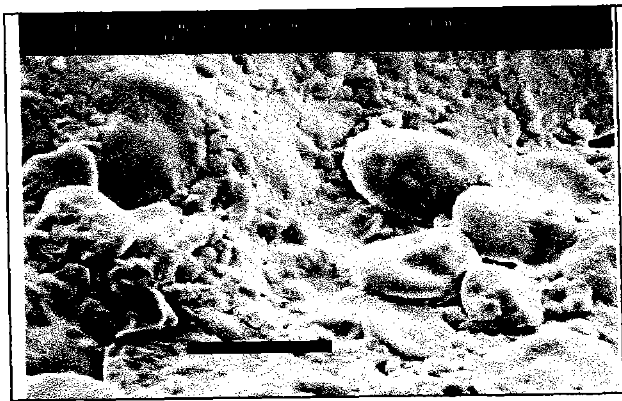

Figure 9a: Microstructure of bread (20% JSF) using SEM with magnification of 1000x

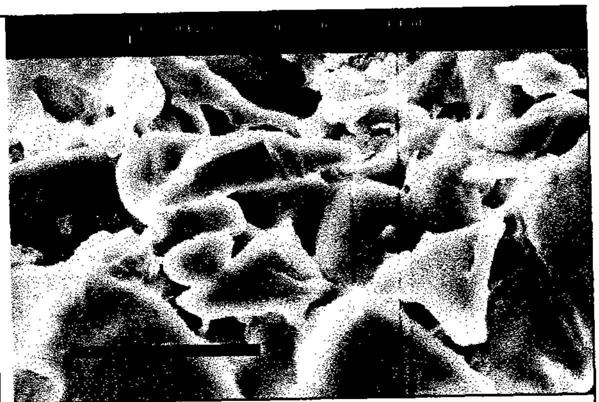

Figure 9b: Microstructure of bread (20% JSF) using SEM with magnification of 3000x

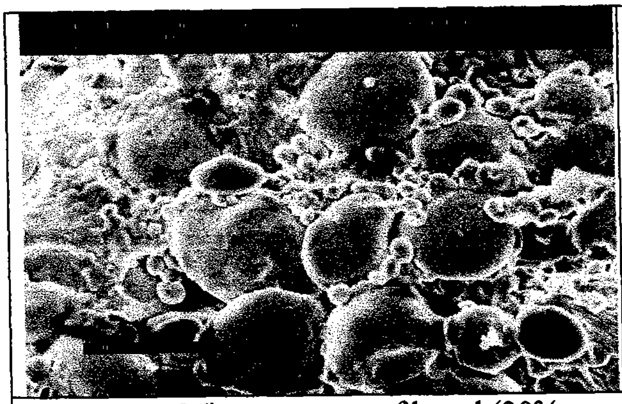

Figure 10a: Microstructure of bread (30% JSF) using SEM with magnification of 1000x

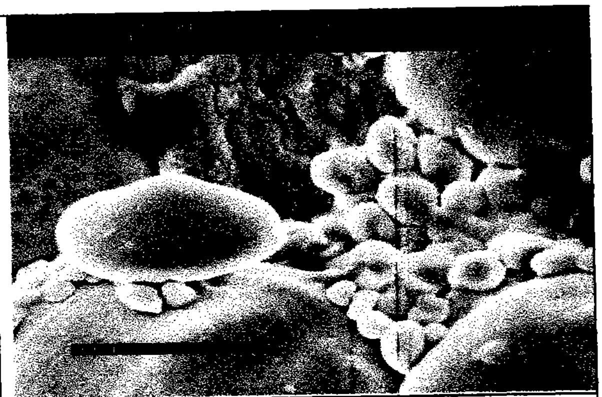

Figure 10b: Microstructure of bread (30% JSF) using SEM with magnification of 3000x

Conclusion

SEM was used to investigate the structure of dough and bread incorporated with different level of JSF. From the analysis, it showed that the starch granules of all bread samples are gelatinized when heat-treated.

Acknowledgement

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JTILIZATION OF JACKFRUIT SEED FLOUR IN FIBRE BREAD

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INTRODUCTION

- **Jackfruit (Artocarpus heterophyllus) originated om India , popular throughout South-East Asia**
- **Young fruit is often cooked as vegetable, pickled r canned in brine or curry; ripe fruit is eaten fresh or ıade into jam, jelly or paste (Verheij & Coronel, 1991)**
- **ripe fruit consist 29% pulp, 12% seeds and 54% rind 3erry & Kalra, 1988)**
- **jackfruit seed (JS) contain 38% carbohydrate, 6.6% rotein and 0.4% fat (James, 1993); other research JS ontain 38% CHO, 12.3% protein & 0.4% fat (Bobio *et* ᛁ., 1978)**

- eeds eaten after boiling, roasting (resembled estnut) or drying (Margaret, 1988; Jacqueline, 1989)
- blended into flour and mixed with wheat flour to oduce bakery product (Verheij & Coronel, 1991)
- 25% JSF could be added in atta bread, 25:75 (Berry Kalra, 1988)
- Diet of developed countries-deficient in fibre, leads health complications
- Dietary fibre(DF) increases the nutritional value of ead but alters the rheological properties of dough & al quality & sensorial properties of bread.

- Reasons for addition of fibre in baked products : to increase DF & decrease calorie
- JSF, good source of dietary fibre , easy to process , can be incorporated into bread without affecting eating quality
- JSF contribute to the development of value added food or functional food – currently high demand e.g bread
- bread – selected because it's easy to process & eaten by all age group

OBJECTIVES

- TO PRODUCE JACKFRUIT SEED FLOUR (JSF) &)ETERMINE ITS CHEMICAL COMPOSITION
- TO APPLY AN INNOVATIVE FUNCTIONAL INGREDIENT, JSF IN HEALTH BREAD
- TO DETERMINE THE CHEMICAL, PHYSICAL AND ORGANOLEPTIC ATTRIBUTES OF BREAD \ICORPORATED WITH DIFFERENT LEVEL OF JSF

MATERIAL & METHODS

Jackfruit seed
↓
Boiling for 30 minutes
↓
Rinsing in water
↓
Removal of skin & hypocotyls
↓
Cut into small pieces, placed on tray
↓
Hot air drier for 24 hours, 60°C
↓
Grinding of seed
[redacted]h micro universal bench top grinder,(0.25μm, 14000 rpm),
↓
Jackfruit seed flour (JSF)
↓
Storage in airtight container

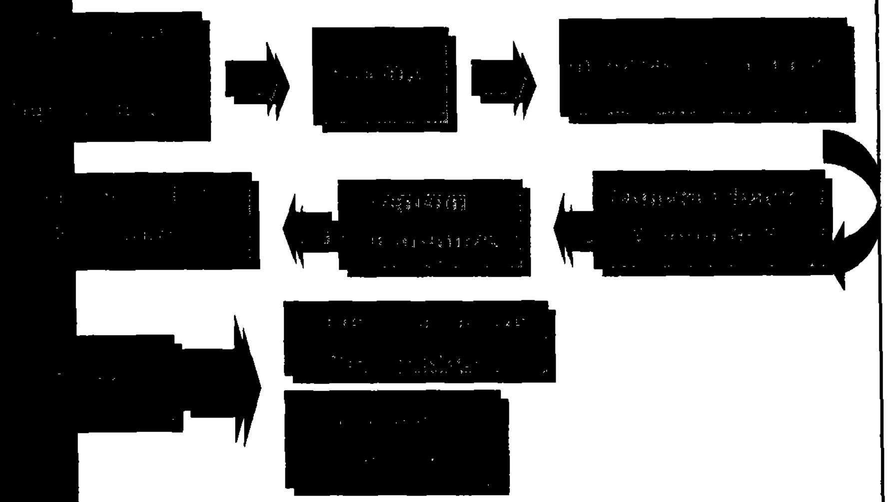
[redacted] 1: Processing of jackfruit seed flour (Kuntz *et al.*, 1978)

[redacted] 1: Formulation of bread with different [redacted]f JSF

[redacted]dient [redacted])	Control Bread	Bread I (10% JSF)	Bread II (20% JSF)	Bread III (25% JSF)
[redacted]lour	400	360	320	300
[redacted]	-	40	80	100
[redacted]	11	11	11	11
[redacted]	5	5	5	5
[redacted] sugar	60	60	60	60
[redacted]er	9	9	9	9
[redacted]ning	28	28	28	28
[redacted]	210	215	220	223

[redacted] jackfruit seed flour

cessing of bread



RESULT AND DISCUSSION

II: Chemical composition of jackfruit seed flour

omposition (%)	Jackfruit seed flour
oisture	8.64 ± 0.09
rotein	11.27 ± 0.33
'at	0.72 ± 0.01
sh	3.66 ± 0.11
rude fibre	3.28 ± 0.02
otal dietary fibre	6.98 ±0.13
arbohydrate^{f}	75.71

ained by difference
an ± standard deviation (n=3)

I: Proximate composition of breads incorporated ferent level of jackfruit seed flour

on	Control	Bread I (10% JSF)	Bread II (20% JSF)	Bread III (25% JSF)
	31.13 ± 0.02^{a}	34.09 ± 0.01^{a}	34.54 ± 0.07^{c}	34.78 ± 0.05^{d}
	14.52 ± 0.02^{a}	13.81 ± 0.17^{b}	13.73 ± 0.14^{b}	12.89 ± 0.11^{c}
	1.43 ± 0.00^{a}	1.23 ± 0.00^{b}	1.22 ± 0.00^{b}	1.22 ± 0.00^{b}
	0.99 ± 0.03^{a}	1.02 ± 0.01^{a}	1.03 ± 0.01^{a}	1.06 ± 0.00^{a}
e	1.95 ± 0.01^{a}	2.49 ± 0.01^{b}	2.78 ± 0.02^{c}	2.90 ± 0.01^{d}
ry fibre	2.83 ± 0.04^{a}	6.02 ± 0.00^{b}	9.43 ± 0.01^{c}	11.10 ± 0.07^{d}
rate^{f}	51.93^{a}	49.85^{b}	49.48^{c}	50.05^{d}
cal/100g)	267.35^{a}	265.71^{b}	263.82^{c}	262.74^{d}

by difference
lues in the same row which is not followed by the same letter are
tly different (p<0.05). Mean ± standard deviation (n=3)

Result

- significant different ($p<0.05$) observed in moisture, protein, crude fibre & TDF among sample
- addition JSF – increase the CF, TD
  – decrease protein, fat, caloric value

e III: Effect of the jackfruit seed flour lementation on loaf vol., specific vol. & oven g of breads

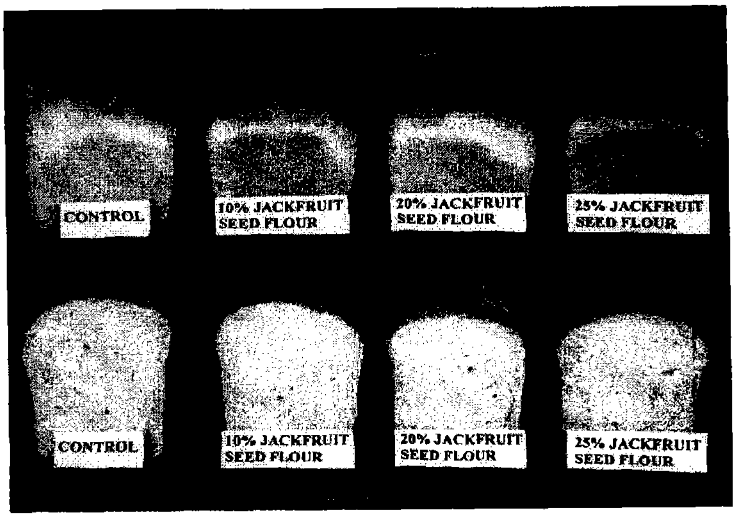
	Control	Bread I (10% JSF)	Bread II (20% JSF)	Bread III (25% JSF)
l. (cm^3)	870±0.00^{a}	880±0.00^{b}	800±0.00^{c}	780±0.00^{d}
vol.	3.66±0.05^{a}	3.75±0.02^{b}	3.41±0.04^{c}	3.32±0.02^{d}
g (cm)	1.60±0.09^{a}	1.40±0.12^{b}	1.20±0.07^{c}	0.90±0.21^{d}

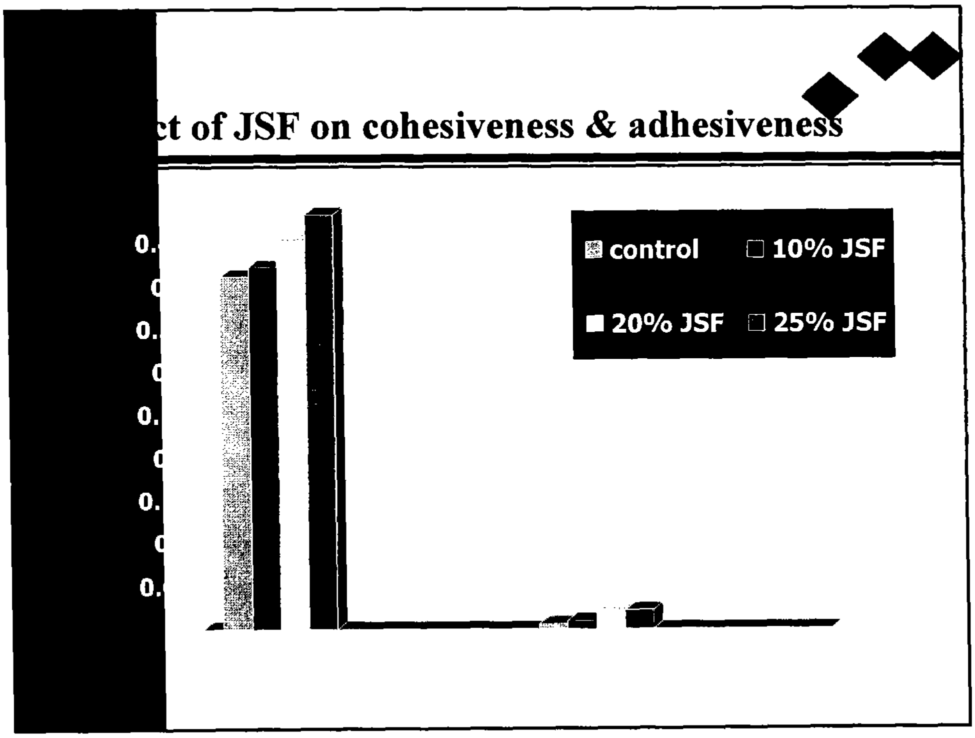
alues in the same row which is not followed by the same letter are tly different ($p<0.05$). Mean ± standard deviation (n=3)

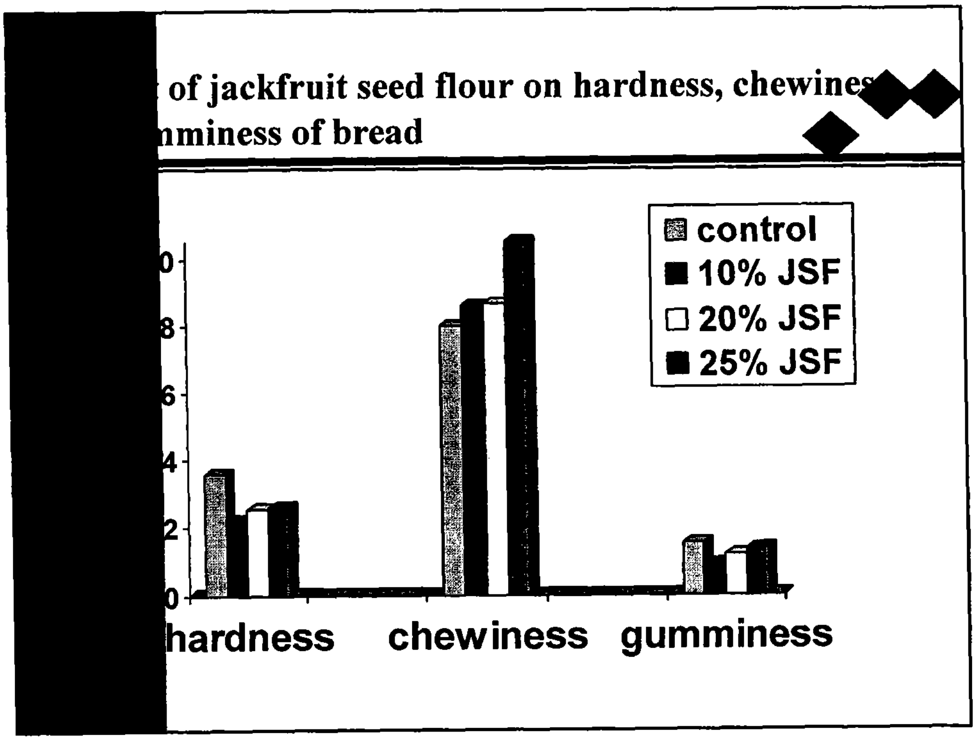
Result

✓ Bread incorporated with JSF – smaller loaf volume, specific volume & oven spring

✓ This result similar with previous study with **apple fibre (Chen et al., 1988); cellulose, wheat bran & oat hulls (Pomeranz et al.,1977) ,carob** fibre, inulin & pea fibre **(Wang et al., 2002)** decreased the loaf vol., specific vol. & oven spring;




t of JSF on cohesiveness & adhesiveness
control
10% JSF
20% JSF
25% JSF


of jackfruit seed flour on hardness, chewines
mminess of bread
control
10% JSF
20% JSF
25% JSF
0
8
6
4
2
0
hardness
chewiness
gumminess

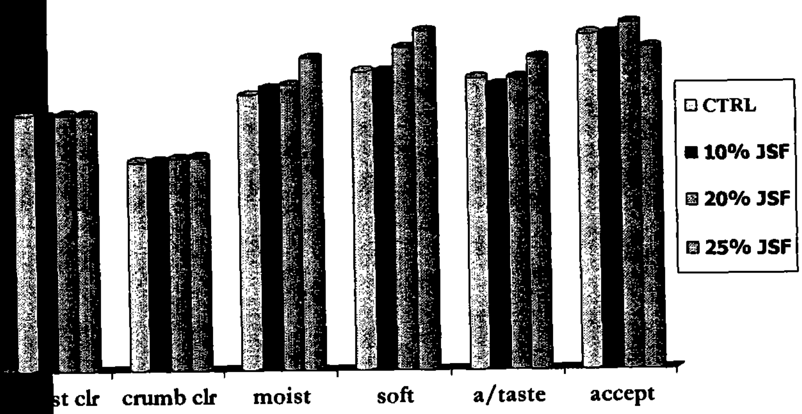
Result

✓ Texture profile analysis – addition of JSF increased the cohesiveness & adhesiveness attributes

✓ increased in hardness & gumminess of bread incorporated with JSF but lower than control bread; effect of decreasing hardness notable with 2-5% fibre increased(Gomez et al.,2003)

✓Chewiness increased with increasing levels of JSF

fect on Sensory Evaluation



Result

✓ Addition of JSF affect the crumb colour, moistness, softness & taste

✓ Sensory evaluation – Sig. different ($p<0.05$) in acceptability between levels of JSF.

✓bread incorporated with 20% JSF – most acceptable

CONCLUSION

- JSF – good source of fibre, low fat content
- Incorporation JSF in bread gave an outstanding ating quality in term of colour, taste, high in fibre & ow fat, hardening tendency reduced
- Lower level of DF produced very similar bread to he control without any noticeable damage to cceptability
- JSF provide physiologically functional ingredient ffering fibre in everyday food without compromising ating enjoyment
- JSF – new generation of fibre for bakery product

ACKNOWLEDGEMENT

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THANK YOU

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EVALUATION OF NOODLES INCORPORATED WITH DIFFERENT LEVELS OF JACKFRUIT SEED FLOUR IN TERM OF THE CHEMICAL AND COLOUR CHARACTERISTICS

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ABSTRACT

The effect of jackfruit seed flour (JFS) in noodles was investigated in terms of its chemical and colour attributes. JFS was substituted at different level (10, 20 and 30%) in noodles. Gluten was also added in the noodles at certain amount respectively. The noodles were then analyzed for chemical composition and colour . The colour of the noodle was measured after 0, 2 and 24 hr using Minolta Spectrocolorimeter. JFS noodles was significantly ($p<0.05$) different in moisture, protein and carbohydrate contents. JFS noodles was significantly ($p<0.05$) lower in fat content as compared to the control. For 30% JFS flour noodle, the contents of crude fibre and ash was differed significantly ($p<0.05$) as compared to other noodles. The results showed that noodles incorporated with JFS flour can increase the nutrient composition of noodle. Colour score of the noodle decreased as substitution level of JFS increased. Discoloration in noodles was correlated with increasing level of protein content in noodle. Dull colour of noodle was increased sharply with the ash content in noodle. The results indicated that JFS noodle have less yellow colour, as compared to the yellow colour of control noodle.

Keywords: Jackfruit seed flour; Noodle; gluten; Colour

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INTRODUCTION

Noodles are popular food in many parts of Asia and are widely consumed by people. People find noodle as inexpensive, versatile, easy to store, quick and simple to prepare. Noodles are made from wheat (*Tritium aestivum*) flour, water, common salt (sodium chloride) and/ or alkaline salt such as sodium carbonate. Raw Cantonese noodles used an alkaline reagent, sodium carbonate or *Kansui* in the preparation. The noodle can be stored for a day and resulted in potential problem such as colour changes in the noodle, which occured before cooking. Miskelly and Moss (1985) reported that straight-grade flours gave raw noodles more yellow in colour, but duller, than those prepared from patent flour.

Colour of the noodle is strongly associated with protein and correlated more closely with protein than ash. Moss (1985) reported that brightness in Japanese noodle made from different wheat varieties was inversely proportional to the flour content. Discoloration was associated with the degree of darkening developed by gluten from the samples.

Flour carotenoid together with flavone was responsible for the yellow colour. The presence of naturally occurring flavones in flour resulted the traditional yellow colour when an alkaline solution, sodium carbonate is applied. The flavones are detached from the starch flour and become yellow under alkaline conditions in noodle production (Moss *et al.,* 1984).

As there are high demands in nutritional food nowadays, it is important to develop noodles that have high in nutritional value, and at the same time, acceptable to the consumer. In terms to increase nutritional value of noodle, noodles were produced from various flours fortified with fish protein concentrate (Kwee *et al.,* 1969, Woo and Erdman, 1971), and there is rice noodles fortified with up to 30% soy flour (Siegel *et al.,* 1975).

Jackfruit (*Artocarpus heterophyllus L.*) is a tropical fruit tree that is widely planted in India and Bangladesh. From the nutritional aspect, jackfruit seed, (JFS) have high nutritive value, because it contains higher amount of carbohydrate, protein and crude fibre (Bobbio *et al.,* 1978; Kumar *et al.*, 1988; Singh *et al.,* 1991). Thus, JFS can be used to substitute in noodles formulation. The objective of this research was to determine the effect of JFS flour, (JFSF) in noodle at different percentage level in terms of nutritional composition and colour of JFS noodle. Colour was investigated in terms of brightness, and yellowness.

MATERIAL AND METHODS

Noodle Preparation

Noodle was prepared using the method previously described by Kruger *et al* (1994). A mixer, Kitchen Aid Mixer (Model K5SS) was used to mix the ingredients. A noodle machine (brand) was used to prepare the noodles. A solution of 1% *Kansui,* (sodium carbonate) was added to 250 g of flour in a mixer over 30-sec period with slow speed mixing of setting 1. Mixing was continued for 30 sec at slow speed, followed by 1 min at high speed (setting 2), an additional 3 min at slow speed. The ingredients were then passed through the noodle machine. The sheet was passed through the machine twice for each gap setting, once with folding, once without folding. The sheet was then processed through the noodle machine with the roller gap successively reduced to 15% for each of the next six passes. The remained was cut into strips using noodle machine.

Proximate Analysis

Moisture, crude fat, ash, crude fibre and protein contents were determined from the noodle samples, according to AACC methods 44-15A, 30-25, 08-01, and 46-11A, respectively (AACC 1983).

Colour Measurement

The colour of noodle was measured with Spectrocolorimeter (Minolta, Model : CM-3500d) using the CIE 1976 L^*, a^*,b^* colour scale. L^* is a measure of lightness; a^* and b^* indicate the green-red and yellow-blue chromaticity, respectively. Positive values of a^* and b^* increased redness and yellowness. Noodle sheets were stored in plastic bags, and colour measurement was made at 0, 2 and 24 hr. The analysis was done in triplicate.

Statistical Analysis

Results of analyses were calculated as mean ± standard deviation. All the data of the analyses were analyzed using SPSS version 11.0 for Windows and subjected to ANOVA. Means and least significant differences (LSD) at $P<0.05$ were used as a basis for significant differences between samples.

RESULTS AND DISCUSSION

The proximate composition of the noodles was shown in Table 1. Substitution of JFS flour in JFS noodle increased moisture content significantly ($p<0.05$) in JFS noodle compared to control. Moisture content in JFS noodle decreased as substitution of JFS flour in noodle increased. Fat content in JFS noodle significantly lower ($p<0.05$) compared to control. Fat content in JFS noodle increased as substitution of JFS flour in noodle increased. Protein content differs significantly ($p<0.05$) among all samples. Protein content of JFS noodles was significantly higher ($p<0.05$) compared to control. Protein content is the primary factor influencing noodle quality. Protein contents of the samples were increasing with the level of JFS flour incorporated in the JFS noodle. JFS is high in protein content (Bobbio *et al.*, 1978; Kumar *et al.*, 1988). There was also correlation between protein contents in the noodles with respective increases of gluten that has been added in the noodles (Karim, 1990). Ash content in the 30% JFSF noodle was significantly higher ($p<0.05$) than others. The increasing of ash content in JFS noodle may be resulted from the respective increases level of JFS flour that has been incorporated in the noodle. Ash content of noodles is largely dependent on the ash content of JFS flour, which is 3.66%. Ash content of noodle also depends on the amount of salt and alkali that has been used. Crude fibre in noodle with 30% JFS flour was significantly higher ($p<0.05$) than others. It may be due to JFS flour contents high crude fibre compared to wheat flour. Carbohydrate content of control was significantly higher ($p<0.05$) compared to others. The carbohydrate contents differs significantly ($p<0.05$) among all the samples. The 30% JFSF noodle has the lowest carbohydrate content.

Addition of lye water, *Kansui* (sodium carbonate) in JFS noodles dough resulted the yellow colour of noodle. The lye water detached the flavones groups from the starch. The dough is colorless at acidic pH and become yellow under alkaline conditions in noodle. Hatcher (1999) reported that addition of alkaline, lye water reagent attributed to the desirable yellow colour through its reaction with the flavonoids in flour. The presence or more flavones compounds will provide more flavonoid available to react with lye water which will result in more yellowness.

In term of yellowness, b^* value the 30% JFSF noodle had significantly lower ($p<0.05$) b^* value compared to other noodles, (b^*23.04) for 0 hr and (b^* 20.09) for 24 hr. Miskelly (1984) reported that discoloration of noodle could be caused from components high in minerals in flour, as 30% JFS flour contents more minerals compared to the other noodles. This is shown, as ash content in noodle with 30% JFS flour is significantly ($p<0.05$) high compared to other noodle, 2.39%. Matsuo *et al.* (1972) reported a highly negative correlation between ash content and spaghetti brightness.

In term of lightness measured at three different intervals, JFS noodle had significantly lower ($p<0.05$) L^* value compared to control. For every hour of colour measurement, control had significantly higher ($p<0.05$) L^* value, compared to other noodles, due to the lower protein content in control. After 24 hr of storage, noodle with 30% JFS flour had significantly lower ($p<0.05$) L^* value compared to other noodle (L^* 51.81). The lightness of raw noodle is related to protein content. Noodles of lower protein content produced lighter noodles while increases in protein content of the noodle decreased lightness and produced dull noodle. Noodle with 30% JFSF had significantly higher ($p<0.05$) protein (17.55%), produced significantly duller ($p<0.05$) noodle, (L^* 51.81) while control which contain significantly lower ($p<0.05$) protein (1.31%), produced significantly lighter ($p<0.05$) noodle, (L^* 58.45). Miskelly (1984) reported that protein content showed significant negative correlations with flour brightness. Protein content of the noodle was the single most important factor affecting the colour of the fresh noodle sheets. Protein could result in discoloration by: 1) acting as a marker of another component highly linked with protein; 2) through the effect of protein content on hardness- starch damage-particle size; 3) and through the effect of rate of water binding (Baik *et al.*, 1995). Pierpoint (1969) also reported that amines and thiols of proteins could react with quinones to produce undesirable reddish-brown complexes. The labile quinones were produced by auto-oxidation of flour phenolics that are susceptible in the alkaline environment of the noodle. The reaction of quinones with protein resulted reddish-brown off-coloured pigments. Kruger *et al.* (1994) also reported that in raw noodle, presence of protein could interfere with starch during reflectance. The reflectance of less light by noodles made from high protein flour may be due to a strong adherence between protein and starch (Oh *et al.*, 1985).

The darkening which occurred after 24 hr as indicated by the decline L^* value indicated that auto-oxidation reaction. The reaction resulted in reddish-brown off-coloured pigments. The reaction was catalyzed by enzyme that may be presence in noodle. This enzyme occurs predominantly in the bran wheat (Kim *et al.*, 1991).

CONCLUSIONS

Addition of JFSF improved the nutritional value of the noodle. Proximate analysis showed that substitution of JFSF in noodles increased protein content, but decreased the fat content in noodles as compared to the control noodle. Moisture content decreased significantly ($p<0.05$) with increases level of JFSF incorporated in noodles, and moisture content for JFS noodle is significantly higher ($p<0.05$) compared to control. For crude fibre and ash contents, 30% JFSF noodle is significantly higher ($p<0.05$) compared to other noodles. Substitution of JFSF decreased lightness and yellowness in noodle. JFS noodle were duller as compared to control noodle. JFS noodles were also susceptible to darkening due to time dependent changes. The reaction of quinones with protein in JFS noodles resulted reddish-brown off-coloured pigments in noodles that made the JFS noodle duller compared to control. Among all the samples, noodle with 10% JFS flour were more acceptable in terms of colour acceptability. In term of L^* value among JFS noodles, noodle with 10% JFS flour had significantly higher ($p<0.05$) of L^* value at 2hr and 24 hr.

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Table 1: Proximate Composition of JFS Flour Noodle

	C	10% JFSF Noodle	20% JFSF Noodle	30% JFSF Noodle
Moisture	35.52 ± 0.05^{a}	37.04 ± 0.06^{d}	36.71 ± 0.01^{c}	35.85 ± 0.09^{b}
Protein	11.43 ± 0.04^{a}	13.83 ± 0.38^{b}	15.79 ± 0.19^{c}	17.55 ± 0.52^{d}
Crude Fat	0.62 ± 0.20^{b}	0.06 ± 0.01^{a}	0.14 ± 0.01^{a}	0.26 ± 0.03^{a}
Crude Fibre	0.60 ± 0.14^{a}	0.88 ± 0.15^{a}	1.12 ± 0.07^{a}	1.92 ± 0.16^{b}
Ash	2.12 ± 0.04^{a}	2.12 ± 0.03^{a}	2.15 ± 0.01^{a}	2.39 ± 0.03^{b}
Carbohydrate	59.78 ± 0.12^{d}	46.06 ± 0.28^{c}	44.09 ± 0.26^{b}	41.20 ± 1.64^{a}

Mean values in the same row, which is not followed by the same letter, are significantly different ($P<0.05$). Mean $\pm$ standard deviation ($n=3$).
C= control, JFSF= jackfruit seed flour

Table 2: Mean *L**, and *b** values of JFS Noodles.

		Lightness *L**			Yellowness *b**		
Noodle	Protein	0 hr	2 hr	24hr	0 hr	2 hr	24hr
C	11.43± 0.04^{a}	69.85± 0.46^{c}	67.14± 0.24^{c}	58.45± 0.47^{d}	24.78± 0.37^{c}	24.57± 0.33^{c}	22.88± 0.17^{c}
10% JFSF	13.83± 0.38^{b}	68.99± 0.20^{b}	66.38± 0.22^{b}	53.90± 0.12^{c}	23.78± 0.41^{b}	23.51± 0.40^{b}	21.04± 0.12^{ab}
20% JFSF	15.79± 0.19^{c}	68.80± 0.34^{ab}	65.59± 0.22^{a}	52.80± 0.21^{b}	24.12± 0.17^{b}	23.17± 0.23^{ab}	21.48± 0.53^{b}
30% JFSF	17.55±0. 52^{d}	68.23± 0.17^{a}	65.55± 0.19^{a}	51.81±0. 21^{a}	23.04± 0.08^{a}	22.56± 0.50^{a}	20.09± 0.99^{a}

Mean values in the same row, which is not followed by the same letter, are significantly different ($P<0.05$). Mean ± standard deviation (n=3).

C= control, JFSF=jackfruit seed flour

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Optimization of reduced calorie chocolate cake with jackfruit seed (*Artocarpus heterophyllus* Lam.) flour and polydextrose using responses surface methodology (RSM)

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ABSTRACT

Response surface methodology (RSM) was used to determine the optimum level of polydextrose and jackfruit seed (JFS) flour in producing an acceptable reduced calorie chocolate cake. JFS flour and polydextrose were used as independent variables which affect the volume, specific volume, symmetry and uniformity of the cake. Regression coefficient showed that polydextrose and JFS was the most significant ($p<0.01$) factor affecting the volume and symmetry. The optimum level for replacement of polydextrose and JFS was found to be 11% flour and 16%, respectively.

Keywords: Responses surface methodology, cake, polydextrose, jackfruit seed flour

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INTRODUCTION

Cake is well liked by consumers all over the world. It is a very important product in the baking industry (USDC, 1979). However, due to its high caloric content, over consumption of cake may contribute obesity to consumer. The current upward trend in nutritional and health awareness among consumer demand for reduced or low calorie and high fiber foods has been accelerated.

However, altering the level of ingredients and increase in fibre content for the purpose of calorie reduction may affect the appearance, flavour and texture of the product. The changes will be noticeable by consumer and this will influence their preferences (Nancy & Carole, 1986). The Responses Surface Methodology (RSM) is used to optimize the cake formulation. RSM is a cost effective approach, time reduction and allows optimization of ingredient levels for specific desirable product characteristic (Johnson & Zabik, 1981). It is an attractive tool to formulate baked product because it is able to detect the optimal levels of several variables without the necessity testing to all possible combinations. Response surface methodology (RSM) has been reported to be widely used in development and optimization of cake formulation (Johnson & Zabik, 1981; Kissel, 1967; Lee & Hoseney, 1982; Neville & Setser, 1986; Vaisey-Genser *et al.*, 1987; Joglekar & May, 1987).

Jackfruit (*Artocarpus heterophyllus* lam.) is popular fruit crop that is widely grown in Thailand and other tropical areas (Vanna *et al.*, 2002). Hasidah & Noor Aziah (2003) reported that jackfruit seed flour is a good source of fibre which contained high amount of TDF (6.98 %) and crude fibre (3.28 %). It has been successfully incorporated into bread at 25 % which has been accepted by sensory panel (Hasidah & Noor Aziah, 2003). Thus, jackfruit seed flour can be substituted at a certain level for wheat flour to satisfy consumer demands for increased fibre content in foods. The seed which is a waste from the fruit industry has potential for commercialization as a cheap source of fiber replacing wholemeal.

Sucrose which is the main ingredient in cakes provides sweetness and energy to the product. Besides that sucrose acts as a tenderizer by retarding and restricting gluten formation and increased the denaturation temperature for eggs protein and gelatinization of starch (Osman, 1975). Polydextrose (Litesse® from Danisco Sweeteners Ltd.) has been widely used as a sugar replacer. Polydextrose is low in calorie (1kcal/g). The lack of in sweetness characteristic in polydextrose would be an advantage for its application in sucrose based food (Anibal & Raul, 1981). It has poor gastrointestinal absorption and is highly resistance to microbial degradation in the colon.

Figdor & Bianchine (1981) reported that after an oral administration about 60% of polydextrose was excreted unchanged in the feaces. Polydextrose was reported to have similar technological properties to sugar and functions in food as humectants, bulking agent, stabilizer and texturiser. Polydextrose (Litesse®) is non-glycemic; hence it does not create an insulin demand. Studies have shown that Litesse ® promotes the growth of intestinal Lactobacillus and bifidus and fermentation in the large intestine was reported to yields short-chain fatty acids (Danisco, 2003).

Polydextrose is a permitted additive in accordance with Good manufacturing Practice (GMP). The purpose of this study are 1) to optimize the levels of polydextrose and JFS flour to partially replaced sucrose and wheat flour in reduced calorie chocolate cake and 2) to compare the textural characteristics of optimized formulation with those of commercial cakes.

MATERIALS AND METHODS

Materials

Polydextrose (Litesse® Ultra) was supplied by Danisco Sweeteners (M) Co., Ltd. The emulsifier system, sucrose ester F-160 was obtained from Dai-Ichi Kogyo Seiyaku Co., Ltd. (Kyoto, Japan). The dry ingredients were purchased from Sunshine Trading Company, Penang. The jackfruit seed were supplied from Tropical Farm, Penang and processed into flour in the Food Technology Department lab.

Cake preparation

Formulation for control chocolate cake was shown in Table 1.0. A single bowl mixing procedure was used. The eggs, sugars, sucrose ester were poured into a mixing bowl. These materials were well mixed for 2 minutes at speed 4 and 5 minutes at speed 6 (Kitchen Aid Mixer, model 5-C, Hobart, IN). The mixture was then mixed at speed 8 for 2 minutes to form lighter, creamier and 'floppy' batter with mechanical aeration. After mixing, the sifted dry ingredient (self-raising flour, jackfruit seed flour and cocoa powder) were then added into a mixing bowl and mix at speed 2 for 2 minutes. Over mixing at this stage will result in poor texture and tough cakes. Milk, margarine and polydextrose were heated together in a saucepan until melted and were cool prior to adding into the mixture in the bowl and mix at speed 2 for 1 minute. The batter (250g) was transferred to 12cm x 5cm x 4cm tin greased cake pan and baked in an electric oven (model

Salva Modular) at 180^{0}C for 35 minutes. The cakes were then removed from the oven and allowed to cool at room temperature for 2 hours prior to packing in a 25x 15cm low-density polyethylene bag which were then analyzed for physical attributes. Data reported were based on the mean of three replications.

Table 1: Formulation of chocolate cake[a]

Ingredients	Control cake (g)	RSM cake (g)
Sugar	130	115.84
Margarine	45	35
Sucrose ester	8	12
Non fat milk	125	140
Egg	100	100
Cocoa powder	25	25
Self-raising flour	115	96.7
JFS[b] flour	-	18.32
Polydextrose	-	14.15

[a] ingredient amounts in grams
[b] jackfruit seed

Jackfruit seed (JFS) flour preparation

The seeds were cleaned under running water and then boiled for 15 minutes. The seeds were cooled before the outer skin (hilum) was peeled off manually. The seeds were sliced and dried in air drying oven at 60^{0}C (model Afos Dryer). The dried seeds were then ground into flour with 60 mesh particle sizes (Retsch, German, 14000 rpm).

Physical measurement of cakes

The volume of cake was determined by rapeseed displacement method according to Lin & Lin, (2001). Proximate analyses of fat, ash, protein (N x 6.2 5), crude fibre, moisture and carbohydrate were conducted according to AOAC (1980) methods. The caloric value was determined according to Basil & Sandra

(1983) method. Cake uniformity and symmetry was determined following the Standard Procedure of the American Association of Cereal Chemist (AOAC method 10-19), AACC, 1984). Specific volume (cc/g) was computed by dividing the cake volume by weight.

Experimental Design & Statistical Analysis

RSM was employed to determine the optimal combination of polydextrose and JFS flour replacement in developing reduced calorie cake. Stat-Ease software (Design Expert version 5.0.7, Corp., MN) was used in this study to provide statistical evaluation to fit the second order equations to all dependent variables. Two variables are used (JFS flour and polydextrose) by employing a central composite like rotatable design (CCD) as shown in Table 2.

Table 2: Level of ingredients for central composite design

Factor	Low	High
Polydextrose[a] (% replacement of sucrose)	10%	15%
JFS flour[b] (% replacement of wheat flour)	20%	25%

[a] % replacement of sucrose
[b] % replacement of wheat flour

The centre points were added to the factorial design to provide a protection against curvature as well as allow an independent estimate of error to be obtained as shown in Table 3.

Table 3: Treatment of chocolate cake

Run	Block	Factor X_1: Poly[a]	Factor X_2:JFS[b]
1	Block 1	15.00	25.00
2	Block 1	8.96	20.00
3	Block 1	12.50	20.00
4	Block 1	10.00	25.00
5	Block 1	16.04	20.00
6	Block 1	12.50	20.00
7	Block 1	12.50	12.93
8	Block 1	12.50	20.00
9	Block 1	12.50	20.00
10	Block 1	15.00	15.00
11	Block 1	12.50	27.07
12	Block 1	10.00	15.00
13	Block 1	12.50	20.00

[a] % replacement of sucrose
[b] % replacement of wheat flour

Responses were measured for volume, specific volume, symmetry and uniformity. Thirteen combinations including 5 replicates of the center point were chosen in random order according to CCRD configuration for 2 factors (Cochran & Cox, 1975) as shown in Table 4.

Table 4: Volume, specific volume, symmetry and uniformity of chocolate cake

Factor X_1: poly[b]	Factor X_2: JFS[c]	Volume[a] (ml)	Specific Volume[a] (ml/g)	Symmetry[a] (cm)	Uniformity[a] (cm)
15.00	25.00	550	2.5	1.0	0
8.96	20.00	560	2.5	1.5	0.15
12.50	20.00	560	2.6	1.7	0
10.00	25.00	560	2.52	0.7	0.15
16.04	20.00	550	2.55	0.6	0.1
12.50	20.00	560	2.65	1.7	0
12.50	12.93	565	2.59	1.65	0.1
12.50	20.00	560	2.6	1.7	0
12.50	20.00	560	2.6	1.7	0
15.00	15.00	555	2.65	1.0	0.15
12.50	27.07	555	2.5	0.5	0.1
10.00	15.00	570	2.55	2.2	0.1
12.50	20.00	560	2.6	1.7	0

[a] Mean of triplicate measurements
[b] % replacement of sucrose
[c] % replacement of wheat flour

Best fitting models were used to plot the responses surfaces as shown in Table 5. For optimization purposes, a mathematical model was developed in this study as follows:

Responses = $ß_0 + ß_1 (X_1) + ß_2 (X_2) + ß_{12} (X_1) (X_2) + ß_1^2 (X_1)^2 + ß_2^2 (X_2)$

Where:

Response = scores of each physical properties evaluated

$ß_0$ = intercept

$ß_1$ = coefficient for polydextrose (poly) level at the first order term

$ß_2$ = coefficient for JFS flour level at the first order

$ß_{12}$ = coefficient for interaction among poly and JSF level

$ß_1^2$ = coefficient for poly level at the second order term

$ß_2^2$ = coefficient for JFS flour level at the second order level

(X_1) = % poly replacement of sucrose

(X_2) = % JFS replacement of wheat flour

Table 5: Best fitting models for all dependent variables

Dependent variables	Best equation[a]
Volume	$Y_1 = 574 + 4.79X_1 - 2.48X_2 - 0.35X_1^2 + 0.012X_2^2 + 0.1X_1X_2$
Specific volume	$Y_2 = 0.69 + 0.21X_1 + 0.066X_2 - 6.0X_1^2 - 1.1X_2^2 - 2.4X_1X_2$
Symmetry	$Y_3 = 0.66 + 0.43X_1 - 0.018X_2 - 0.045X_1^2 - 0.011X_2^2 + 0.03X_1X_2$
Uniformity	$Y_4 = 1.39 - 0.17X_1 - 0.027X_2 + 9.5X_1^2 + 1.87X_2^2 - 4.0X_1X_2$

[a] Full model, where X_1 = polydextrose, X_2 = JFS flour, is:
$Y = ß_0 + ß_1 (X_1) + ß_2 (X_2) + ß_{12} (X_1)(X_2) + ß_1^2 (X_1)^2 + ß_2^2 (X_2)$

RESULTS AND DISCUSSION

The proximate analyses and results for volume, specific volume, symmetry and uniformity of the control and RSM cake (cake produced from optimal level of polydextrose and JFS flour) was shown in Table 6. RSM cakes showed higher symmetry index as compared to control cake. High values of the symmetry index were associated with large tunnels that terminated in the center of the cake (Cloke *et al.*, 1984).

Table 6: Proximate analysis[a] (db), physical analysis[a] and calorie value of control and RSM cake[b]

Attribute	Control cake (%)	RSM cake (%)
Moisture	$22.38^{a} \pm 0.007$	$31.17^{b} \pm 0.76$
Fat	$15.73^{a} \pm 0.28$	$3.52^{b} \pm 0.01$
Protein	$5.68^{a} \pm 5.68$	$9.89^{b} \pm 9.88$
Ash	$1.58^{a} \pm 0.01$	$5.02^{b} \pm 0.03$
Crude fiber	$0.91^{a} \pm 0.75$	$5.36^{b} \pm 0.17$
Carbohydrate[c]	53.72^{a}	45.04^{b}
Volume	$580^{a} \pm 0.70$	$570^{b} \pm 0.70$
Specific volume	$2.64^{a} \pm 0.28$	$2.63^{a} \pm 0.3$
Symmetry*	$1.4^{a} \pm 0.28$	$2.2^{a} \pm 0.57$
Uniformity*	0^{a}	0^{a}
Caloric value (kcal/100g)	$379^{a} \pm 0.70$	$251^{b} \pm 0.70$

db = dry basic
[a] Mean values ± SD of duplicate analysis in the same column with different superscript letter are significantly different at $p \leq 0.05$ using Duncan's multiple range test. Determined according to the AOAC method (1980).
[b] RSM cake = cake produced from optimal level of 16 % polydextrose and 11 % JFS flour.
[c] by difference
* indices determined according to the AACC method 10 – 91 (AACC, 1984)

The AACC indices for symmetry and uniformity were based on measurements of heights at specific locations in the centre cross section of the cake. Ideally, high quality cakes have slightly rounded symmetrical tops, a large volume and a low degree of shrinkage. The symmetry index described the top surface of cakes, which may be sunken, or rounded and was indicated by negative, zero or positive values, respectively. In contrast, a positive value indicates a lop-sided cake (Stinson, 1986).

The optimum level of 10% polydextrose, replacement for sucrose was about 14g in the formulation. According to 21 CFR Part 105, the level of polydextrose in a single serving should not exceed 15g because it was potential for laxative effect.

Basil & Sandra (1983) reported that the ability of water to entrap leavening gases released from the baking powder system will affect the volume of cake (Basil & Sandra, 1983). Table 6 showed that volume of control cake (580) is significantly ($p<0.05$) higher that RSM cake (570) because the replacement of the wheat flour with JFS flour will weaken the gluten matrix which is responsible for retaining the leavening gases. Table 6 showed no significant different ($p>0.05$) of specific volume between the control and RSM cake. Thus the result obtained was in agreement as reported by El-Said *et al.* (1973) which stated that using polydextrose in the cake formula yielded cake samples having almost the same specific volume as that of the control cake.

RSM cake was found to have significantly ($p<0.05$) higher moisture content than the control cake. Polydextrose was hygroscopic in nature (Freeman, 1982, Torres & Thomas, 1981) which will retain moistness in RSM cake than control cakes. The water absorption capacity of JFS flour was 205% (dwb) higher than wheat flour, which was only 66.6% (dwb) (Vanna *et al.*, 2002). This indicated that JFS flour has a good ability in binding water. RSM cake contained 3.52% fat (dwb) which was significantly ($p<0.05$) lower than the control cake (15.73%) because of a few factors such as, the reduction of margarine from 45g to 35g in the formulation, polydextrose also acted as a fat replacer (Danisco, 2003) and low of fat content in JFS flour that is 0.72 % (Hasidah & Noor Aziah, 2003). RSM cake indicated significantly ($p<0.05$) high content of crude fiber about 5.36% (dwb) as compared to control cake was about 0.91% (dwb). This indicated that partial replacement of JFS flour increase the fiber content in the cake because JFS flour have been reported to have a high content of crude fibre about 3.28 % (Hasidah & Noor Aziah, 2003).

The RSM cakes contained 251 kcal/ 100g. This is in compliance with the federal regulation (21 CFR 106.66) that a food can be labeled 'reduced calorie' on the basis that an alteration of special results in a calorie reduction of at least one third (1/3) from the control cake which contained 379 kcal/100g.

Table 7 showed the estimated regression coefficient for volume, specific volume, symmetry and uniformity. The R^2 values obtained were 0.9498, 0.9092, 0.9788, and 0.9678 for volume, specific volume, symmetry and uniformity, respectively. The closer the R^2 value to unity the better the empirical model fits the actual data, which supported by the lack of fit test. This meant that R^2 of more than 0.75 were satisfactory and considered accurate enough for prediction purposes (Breene & Coulter, 1967 and Irwandi *et al.*, 2000).

Table 7: Estimated regression coefficient for volume, specific volume, symmetry and uniformity.

Coefficient	Volume	Specific volume	Symmetry	Uniformity
$ß_0$	560	2.61	1.70	0
$ß_1$	-4.89***	0.019*	-0.27***	-0.021**
$ß_2$	-3.64***	-0.038**	-0.39***	-0.012
$ß_1ß_2$	1.25	-0.038*	0.38***	-0.05
$ß_1^2$	-2.19**	-0.028**	-0.28***	0.059***
$ß_2^2$	0.31	-0.03*	-0.27***	0.047***
P-value	0.0002	0.0016	0.0001	0.0001
R^2	0.9498	0.9092	0.9788	0.9678

$ß_1$ = Polydextrose
$ß_2$ = JFS flour
* Significant at 0.05 level
** Significant at 0.01 level
*** Significant at 0.001 level

Some models or equations could be developed with confidence based on the results from Table 7. An optimum level of polydextrose and JFS flour for developing reduced calorie cake represented conditions that would yield acceptable high volume and specific volume, slightly rounded top surface (or at least a flat, not sunken), a uniform cell size, and a moderately open crumb structure (Kim & Walker, 1992).

Figure 1.0 showed that increasing the level of polydextrose and JFS flour contributed to lower volume. During cake baking, sugar delayed the starch gelatinization which allowed the air bubbles to be expanded sufficiently by carbon dioxide and water vapour before the cake sets (Yamazaki & Kissel, 1978). This resulted in highly aerated and higher volume in cake structure.

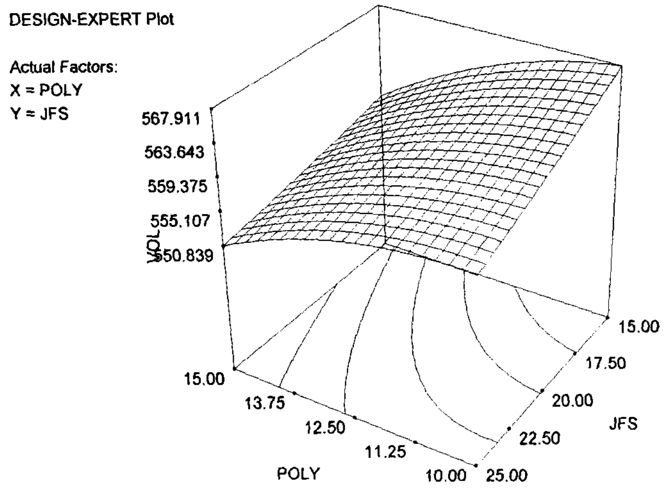

Figure 1.0 – Response surface for volume

Delayed gelatinization of starch in sugar solution was attributed to the abilities of sugar to 1) limit the availability of water to starch granule, 2) lower the water activity, 3) form sugar bridges between starch chains and 4) form an anti-plasticizing effect, relative to water (Kim & Walker, 1992). Thus, lowering sugar by substituting with polydextrose resulted in an early gelatinization of starch during baking process and restricted the volume of cake.

It was shown that the incorporation of JFS flour into the formulation resulted in a progressive decreased in loaf volume. To overcome the problem, prolong beating was carried out to incorporate air, and the resultant batter was found thicker than the traditional batter. It was also shown that polydextrose and JFS flour were the most significant factor ($p<0.001$) affecting the volume, symmetry, specific volume and uniformity. Figure 2.0 indicated that the increased in polydextrose and decreased in JFS flour contributed to the increase in specific volume.

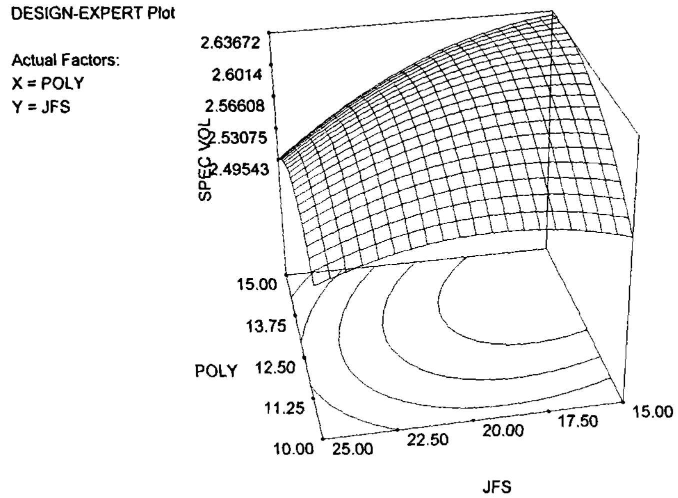

Figure 2.0 – Response surface for specific volume

Figure 3.0 showed that decreased in polydextrose and JFS flour led to a progressive increased in symmetry. Table 7, indicated that polydextrose and JFS flour resulted an inversed effect on symmetry.

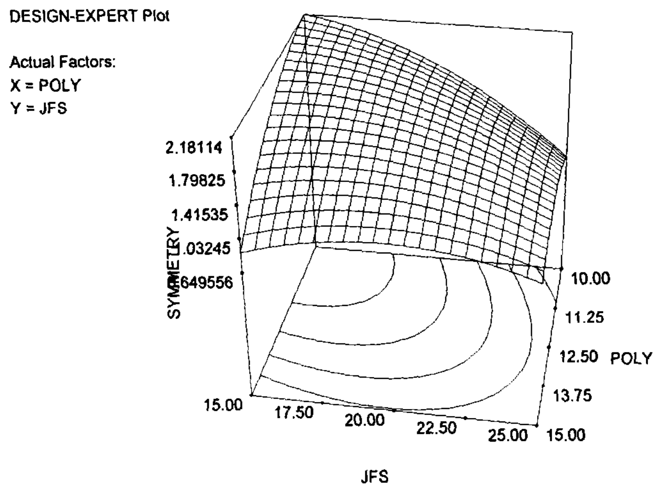

Figure 3.0 – Response surface for symmetry

Figure 4.0 showed that increased in JFS flour and decreased in polydextrose resulted in an increased in uniformity. The JFS flour was found to affect volume and symmetry but not the uniformity significantly (p<0.001).

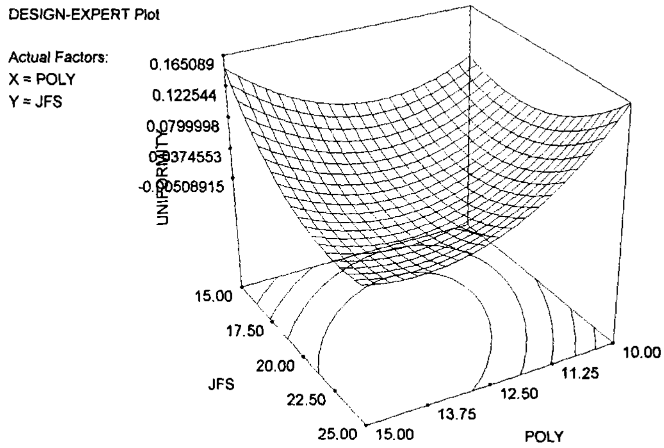

Figure 4.0 – Response surface for uniformity

CONCLUSION

The textural optimization for the reduced calorie and high fiber cake system was successful in partially replacing sucrose with polydextrose at 11% and wheat flour with JFS flour at 16% by using the Responses Surfaces Methodology (RSM). Final optimized cake formulations resulted in a cake with calorie reduction of 128 kcal from the control cake.

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EFFECTS OF DIFFERENT LEVELS OF JACKFRUIT SEED FLOUR ON THE QUALITY CHARACTERISTICS OF REDUCED FAT MUFFINS

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ABSTRACT

Reduced fat muffins were prepared with 35% polydextrose as fat replacer and supplementation with different levels (control-0%, 10% and 20%) of jackfruits seed flour (JSF). The physico-chemical and sensory characteristics of the muffins were investigated. Batters of all muffins samples were determined for specific gravity and viscosity. The specific gravity and viscosity of batter was increased and decreased respectively, with increasing levels JSF. Compared to the control, addition of JSF indicated a reduction on the physical characteristics (height, volume and specific volume) of muffins. From SEM results, it was noted that starch granules from batter with polydextrose was not seen clearly but those crumbs with added JSF exhibited higher degree of gelatinization compared to the C and C+P muffins. The fat content was significantly ($p<0.05$) reduced (26-38%) for muffins with polydextrose (C+P, 10%JSF+P, 20%JSF+P) as compared to muffins without polydextrose. Muffins with added JSF showed an increased in moisture, ash, dietary fibre and resistant starch content. Addition of JSF in muffins reduced the stachyose and raffinose composition significantly ($p<0.05$) as compared to the C. There was no significant different ($p>0.05$) in all sensory attributes in all sample.

Keywords: Polydextrose; jackfruit seed; reduced-fat; dietary fibre; resistant starch

INTRODUCTION

Recently, more attention has been focused on the utilization of food processing by-products and wastes, as well as under-utilized agriculture products. Only a small portion of plant material is utilized directly for human consumption. The remainder, or part of it, may be converted into fertilizer; thus an important contribution to food resources or industrial products could be made (El-Adawy et al., 1999). For example, jackfruit seed, which remain in large quantities as waste products after the removal of peel and flesh, could be utilized in food product.

Studies showed that jackfruit seed was good in nutritional value (Singh et al., 1991; Tulyathan et al., 2002). It contains 38% carbohydrate, 6.6% proteins and 0.4% fat (James, 1993). The fresh seeds are considered to be high in starch, low in calcium and iron and good sources of vitamin B_1 and B_2 (Morton, 1987). The seeds has been reported blended into flour, and later mixed with wheat flour for baking (Verheij & Coronel, 1991). Thus, incorporation of JSF flour can be utilized as value added ingredient in muffins.

Muffins are popular, quick breads commonly taken as breakfast or as a snack. Many muffins are high in fat and sugar and may make a significant contribution to an individual's calories intake.

The production of low-fat product could lower risk of chronic diseases. Thus, there is a great need to prepare foods that contain little or no fat which can be accomplished by using fat replacer in food product. Polydextrose, which can be used as a sugar- and fat-replacer, is a cross-linked, partially metabolized glucose polymer that adds body and texture to reduced-calorie foods. Its provides 1 kcal/g in comparison with 4 kcal/g by sucrose and 9 kcal/g by fat (Xyrofin, 1997). The low calorie of polydextrose is a result of its poor digestibility in the small intestine and incomplete fermentation in the large intestine (Flood et al., 2004). FDA extensively studied polydextrose for safety prior to its 1982 approved as a food additive under 21 CFR §172.641 (Burdock & Flamm, 1999).

The objectives of this research are to develop a reduced fat muffin by addition of polydextrose and incorporating with different level of JSF. To evaluate the effects of different levels of flour substitution on physicochemical of batter and muffin quality.

MATERIALS AND METHOD

The JSF was prepared according to the method of Hasidah (2005). Muffins (Table 1) were prepared according to the muffin method (Campbell et al. 1979). The dry and liquid ingredients were first mix separately. The liquid ingredients were then combined for 25 strokes with wooden spatula. Specific gravity of muffins batter was calculated by dividing the weigh of a standard cup of the batter by the weight of an equal volume of water (AACC, 2000). The viscosity of batter was measured using the Brookfield viscometer (DV-E) at different speeds of 2.5, 5, 10, 20, and 50 rpm. The volume of muffins was determined by rapeseed replacement. The muffins were weighed after removal from pan and the specific volume was calculated by ratio volume to weight. The height of muffins was measured using ruler. A Field Emersion Scanning Electron Microscopy (FESEM-Leo Supra 50VP) was used for characterization of batter and muffin microstructure. Moisture, ash, crude fibre, fat and protein were determined according to the method of AOAC (1990). Moisture and fat free samples were analyzed for dietary fibre content by enzymatic and gravimetric method of the AACC (2000). Extraction of oligosaccharide was followed by the method of Trugo et al., (1995). The oligosaccharide was determined using an HPLC and a refractive index detector. Resistant starch (RS) was measured by the procedure of Goñi et al., (1996). Sensory evaluation was conducted using a 9-point hedonic scale comprising of 32 panelists.

Table 1: Muffins formulation

Ingredients (g)	C	C+P	10%JSF	10%JSF+P	20%JSF	20%JSF+P
Flour	112.50	112.50	101.20	101.20	90.00	90.00
Jackfruit seed flour	0.00	0.00	11.20	11.20	22.50	22.50
Brown sugar	42.50	42.50	42.50	42.50	42.50	42.50
Salt	1.20	1.20	1.20	1.20	1.20	1.20
White egg	21.50	21.50	21.50	21.50	21.50	21.50
Vanilla	2.30	2.30	2.30	2.30	2.30	2.30
Low-fat milk	59.00	59.00	73.00	73.00	92.00	92.00
Vegetable oil	29.60	19.20	29.60	19.20	29.60	19.20
Polydextrose	0.00	10.40	0.00	10.40	0.00	10.40

C=Control, C+P= Control + Polydextrose, 10%JSF= 10% Jackfruit seed flour, 10%JSF+P= 10% Jackfruit seed flour + Polydextrose, 20%JSF= 20% Jackfruit seed flour, 20%JFS+P= 20% Jackfruit seed flour + Polydextrose.

RESULTS AND DISCUSSION

Specific gravity and viscosity of batter

The specific gravity of the muffins batter was shown in Table 2. Indicated significant different between C, C+P and 20%JSF. The C and C+P batters showed lower specific gravity as compared with 20%JSF batter. Added JSF increased the specific gravity of batter. The specific gravity can be related to a viscosity of batter.

Table 2: Specific gravity for muffins batter

Batters	Specific Gravity
C	1.08 ± 0.02^{a}
C+P	1.08 ± 0.01^{a}
10% JSF	1.11 ± 0.01^{ab}
10% JSF+P	1.11 ± 0.02^{ab}
20% JSF	1.12 ± 0.01^{b}
20% JSF+P	1.11 ± 0.00^{ab}

*Means in the same column with different superscripts are significantly different ($p<0.05$) (n=3). C=Control, C+P= Control + Polydextrose, 10%JSF= 10% Jackfruit seed flour, 10%JSF+P= 10% Jackfruit seed flour + Polydextrose, 20%JSF= 20% Jackfruit seed flour, 20%JFS+P= 20% Jackfruit seed flour + Polydextrose.

Apparent viscosity values versus shear rate for the different batter formulations are shown in Figure 1. All batters were shown to have be non-Newtonion pattern. Batter viscosity was observed to decrease with increasing shear rate, revealing the shear thinning characteristics of batters. Sample viscosities varied from 9.09 to 266.33 Pa.s at different shear rates. Batter containing JSF showed lower viscosity than the C and C+P batter. This could be attributed to the ability of wheat gluten to absorb water, resulting in reduction of free water in the batter system. Incorporated of JSF diluted the wheat flour protein which caused development of batter viscosity during mixing (Loewe, 1993; Sanz et al., 2005). According to Mitchell (1996), addition of polydextrose in dry form is bind the water and control the viscosity.

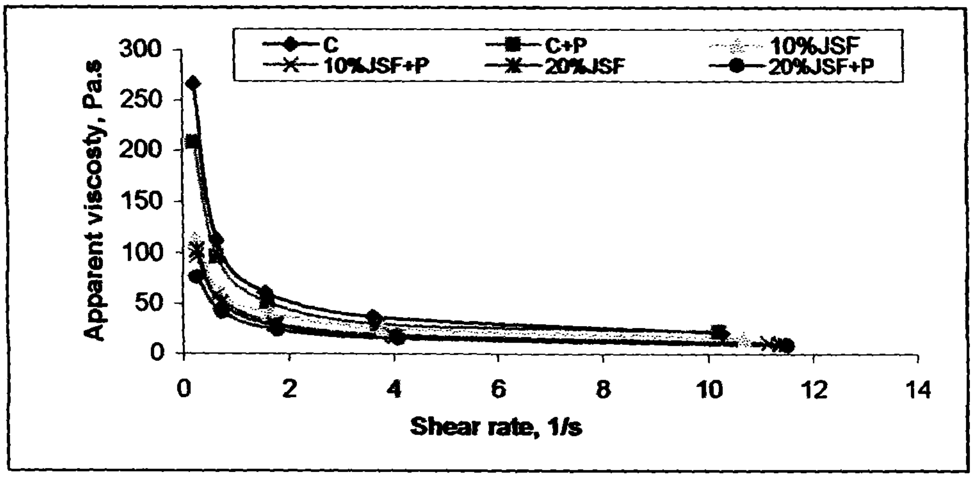


Figure 1: Changes in viscosity of batter with different formulation.

Physical characteristic of muffins

As shown in Table 3, the addition of JSF tend to reduce the height, volume and specific volume of muffin as compared to C and C+P. This might be due to the decrease in wheat gluten content (dilution effect) (Deshpande et al., 1983). The C and C+P have high volume, specific volume and height can be related to higher viscosity and lower specific gravity of batter. The addition of JSF did effect the air incorporation into the batters and which resulted in significant decreases in muffin volume.

Table 3: Result of physical characteristic of muffins.

muffins sample	Height(cm)	volume (ml)	Specific volume (ml/g)
C	4.48±0.12^{c}	130.00±0.00^{c}	2.28±0.01^{c}
C+P	4.50±0.06^{c}	126.00±0.00^{c}	2.24±0.28^{c}
10% JSF	4.37±0.06^{ab}	113.33±0.22^{b}	2.02±0.11^{b}
10% JSF+P	4.38±0.06^{ab}	113.00±0.00^{b}	2.00±0.01^{b}
20% JSF	4.29±0.00^{a}	110.00±0.00^{a}	1.95±0.01^{a}
20% JSF+P	4.30±0.00^{ab}	111.00±0.00^{a}	1.96±0.02^{a}

*Mean values in a column followed by different letters are significantly different (P<0:05). (n=3). C=Control, C+P= Control + Polydextrose, 10%JSF= 10% Jackfruit seed flour, 10%JSF+P= 10% Jackfruit seed flour + Polydextrose, 20%JSF= 20% Jackfruit seed flour, 20%JFS+P= 20% Jackfruit seed flour + Polydextrose.

SEM of batters and muffins

The images obtained in the SEM of batters are shown in Figure 2. A micrograph from batters without added polydextrose [Figure 2 (a, c, e)] Showed that small and large starch granules were interlinked together by thin gluten matrix. Although, the starch granules in batters with polydextrose [Figure 4.2 (b, d, f)] was not seen clearly, because it was immersed and covered by thin layer of gluten and polydextrose matrix. Micrographs of muffin crumbs at 500x magnification are shown in Figure 3. Starch granules in the crumbs with added jackfruit seed flour exhibited higher degree of gelatinization as compared to C and C+P. Most of starch granules in the JSF muffins were distorted and immersed in the continuous matrix formed by the denaturated protein. The high amount of water absorbed in JSF might have caused the high degree of gelatinization in jackfruit seed flour muffins.

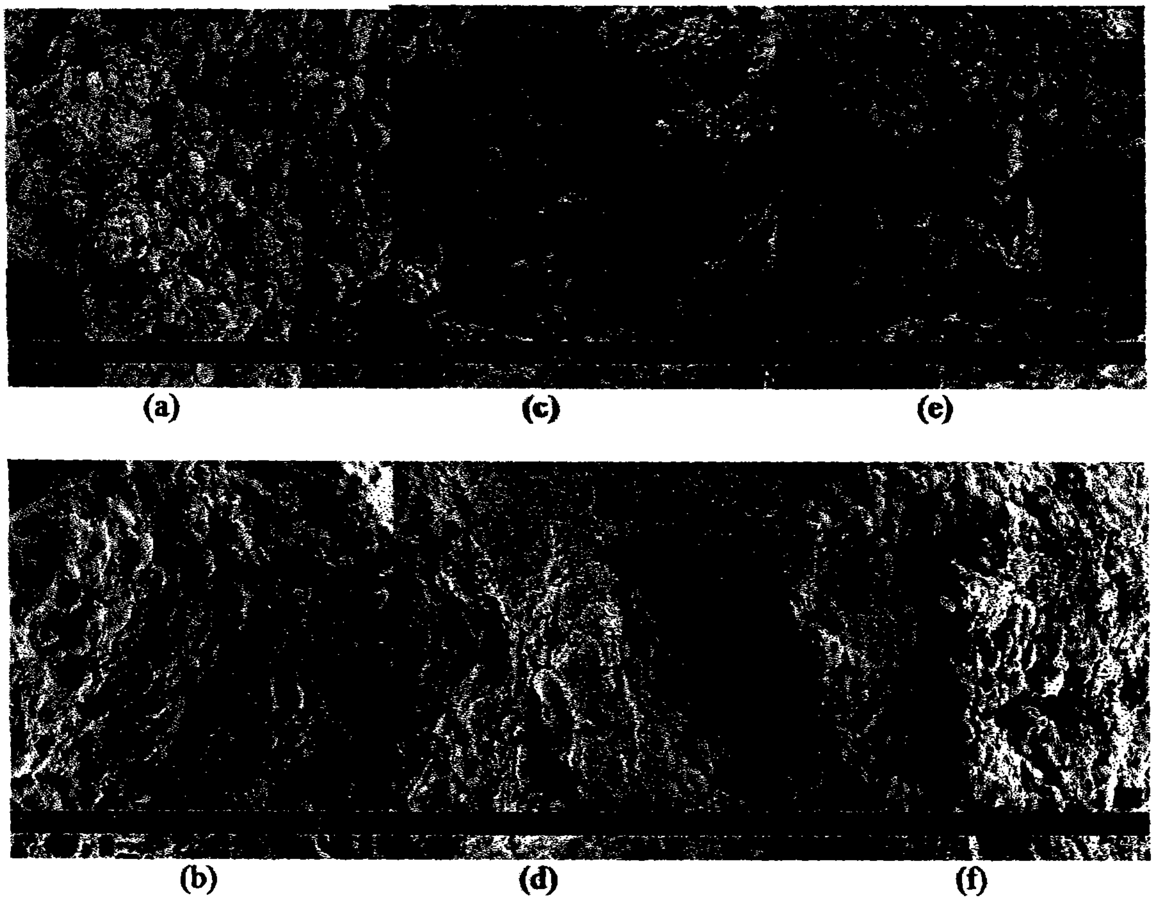
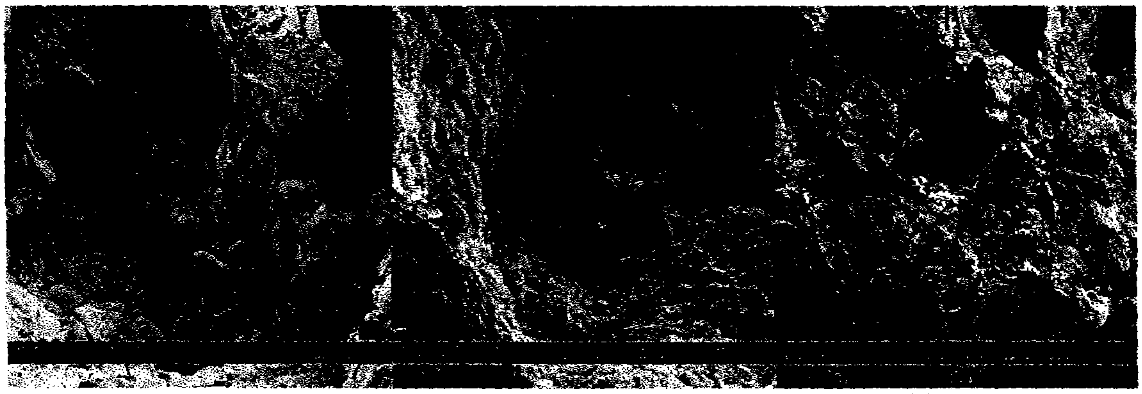
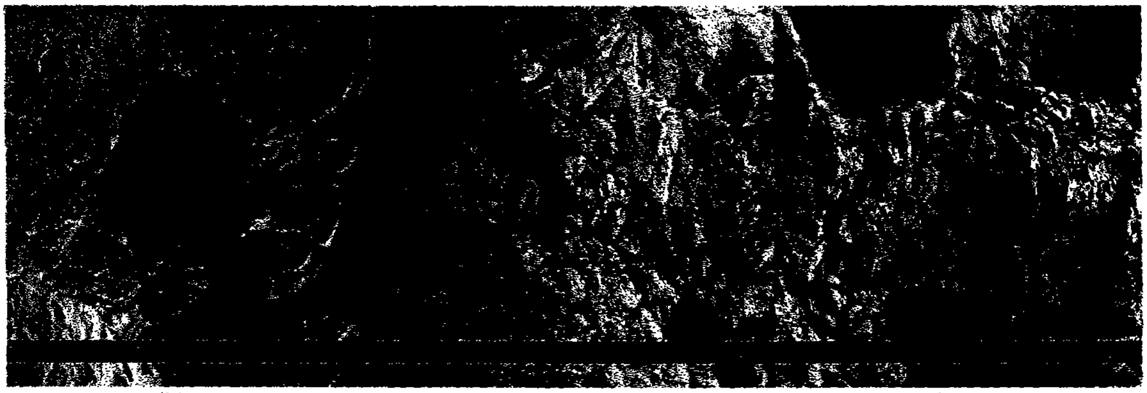


Figure 2: Microstructure of batters at 500x magnification; a) C, b) C+P, c) 10%JSF, d) 10%JSF+P, e) 20% JSF, f) 20% JSF+P



(a) (c) (e)



(b) (d) (f)

Figure 3: Microstructure of muffins at 500x magnification a) C, b) C+P, c) 10%JSF, d) 10%JSF+P, e) 20% JSF, f) 20% JSF+P

Chemical composition

The proximate compositions of muffins were shown in Table 4. There was significant difference ($p<0.05$) in terms of moisture, protein, fat, ash, crude fibre and carbohydrate content among all sample. Muffins with polydextrose (C+P, 10%JSF+P and 20%JSF+P) had significantly lower ($p<0.05$) fat content than muffin without polydextrose (C, 10%JSF, 20%JSF). The reduction of fat content was in the ranged of 26-38%. Crude fibre, protein and ash content were slightly higher with increasing levels of jackfruit seed flour as compared to C and C+P muffins. The carbohydrate content showed significantly increase ($p<0.05$) in muffins replaced with polydextrose.

Table 4: Chemical composition of muffins

Composition (%)	C	C+P	10% JSF	10% JSF+P	20% JSF	20% JSF+P
Moisture	26.24±0.12[a]	26.41±0.16[a]	29.17±0.24[b]	29.43±0.37[b]	32.46±0.36[b]	32.68±0.34[b]
Protein	8.27±0.12[a]	8.26±0.10[a]	8.50±0.11[b]	8.53±0.07[b]	8.52±0.10[b]	8.53±0.04[b]
Fat	7.64±0.11[b]	5.65±0.13[a]	7.56±0.28[b]	5.28±0.08[a]	7.43±0.28[b]	4.64±0.21[a]
Ash	1.70±0.01[a]	1.73±0.03[ab]	1.74±0.00[bc]	1.75±0.01[bc]	1.85±0.02[c]	1.84±0.06[bc]
Crude fibre	0.47±0.04[a]	0.51±0.04[a]	0.75±0.04[b]	0.77±0.08[b]	1.34±0.02[c]	1.38±0.06[c]
Carbohydrate	81.92±0.09[b]	83.85±0.01[c]	81.45±0.10[ab]	83.67±0.03[c]	80.86±0.11[a]	83.61±0.07[c]

* Mean values in a row followed by different letters are significantly different (P<0.05). (n=3). C=Control, C+P= Control + Polydextrose, 10%JSF= 10% Jackfruit seed flour, 10%JSF+P= 10% Jackfruit seed flour + Polydextrose, 20%JSF= 20% Jackfruit seed flour, 20%JFS+P= 20% Jackfruit seed flour + Polydextrose.

Dietary fibre composition

Figure 4 and 5 showed the soluble, insoluble and total dietary fibre for the batters and muffins. It was observed that insoluble and total dietary of batters and muffins with added JSF increased significantly (p>0.05) but soluble dietary fibre was insignificantly (p>0.05) different among batters and muffins. It was observed that baking process tend to increase the dietary fibre content. This is primarily due to the formation of resistant starch by retrograded of amylose. The retrogradation amylose is indigestible and constitutes the main resistant starch (RS) in processed food. The increase in total dietary fibre was solely due to the insoluble dietary fibre fraction represented as RS.

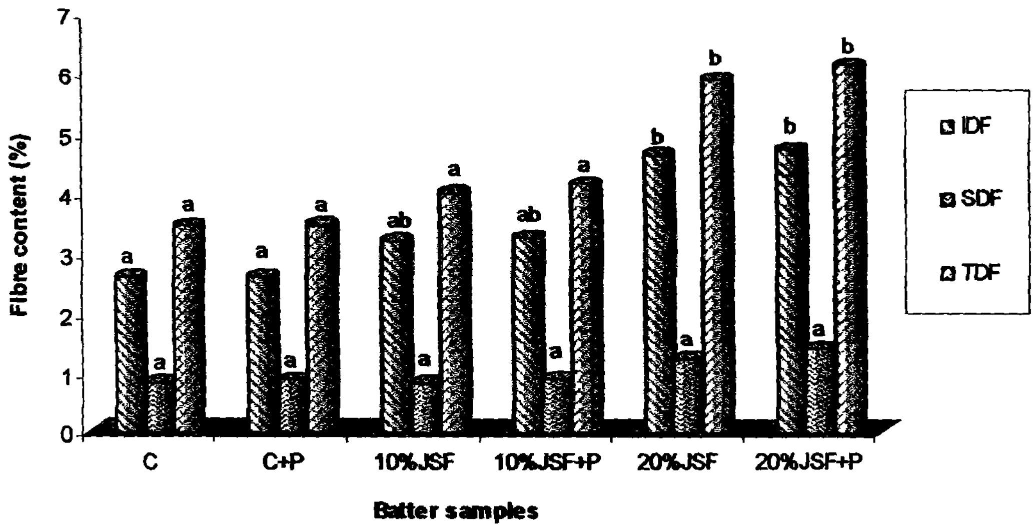


Figure 4: Dietary fibre profile of batters with incorporated jackfruit seed flour (with and without polydextrose)

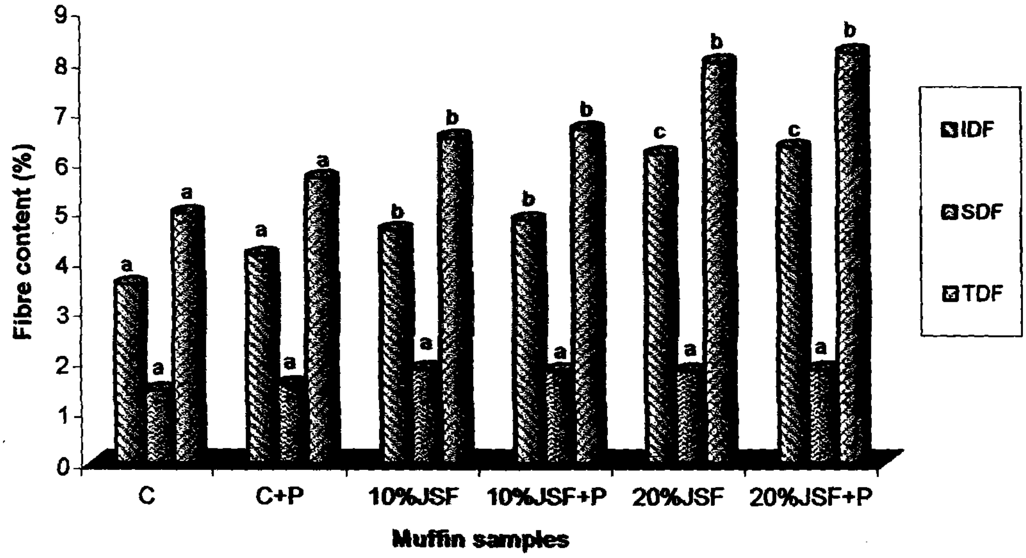


Figure 5: Dietary fibre profile of muffins with incorporated jackfruit seed flour (with and without polydextrose)

Oligosaccaride composition
It was observed that stachyose content of control muffin was 0.64g/100g. This was higher than the muffin incorporated JSF (0.18-0.24g/100g) (Table 5). The reduction might be due to hydrolysis of stachyose during heat treatment in processing of JSF. Onigbinde & Akinyele, (1983), reported reduction in oligosaccharide during cooking. The stachyose content was not detected in muffins with polydextrose. This might be due to the formation complex of polydextrose chain and stachyose during baking process. The control muffin had significant higher ($p<0.05$) raffinose content as compared to other muffins. The result showed significantly decreased ($p<0.05$) in raffinose content with increasing levels of JSF. Hasidah (2004) reported that no raffinose content was detected in jackfruit seed and its flour.

Table 5: Result for oligosaccharide (stachyose and raffinose) (g/100g) in muffin samples.

Sample	Stachyose	Raffinose
C	0.64 ± 0.51^a	1.44 ± 0.21^c
C+P	ND	0.65 ± 0.00^b
10%JSF	0.18 ± 0.12^b	0.34 ± 0.01^a
10%JSF+P	ND	0.58 ± 0.07^b
20%JSF	0.24 ± 0.30^b	0.30 ± 0.01^a
20%JSF+P	ND	0.29 ± 0.03^a

* Mean values in a column followed by different letters are significantly different (P<0:05).
ND- Not detected. C=Control, C+P= Control + Polydextrose, 10%JSF= 10% Jackfruit seed flour, 10%JSF+P= 10% Jackfruit seed flour + Polydextrose, 20%JSF= 20% Jackfruit seed flour, 20%JFS+P= 20% Jackfruit seed flour + Polydextrose.

Resistant starch (RS)
Table 6 showed the resistant starch (RS) content of the batters and muffins. The RS content was increase significantly ($p<0.05$) with increasing levels of JSF in muffins, but not different ($p>0.05$) in the batter samples.In this study, result showed slightly increased in RS value after baking process. This is in agreement with the results reported by Thed & Phillips (1995), that microwave-heating significantly increased the amount of RS. Retrogradation of amylase has been identified as the main mechanism for the formation of RS (Tharanathan & Mahadevamma, 2003) in food. The high RS content in muffin with added jackfruit seed flour must be related to the flour processing, which involved heat treatment such as boiling and drying. Therefore, it will induce the RS formation in the flour and muffins.

Table 6: Resistant starch (RS) content of batters and muffins.

Samples	Batter (%)	Muffin (%)
C	2.99 ± 0.11^{a}	3.35 ± 0.10^{a}
C+P	2.47 ± 0.05^{a}	3.57 ± 0.09^{ab}
10% JSF	3.71 ± 0.03^{a}	4.40 ± 0.02^{ab}
10% JSF+P	4.58 ± 0.06^{a}	4.75 ± 0.10^{ab}
20% JSF	5.72 ± 0.11^{a}	5.85 ± 0.06^{ab}
20% JSF+P	6.56 ± 0.07^{a}	6.71 ± 0.11^{b}

* Mean values in a column followed by different letters are significantly different (P<0:05). (n=3). C=Control, C+P= Control + Polydextrose, 10%JSF= 10% Jackfruit seed flour, 10%JSF+P= 10% Jackfruit seed flour + Polydextrose, 20%JSF= 20% Jackfruit seed flour, 20%JFS+P= 20% Jackfruit seed flour + Polydextrose.

Sensory evaluation

Sensory evaluations result are presented in Table 7. Results showed that substitution of wheat flour with JSF at different levels and replacement of fat with polydextrose were not affected significantly in all the sensory parameters except for the crust and crumb colour of muffins. The crust and crumb colour score decreased with addition of jackfruit seed flour. Rehman et al., (2007) also found that the colour of crust and crumb had lower score as the level of vetch flour substitution increased in doughnuts. The addition of polydextrose promoted browning reaction in muffins as a result of thermal degradation (Ronda et al., 2005).

Table 7: Score for sensory evaluation of muffins prepared from jackfruit seed flour (with and without polydextrose)

Sensory attributes	C	C+P	10%JSF	10%JSF+P	20%JSF	20%JSF+P
Crust colour	6.22 ± 1.02^{b}	6.13 ± 0.98^{b}	5.91 ± 1.07^{a}	5.81 ± 1.02^{a}	5.13 ± 1.00^{a}	4.6 ± 1.09^{a}
Crumb colour	6.88 ± 1.33^{b}	6.78 ± 1.48^{b}	6.41 ± 1.10^{ab}	6.38 ± 1.36^{ab}	5.72 ± 1.21^{a}	5.75 ± 0.94^{a}
Cell saiz	4.78 ± 0.12^{a}	5.38 ± 0.10^{a}	5.00 ± 0.10^{a}	5.38 ± 0.13^{a}	5.50 ± 0.09^{a}	5.09 ± 0.10^{a}
Aroma	5.94 ± 1.41^{a}	6.25 ± 1.02^{a}	6.09 ± 1.38^{a}	5.69 ± 1.67^{a}	5.50 ± 1.65^{a}	5.52 ± 1.74^{a}
Moistness	5.56 ± 1.11^{a}	5.63 ± 1.21^{a}	5.60 ± 1.13^{a}	5.94 ± 1.20^{a}	5.49 ± 1.14^{a}	5.53 ± 1.12^{a}
Softness	5.34 ± 1.46^{a}	5.34 ± 1.48^{a}	5.56 ± 1.20^{a}	5.59 ± 1.27^{a}	4.62 ± 1.42^{a}	4.73 ± 1.32^{a}
Overall acceptability	6.16 ± 1.39^{a}	6.19 ± 1.24^{a}	6.13 ± 1.35^{a}	6.14 ± 1.26^{a}	5.56 ± 1.29^{a}	5.66 ± 1.22^{a}

* Mean values in a row followed by different letters are significantly different (P<0;05). C=Control, C+P= Control + Polydextrose, 10%JSF= 10% Jackfruit seed flour, 10%JSF+P= 10% Jackfruit seed flour + Polydextrose, 20%JSF= 20% Jackfruit seed flour, 20%JFS+P= 20% Jackfruit seed flour + Polydextrose.

CONCLUSIONS

Incorporation of JSF affected the batter characteristics in term of specific gravity and viscosity. Increased water absorption of jackfruit seed flour may provide more water for starch gelatinization in the batter during baking as observed in SEM. Application polydextrose as fat replacer reduced the fat from 26 to 38 % in muffins. The incorporation of 20% jackfruit seed flour and polydextrose showed to be effective in improving the proximate composition, dietary fibre and resistant starch of muffins. However, the result showed the oligosaccharide content were reduced significantly with increasing levels of jackfruit seed flour but the free sugar were not different. Although addition of JSF slightly affect the physical characteristics of muffins, but it was acceptable as the C and C+P.

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Functional Properties of Jackfruit Seeds Flour
(*Artocarpus heterophyllus L.*)

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ABSTRACT

The functional properties of jackfruit seed flour prepared from three different treatment were evaluated. The three treatments include (i) A – dipping in sodium metabisulphite (Na_2SO_4) solution; (ii) B – soaking in water and boiling for 20 minutes and (iii) C – boiling for 15 minutes and boiling in sodium hydrogen carbonate ($NaHCO_3$) solution for 30 minutes. Flour from treatment C, boiled for 15 mins, then boiled in $NaHCO_3$ for 30 mins was observed to have the highest water holding (126.78 ± 0.075 %) and lowest of oil holding (46.55 ± 0.195 %) capacity than A and B. Flour from A showed high foaming capacity and stability during the whipping process followed by B and C. The lowest gelation concentration was found in flour A (8 %) and highest in flour B (20 %). Treatment from flour A was the highest in emulsifying activity and lowest in emulsion stability.

Keywords : jackfruit seed flour, water and oil holding capacity, gelation, foaming, emulsion

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1.0 INTRODUCTION

Jackfruit is a non-seasonal tropical fruit belonging to the family Moraceae. Jackfruit, a dicotyledonous compound fruit was grown in South-East Asia but was particularly abundant in India and Bangladesh. These fruit can contribute substantially to the nutrition of the local population and their livestock. The gross composition of jackfruit, its vitamin content and some of the volatile compound contributing to its flavour have been reported (Bhattarcherjee, 1986; Bose, 1985; Ahmed et al., 1986; Narasimham, 1990).

The seeds are used in several culinary preparation while the skin fruit and the leaves used as a cattle feed. The seeds were rich in starch and high in protein. An average, fruit comprised three parts of bulb with 30 % of the fruit weight, 12 % seed and 50% of jackfruit waste (Berry & Kalra 1988; John & Narasimham 1992). The seeds are eaten after boiling or roasting or dried and salted as table nuts or ground to make flour which is blended with wheat flour for baking. The seeds were also used as a protein substitute because of the nutritional supplements and prominent functional roles in foods.

A legume protein can be integrated as a food component, information about the functional properties of the protein as well as the effect of pH, temperature, ionic strength and presence of other food components such as lipids, sugars and starches are important to be considered (Damodaran, 1989; Myers, 1988). The protein quality during processing can affect the functional performance of protein products (Jane, Rivas & John, 1981) and contribute different characteristic in food product (Kolar et al., 1985).

Solubility of a protein is one of the critical functional attributes required for its application as food ingredients. Solubility greatly influences other properties such as emulsification, gelation and foaming (Wang & Kinsella, 1976). Emulsification was incriminated when molecules protein absorbed rapidly at the newly created oil-water interfaces and undergo conformational change and rearrangement at the interface, followed by formation of a cohesive film with viscoelastic properties as a result of intermolecular interactions (Damodaran, 1989; Kinsella, 1982). Gelation formation was influenced by different protein concentration, heating conditions, pH, ionic strength, types and concentration of salt, reducing agents, hydrophobicity and protein structure (Schmidt, 1981; Kinsella, 1984; Mulvihill & Kinsella, 1987; Morr & Ha, 1993). The objective of this present study was to determine the functional properties of jackfruit seed flours in the (i) water and oil holding capacity; (ii) foam capacity and stability; (iii) gel formation; (iv) emulsifying activity and (v) emulsion stability.

2.0 MATERIAL AND METHODS

2.1 Preparation of jackfruit seed flour

Raw jackfruit seeds were obtained from the Tropical Fruit Farm, Balik Pulau, Penang. The seeds were prepared by three different treatment – A, B and C.

Treatment A flour : The pulp were nipped from the seeds. The seeds were rinse and dry at room temperature. The aril and spermoderma of the seeds were removed and cut into slices with a knife. The slices were then soaked in the sodium metabisulphite (0.1 % w/v) for 10 minutes to avoid browning. The slices were then rinse with running tap water before oven-dried (Afos, Model mini, No CK 80520, England) at 60°C for removal of moisture. After 24 hours, the slices were grind using a blender (Moulinex Super Blender Mill 2, 720) into powder. Continually with grind in a Bench Top Grinder (Micro Universal Bench Top Grinder Type ZM 100). The flour was then sieve using a 60-mesh size. The flour was stored in clean and airtight container at room temperature for subsequent use or in the refrigerator at 4°C.

Treatment B flour : The seeds were soaked in water for 8 hour to remove dirt or rubbery and later boiled for 20 minutes. The seed were immediately put in water. Next the aril and spermoderma of the seed were removed and dried in the oven-dried (Afos, Model mini, No CK 80520, England) at 60°C for 24 hours for removal of moisture. The slices were milled in a grinder to later blend finely using a blender (Moulinex Super Blender Mill 2, 720) and continue with a Bench Top Grinder (Micro Universal Bench Top Grinder Type ZM 100). The flour was then sieve using a 60-mesh size. The flour were kept in the dry place.

Treatment C flour : The seeds were boiled for 15 minutes in water. The aril and spermoderma were removed from the seeds. The seeds were cut into slices and boiled for 30 minutes in the aqueous solution of sodium hydrogen carbonate (0.25 % w/v) to inactivate the enzyme in the seeds. The pieces were then rinsed and dry in an oven (Afos, Model mini, No CK 80520, England) at 60°C for 24 hours. The slices were grind into flour using a blender (Moulinex Super Blender Mill 2, 720) and continue with a Bench Top Grinder (Micro Universal Bench Top Grinder Type ZM 100). The flour was then sieve using a 60-mesh size. The flour was then stored in a clean container.

2.2 Oil and water holding capacity

Each 2 g of flour samples were weighed and was then added with 20 ml of water or 20 ml of oil. The mixture was centrifuged 600 rpm, 1 min and stored at a room temperature, 23°C for 1 hour. The suspension were then centrifuged at 1600 rpm for 25 minutes. Excessed water or oil (supernatant) was removed from the centrifuge tube and the sendiment were dried using an absorbent paper at room temperature, 23°C. The weight of water or oil bound were determined by difference.

2.3 *Foam capacity and stability*

10g of each samples were diluted with water and sodium cloride (NaCl) at different concentration : 0.05, 0.25, 0.50 and 0.75 M solutions to 100 ml solution. The suspension was adjusted to pH 7.0 with 0.1 M NaCl or 0.05 M H_2SO_4 solution. The suspension were homogenized (T-homogenizer, CKL Multimise) for 5 minutes at 6000 rpm and then poured into a 250 ml measuring cylinder. Foam capacity was determined by reading the volume of foam after 30 seconds. The foam stability was determined by measuring the volume of foam at 5, 30, 60 and 120 minutes after pouring the suspension into the measuring cylinder and is expressed as ml volume.

2.4 *Gel formation*

Samples of water dispersion with protein concentration between the range of 2-20 % (w/v) were prepared. The suspension was stirred at 600 rpm for 1 minutes. Aliquot of 5 ml was transferred to each of three test tube at each concentration and heated for 1 hour in a boiling water bath at 95°C. It was followed by rapid cooling under running tap water and then kept at 4°C for 2 hours. The least gelation concentration was recorded as the concentration when the sample did not fell or slip from the inverted test tube (Coffman & Garcia, 1977). Indices for gelation capacity for protein concentration were according to Padilla et. al, 1995 as shown in Table 1.

2.5 *Emulsifying activity and emulsion capacity*

Emulsifying activity and emulsion capacity was determined by weighing protein concentration of 0.50 % (w/v) prepared in an aqueous solvent comprised of water and sodium cloride (NaCl) at different concentration of 0.05, 0.25, 0.50 and 0.75 M into 100 ml volumetric flask. The pH solution was adjusted to 6.4 using 0.1 M NaOH and 0.1 M HCl. The suspension were vortexed for 1 minutes at 750 rpm. 20 ml of the suspension was added to 20 ml of oil and homogenized (T-homogenizer, CKL Multimise) for 1 minutes at 2500 rpm. Aliquots of 40 µl of each emulsion were diluted to 10 ml with 0.1 % (w/v) sodium dodecyl sulfate (SDS) solution. Absorbance was determined at 500 nm with a Shimadzu spectrofotometer using the SDS solution as a reference cell. A plot of absorbance vs sodium cloride concentration is used to determine the emulsifying activity. The emulsion stability was determined by reading the volume of emulsion remaining after 24 hours at room temperature (Pierce & Kinsella, 1978).

3.0 RESULTS AND DISCUSSION

3.1 Water and oil holding capacity

Table 2 indicated flour from treatment C had the highest water holding capacity (126.78 ± 0.075 %). This might have resulted from prolong heat treatment which make proteins swelled and thus increased the water holding capacity. The results also showed that heat denaturation did not lower the water holding capacity of each samples but instead improved the property. A similar effect was reported on the sunflower meal products (Lin & Humbert, 1974a). Soy products also gave the highest water holding capacity (130.0 %) and 84 % for oil holding capacity among jackfruit seeds flour and sunflower meal. It may suggest that soy proteins are more hydrophilic in nature than the other two proteins (Lin & Humbert, 1974b).

Flour from treatment A also had the highest (56.95 ± 0.201 %) oil holding capacity. This might have resulted from the increase in nature lipophilic and increasing of non-polar amino acids content. Fat absorption is attributed to the combination of fats to the non-polar groups of proteins (Kinsella, 1976) or the availability of the lipophilic groups (Sumner et al., 1981).

3.2 Foam capacity and stability

From Table 3, flour from treatment A had the highest volume of foam. This may be due to the highest protein content in that treated flour which did not undergo any heat treatment. In these measurement, the pH of the meal suspension was 6.4. Effect of NaCl concentration on the foam capacity of jackfruit seed flour at pH 6.4 was shown in Figure 1. Addition of salts was found to improve solubility, viscosity and protein aggregation as there was an increased in foaming properties. Fennema (1993) observed that NaCl can increased overflows and decreased foaming stability which constitute the chain between the carboxyl group and protein. In soybean flour products, there was also increasing in foam volume as increasing in pH due to its higher content of protein (Kinsella, J.E., 1979a).

In our study, the treatment A was found to increase in volume after whipping for the first 30 second with increased the NaCl concentration. The salts added affected foaming by enhancing solubility at lower concentration. At higher concentration salting out may occur and thus reduce foaming (Kinsella, 1976). Foaming properties are dependent on the ionic strength of the dispersion. These results was shown in Figure 2. There was a decline in foaming stability which occurred in each of the solutions as the ionic strength increased. Further increased in ionic strength, 0.75 M, resulted in charge-screening, which enhanced hydrophobic interaction. The increased in hydrophobic interaction can lead to a 'salting-out' effect, which lead to a reduction in the foaming capacity and stability.

Effect of pH on foaming capacity and stability of the jackfruit seed flour with different treatment was presented in Figure 3. The result indicated that maximum foaming capacity was recorded at pH 2 and an increase in foaming capacity observed at pH 8. Foaming capacity was observed to be highest in acidic regions than in alkaline. Treatment A flour resulted more foam from B and C flour. Resulted showed that foaming capacity increased with increasing concentration of NaCl in all types of treatment until 0.75 M cohereby there was a trend in decreasing foam stability. This might be due to the decreasing in attractive hydrophobic forces among the protein molecules occurs at the high acidic and alkaline regions, with addition of salt in which cases, the protein molecules become net positively charged and net negatively charged, respectively. In the past, studies have revealed that protein stabilized foams are more stable in the neighbourhood of the isoelectric pH of the protein than at any other pH (Aluko & Yada, 1995, Buckingham, 1970).

3.3 Gel formation

Gelation capacity of jackfruit seed flour in water at different protein concentration was shown in Table 4. The lowest gelation concentration of the treatment A, B and C flour were 8 %, 20 % and 16 % respectively in Table 4 after heating at 95°C for 1 hour. According to Schmidt (1981), considerably high protein concentration is usually required for the gelation of globular proteins. For the three samples, no gelling was found for 2 % and 4 % protein concentration. Some sediment was found in flour from treatment B (6 %, 8 %, 10 %) and C (6 %, 8 %). Hermansson (1982a, 1982b) stated that as protein gel structure becomes increasingly fine and continuous, the gel possessed an improved capacity to retain moisture.

Unlike jackfruit seeds flour, soy flour need a minimum protein concentration of 8 % to become gel. The higher protein concentration will increased the temperature that required to attain maximum viscosity and the firmness of the gel (Kinsella, 1979b)

3.4 Emulsifying activity and emulsion stability

The effect of NaCl concentration on emulsion capacity of jackfruit seed flour was shown in Table 5. The emulsifying activity of the samples were determined by using sodium dodecyl sulphite because it can disrupt any flocs or clumps (Pierce & Kinsella, 1978) and small amounts of NaCl produce ion and counter-ion layers which constitute an additional help in avoiding aggregation. The result showed that flour from treatment A, the emulsion activity increased with increasing NaCl concentration. Addition of NaCl concentration until 0.5 M, resulted an increased in emulsification capacity of the proteins due to improve solubility even at the isoelectric pH. Beyond this salt concentration, the emulsification capacity gradually decreased as a result of salting effect of NaCl (Chobert et. al, 1987).

Flour from treatment A indicated minimum stability which decreased greatly with time for about 24 hours. However, flour from treatment B and C, the emulsion indicated maximum stability and the volume of emulsion increased as concentration of NaCl increased. Flour from treatment C also indicated a more stable emulsion than treatment B. Hung and Zayas (1991) suggested that various factors including pH, droplet size, net charge, interfacial tension, viscosity and protein conformation could have effect the values of emulsion stability.

4.0 CONCLUSION

The jackfruit seed flour can be used as a protein substitute because of the excellent properties in terms of water and oil holding capacity, foaming properties, gel formation and emulsifying activity and emulsion stability. Treatment A has the highest water holding and lowest oil holding capacity. Foaming and gel formation property is better from flour A which has higher emulsifying activity but not in emulsion stability.

5.0 ACKNOWLEDGEMENT

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Table 1 : Symbol of gelation capacity for protein concentration (Padilla et. al, 1995)

Gelling		Gel structure
-	No gelling	Liquid
+ -	Some floccules	Pourable
+ + -	Almost homogenous gel	Gel remains fixed on turning the tube upside down
+ + +	Complete gelation	Gel remains fixedon shaking the tube upside down

Table 2 : Comparison of water and oil holding capacity of jackfruit seeds flour

Flour samples	Water %	Oil %
Treatment A	122.2 ± 0.185	56.95 ± 0.201
Treatment B	124.43 ± 0.030	50.75 ± 0.001
Treatment C	126.78 ± 0.075	46.55 ± 0.195
Soy Flour	130.0	84.0

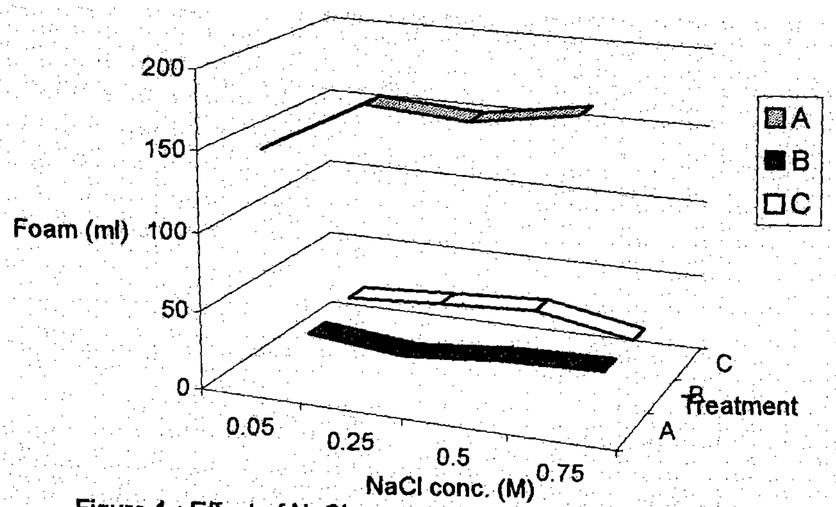
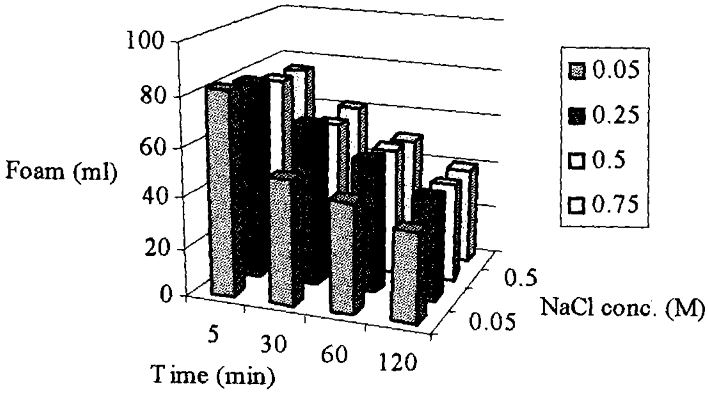


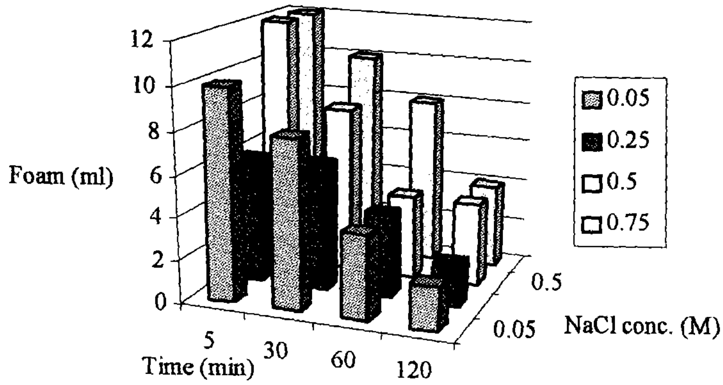
Figure 1 : Effect of NaCl concentration on the foam capacity of jackfruit seed flour at pH 6.4

Table 3 : Effect of NaCl concentration on foam capacity and stability of jackfruit seed flour

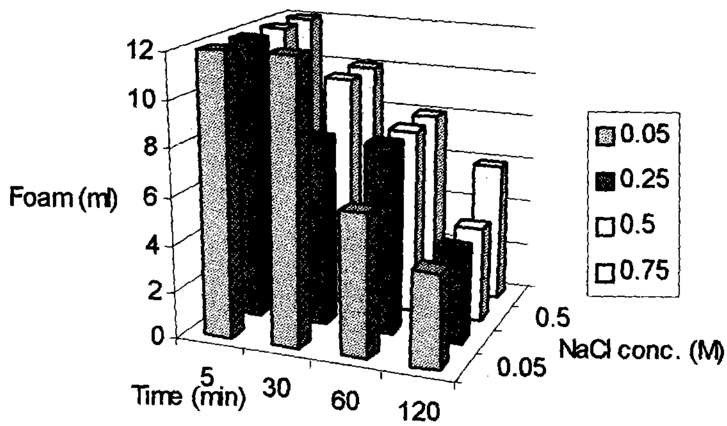
Flour samples	NaCl Conc, M	Volume increase on whipping (%)	Volume of foam after whipping (ml)			
			5 min	30 min	60 min	120 min
Treatment A	0.05	150	82	50	44	36
	0.25	184	80	66	54	42
	0.50	180	76	60	52	40
	0.75	190	76	62	50	40
Treatment B	0.05	14	10	8	4	2
	0.25	8	6	6	4	2
	0.50	14	12	8	4	4
	0.75	16	12	10	8	4
Treatment C	0.05	20	12	12	6	4
	0.25	24	12	8	8	4
	0.50	28	12	10	8	4
	0.75	16	12	10	8	6
Soy Flour	-	70	131 (10min)	108	61	20



NaCl concentration effect on the foam stability of treatment A



NaCl concentration effect on the foam stability of treatment B



NaCl concentration effect on the foam stability of treatment C

Figure 2 : NaCl concentration effect on the foam stability of jackfruit seed flour at pH 6.4

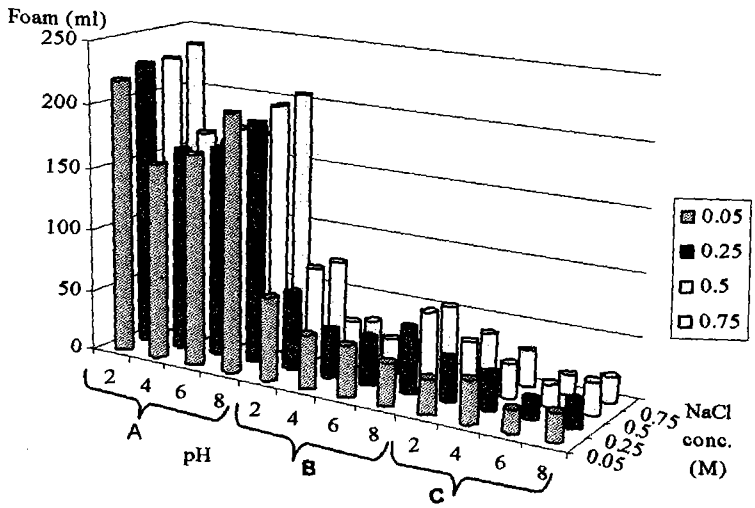


Figure 3: Effect of NaCl concentration on the foam capacity of jackfruit seed flour at different pH

Table 4 : Gelation capacity of jackfruit seed flour in water at different protein concentration

Protein concentration (g / 100 ml)	Gelation capacity in water		
	Raw	Blanch	Alkaline
2	-	-	-
4	-	-	-
6	+ + -	+ -	+ -
8	+ + +	+ -	+ -
10	+ + +	+ -	+ + -
12	+ + +	+ + -	+ + -
14	+ + +	+ + -	+ + -
16	+ + +	+ + -	+ + +
18	+ + +	+ + -	+ + +
20	+ + +	+ + +	+ + +

* Values are means of triplicate samples
* Symbols : - no gelling, +- some floccules, ++- almost homogenous gel, +++ complete gelation

Table 5 : Emulsifying activity and emulsion stability of jackfruit seed flour

Flour sample	NaCl conc. (g/100ml)	Emulsifying activity	Emulsion stability (ml)
Treatment A	0.05	1.028 $\pm$ 0.044	-
	0.25	1.492 $\pm$ 0.189	1
	0.50	1.876 $\pm$ 0.247	3
	0.75	2.068 $\pm$ 0.164	-
Treatment B	0.05	0.192 $\pm$ 0.019	4
	0.25	0.169 $\pm$ 0.005	6
	0.50	0.223 $\pm$ 0.040	10
	0.75	0.119 $\pm$ 0.038	16
Treatment C	0.05	0.365 $\pm$ 0.013	5
	0.25	0.228 $\pm$ 0.047	7
	0.50	0.222 $\pm$ 0.014	12
	0.75	0.267 $\pm$ 0.045	20

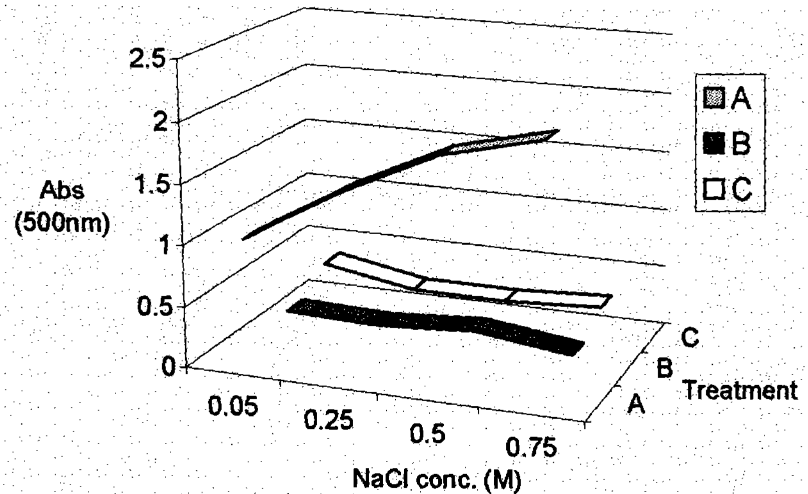


Figure 4 : NaCl concentration effect on the emulsifying activity of jackfruit seed flour at pH 6.4

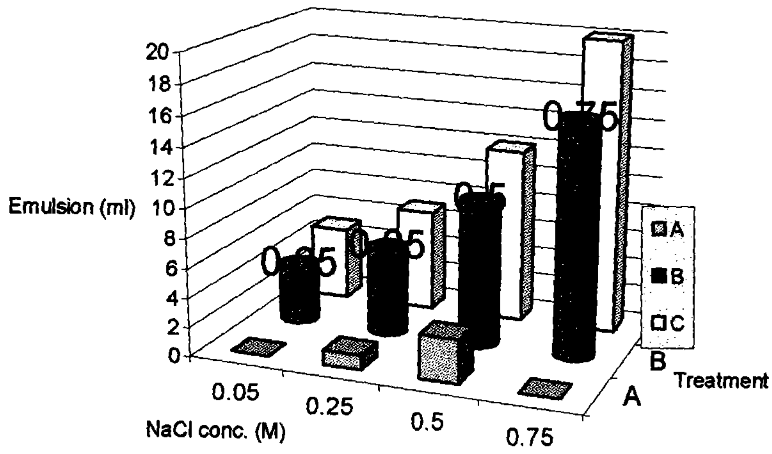


Figure 5 : NaCl concentration effect on the emulsion stability of jackfruit seed flour at pH 6.4

KESAN PENAMBAHAN TEPUNG BIJI NANGKA (*Artocarpus heterophyllus*) KE ATAS SIFAT FIZIKO-KIMIA, ORGANOLEPTIK DAN NILAI PEMAKANAN ROTI

Oleh

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EFFECT OF ADDITION OF JACKFRUIT SEED FLOUR (*Artocarpus heterophyllus*) ON THE PHYSICO-CHEMICAL PROPERTIES, ORGANOLEPTIC AND NUTRITIONAL VALUE OF BREAD

ABSTRACT

Bread was incorporated with different levels of jackfruit seed flour (10, 20, 25 and 30%) and evaluated for physicochemical, nutritional and organoleptic properties. Proximate, nutritional and functional properties of jackfruit seed and jackfruit seed flour (JSF) were also investigated. Result indicated that jackfruit seed and its flour are good sources of carbohydrate, protein, dietary fibre, amino acid and mineral but low in fat content. Incorporation of JSF (10-30%) in bread significantly increased ($p<0.05$) the moisture and crude fibre content but significantly decreased ($p<0.05$) the protein, fat, carbohydrate and caloric value. Jackfruit seed has more insoluble fibre (IDF) than soluble fibre (SDF) content. Result indicated that increasing level of JSF in bread from 10-30% significantly increased ($p<0.05$) the TDF (2.83-12.84%), IDF (1.78-7.53%) and SDF (1.05-5.31%) content. Jackfruit seed contain 2.38% resistant starch (RS) but increased to 3.33% when processed into flour. Addition of JSF in bread significantly increased ($p<0.05$) the RS content (1.12-4.58%). Jackfruit seed was indicated to be high in amino acid such as methionine (35.31 mg/100g), threonine (64.73 mg/100g), arginine (47.31 mg/100g), histidine (41.87 mg/100g) and glutamic acid (32.03 mg/100g). The addition of JSF increased the arginine, leucine, methionine, phenylalanine, threonine and lysine in bread. Potassium (620.14 mg/100g) and phosphorus (1122.98 mg/100g) were found to be high in jackfruit seed but in bread, levels of minerals such as Zn, Ca, Na, Mg, K and P increased significantly ($p<0.05$) with different levels of JSF (10-30%). Trypsin inhibitor content of jackfruit seed was 229 TIU/100g but was reduced to 104 TIU/100g in the flour form. SEM

of jackfruit seed showed the presence of various sizes and forms of starch granules that were gelatinized after heat treatment. Jackfruit seed and JSF have high sucrose but low in glucose and fructose content. Jackfruit seed and JSF were low in oligosaccharides content. Raffinose and verbascose were undetected in jackfruit seed, JSF and breads. The loaf volume (870-750 ml), specific volume (3.66-3.25 cm^3) and oven spring (1.60-0.64 cm) were found to decrease with increasing level of JSF. Increasing levels of JSF increased the hardness, chewiness, cohesiveness, gumminess, adhesiveness and crumb colour. Overall acceptability showed that Bread II (20% JSF) was the highest in acceptability (6.80) as compared to other samples and the control.

KESAN PENAMBAHAN TEPUNG KOMPOSIT DAN PENGGANTIAN LEMAK KE ATAS PARAMETER KUALITI MUFIN

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THE EFFECTS OFSUBSTITUTION OF COMPOSITE FLOUR AND FAT REPLACER ON PARAMETERS QUALITY OF MUFFINS

ABSTRACT

Different levels (10% and 20%) of jackfruit seed flour was substituted for wheat flour and 35% polydextrose was replaced for fat in muffins. The sample was then evaluated for physico-chemical, nutritional, organoleptic and keeping quality of muffins at ambient (30±2°C) and frozen (-18±2°C) temperatures. Substitutions of jackfruit seed flour and polydextrose increased the specific gravity and decreased the viscosity of batter. The pH value of batters ranged from 6.50-6.70. Physical characteristics (height, volume and specific volume) of muffins were reduced significantly ($p<0.05$) with addition of jackfruit seed flour. The Colour of crumb and crust was observed to reduce L and hue values and increased a and b value with addition of jackfruit seed flour. Muffins with added jackfruit seed flour (10TBN, 10TBN+P, 20TBN, 20TBN+P) showed significantly high ($p<0.05$) in moisture, protein, ash and crude fibre content than control muffins (K, K+P). Muffins with the present of polydextrose (K+P, 10TBN+P, 20TBN+P) indicated reduction in fat content (26-38%) and increased in carbohydrate (83.61-83.85%) content significantly ($p<0.05$). Baking process indicated an increased in dietary fibre and resistant starch content of muffins. Results showed significant increase for total dietary fibre (6.51-8.20%), insoluble dietary fibre (4.65-6.33%) and resistant starch (4.40-6.71%) in muffins with addition jackfruit seed flour. Addition of jackfruit seed flour in muffins reduced the

stachyose and raffinose composition significantly ($p<0.05$) as compared to the control. The stachyose content was undetected in muffins with polydextrose. Mineral content such as K, Ca, Mg and Cu indicated significantly increased ($p<0.05$) in muffins with added jackfruit seed flour. Images from SEM, showed that starch granules from batters with polydextrose was not seen clearly and those from crumbs with added jackfruit seed flour exhibited higher degree of gelatinization as compared to the controls (K and K+P) muffins. The sensory results indicated that all muffins were not significantly different ($p\geq0.05$) and acceptable. Staling parameter studied (a_w, moisture content, soluble amylose and texture) showed the rate of muffins staling was slower at frozen temperature as compared to ambient temperature.

PENGHASILAN MINUMAN KOKO DARI BIJI NANGKA

(*Artocarpus heterophyllus*)

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ABSTRACT

The composition of blanched and raw jackfruit flour (*Artocarpus heterophyllus* Lam.), the viability as one of the ingredients in chocolate milkshake drink and its functional properties as a beverage were investigated. Proximate analysis were done with blanched and raw jackfruit flour. The functional properties investigated for this beverage is the foaming capacities, emulsification activities and emulsification stability. Results showed that the chocolate milkshake is more palatable with the incorporation of blanched jackfruit flour as an ingredient as compared to raw jackfruit flour. Total dietary fiber was conducted on raw and blanched jackfruit flour, controlled chocolate milkshake and the drink with blanched jackfruit flour. The functional properties in the controlled chocolate milkshake and the chocolate milkshake containing blanched jackfruit flour were determined. The total dietary fiber in raw jackfruit flour is 5.86 % as compared with 6.44 % in blanched jackfruit flour. In the controlled chocolate milkshake, the total dietary fiber is 3.64 % as compared with 5.16 % in chocolate milkshake containing blanched jackfruit flour. The foaming capacity after 15 minutes for the chocolate milkshake with blanched jackfruit flour is 57.5 % and after its been left standing for 1 hour, it was 45.00 %. Emulsification capacity for the beverage containing blanched jackfruit flour was 53.99 % and its emulsification stability at 80°C for 30 minutes was 44.46 %.