QUALITY CHARACTERISTICS OF NUTRITIONALLY ENRICHED MUFFINS PRODUCED FROM PLANTAIN-WHEAT COMPOSITE FLOURS

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INTRODUCTION

Muffins have become one of the most desirable snacks for both youth and elderly people due to their low manufacturing cost, more convenience, long shelf-life and ability to serve as a vehicle for important nutrients. Most developing countries are importers of wheat flour and they are totally dependent on foreign countries for their bakery production. The possibility of using starchy staples for dough making depends on the physical and chemical properties of the baked product. Efforts have been made to promote the use of composite flours in which flour from locally grown crops replace a portion of wheat flour for use in bakery products, thereby decreasing the demand for imported wheat while producing nutritious bakery products. In Sri Lanka, plantains are a widely growing important food crop and are sources of income for subsistence farm families. There has been an increasing trend towards large-scale production of plantains. The plantain has a high carbohydrate content (35g/100g) and low fat (0.4 g/100g) content. They are good sources of vitamins and minerals, particularly iron (24 mg/kg), potassium (9.5 mg/kg), calcium (715mg/kg), vitamin A, ascorbic acid, thiamine, and niacin (Akingbala, *et al*., 2007). Green banana flour is a low-cost ingredient for the food industry and is an alternative to minimizing the postharvest losses of plantain. The new economical strategy to increase utilization of plantain includes the production of plantain flour when the fruit is unripe, and to incorporate the flour into various innovative products such as slowly digestible muffins, biscuits, high-fibre bread and edible films. The clear advantage presented by green plantain flour includes a high total starch, resistant starch and dietary fibre content. Experiences gained in the use of composite flours has demonstrated that for reasons of both product technology and consumer acceptance, wheat is an essential component in many of these flours (Giami *et al*., 2004). The percentage of wheat flour required to achieve a certain effect in composite flours depends heavily on the quality and quantity of wheat gluten and the nature of the product involved (Smith *et al.*, 1998). Plantain flour contains no gluten and consequently cannot be used solely for making muffins. When plantain flours are used, a limit of substitution level with wheat flour was necessarily imposed on the extent to which the plantain flour could be used as a substitute for wheat flour in muffins. This investigation evaluated the nutritional, functional and sensory properties of muffins made from various proportions of wheat-plantain composite flours.

METHODOLOGY

Matured green plantains (*Musa paradisiaca cv. Green Java*) were purchased from the commercial farm of the Department of Agriculture. The wheat flour used was white milled grain imports from USA by the Prima Flour Mills.

SAMPLE PREPARATION

Plantain heads were cut into separate bunches which were subsequently de-fingered. The fingers were washed, peeled, cut into thin slices of 5 mm diameter and blanched in 1.25% $NaHSO_3$ solution at 80°C for 5 min to prevent the darkening of tissues due to enzymatic browning. Blanched plantain slices were drained and dried in an air re-circulation oven at 60°C for 24 hours. Dried plantain slices were milled into flour in a

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Food Hammer mill (BH 2310). The flour obtained was sifted through a 250 μm aperture sieve and packed in medium density (20 μm thickness) polythene bags. Composite flour samples containing wheat and plantain flours were formulated at 0, 10, 30 and 50% (w/w) level of wheat flour substitutions for making the muffins. A digital weighing balance (Metler-3200) and a blender (Philips, HR 1500) were used for weighing and mixing the flours respectively.

INGREDIENTS AND MEASUREMENTS USED FOR MUFFINS

Composite flour - 250g; Granulated sugar - 200g; Baking powder - 1 Tbsp; Salt - ½ tsp; Whole milk - 1 cup; Vanilla extract - 1 tsp; Egg - 1 large (or 2 medium); Butter or shortening - 1 Tbsp.

The following treatment combinations of plantain – wheat flour muffins were developed.

T_1– Muffin produced from flour of 100% wheat

T_2 – Muffin produced from composite flours of 90% wheat and 10% Plantain

T_3 – Muffin produced from composite flours of 70% wheat and 30% Plantain

T_4 – Muffin produced from composite flours of 50% wheat and 50% Plantain

PREPARATION

The oven was pre-heated to 200°C. The composite flour, baking powder and salt were mixed and sieved thrice. The eggs were beaten in a separate bowl and the sugar, milk and vanilla were added to the egg. The muffin pan was thoroughly greased with butter. The melted butter was poured into the egg-vanilla-milk mixture and stirred well. This mixing process was repeated 3-4 more times, until all the ingredients were incorporated. The batter was poured into the prepared greased muffin pan and baked for 20 minutes.

PHYSICO-CHEMICAL ANALYSES OF MUFFINS

The physico-chemical properties of the developed muffins were investigated. The bulk density of the sample was determined by weighing the sample (100 g) into 200 ml graduated cylinder, tapping cylinders ten times against the palm of the hand and expressing the final volumes as g/ml. The Stevenson's Micro Texture Analyzer was used to determine the force involved in the compression of 2 cm core sample of the muffins. Nutritional analyses of the samples were carried out using official AOAC methods (2000) for moisture (14.004), fibre (7.0006) and ash (14.006). Soluble carbohydrate was calculated by difference. Major elements were quantified by the Atomic Absorption Spectro-photometer (Model-CARYO 2231-D, USA).

SENSORY EVALUATION

Sensory evaluation was performed 12 hours after baking to evaluate the shape, aroma, internal texture, taste and overall acceptability of the muffins. The samples were cut into pieces and served. Twenty trained panel members were randomly selected to perform the organoleptic evaluation. The panelists evaluated the samples using a 9 point hedonic scale with 9 - liked extremely and 1 - disliked extremely.

STATISTICAL ANALYSES

Data obtained in physico-chemical analyses were subjected to Analysis of Variance and mean separation was done with Duncan's Multiple Range Test (DMRT). Descriptive statistics was done on sensory attributes and the means were compared using the Tukey's test ($p<0.05$).

RESULTS AND DISCUSSION

The results of the physico-chemical characteristics of the muffins made from the plantain-wheat composite flour are shown in Table: 1. The lowest value for bulk density of 0.31 g/cm^3 was observed in 100% wheat flour muffins while the highest value of 0.47 g/cm3 was

recorded in 50% plantain flour substituted product. The bulk density of the muffins made with 30% plantain flour was 0.42 g/cm^3.There was no significant differences ($p<0.05$) in relation to bulk density in all the muffins samples made with different percentages of plantain flour. Ogunjobi and Ogunwolu (2010) reported that the bulk density for cake made from 30% cassava flour was 0.49 g/cm^3. Therefore, the bulk density of the muffins supplemented with plantain flour was within the acceptable level and may not have had adverse effect on the quality attributes of the product.

Table 1: Physico-chemical properties of Plantain – wheat composite flour muffins

Treatments	Bulk density (g/cm^3)	Volume (cm^3)	Texture (g)	Moisture (%)	Soluble solids (%)
T_1	0.31 ± 0.001^a	121 ± 7.7^a	443.5 ± 27.7^a	12.6 ± 0.01^a	9.01 ± 0.16^a
T_2	0.38 ± 0.003^a	112 ± 5.8^a	514.6 ± 17.7^{ab}	11.5 ± 0.01^a	8.75 ± 0.20^a
T_3	0.42 ± 0.001^a	102 ± 4.3^{ab}	595.3 ± 15.7^b	$10.9 \pm 0.^{02ab}$	7.56 ± 0.17^{ab}
T_4	0.47 ± 0.004^{ab}	94 ± 5.1^b	645.6 ± 20.7^c	9.4 ± 0.03^{ab}	6.98 ± 0.24^b

The values are means of three replicates $\pm$ standard error.
The means with the same letters are not significantly different from each other at 5% level on DMRT.

The texture, fibre and mineral contents of the plantain flour supplemented muffins increased with progressive increase in the proportion of plantain flour, with 30% having the values of 595.3 g, 2.14% and 3.56% respectively, while lowest values were recorded for the whole wheat muffins. The increased fibre and mineral contents at downstream dilutions of wheat flour suggest that at higher dilution levels the coarse plantain flour enhanced the fibre and mineral contents of the mixtures. There was no significant differences ($p<0.05$) in relation to moisture content in all the muffins samples made with different percentages of plantain flour. The average moisture content value of the muffins made with 30% plantain flour was 10.9%. Plantain flour has a good potential for use as a functional agent in bakery products on account of its high water absorption capacity. Ogunjobi and Ogunwolu (2010) reported that the total moisture content for cakes and muffins should not exceed 14% and that 11% is the best. Therefore, the moisture contents of the muffins supplemented with plantain flour were within the acceptable level and may not have had an adverse effect on the quality characteristics.

As shown in Figure: 1, the fibre content of the muffins increased with the increase in the substitution of the plantain flour from 1.87% in the control sample to 2.30% in the muffins with the 50% plantain flour. The findings are in agreement with Eddy (2004). This is due to the higher fibre content of plantain flour compared to wheat flour and fibre content of the composite samples which was higher than those of 100% wheat flour. The plantain flour contains high amounts of resistant starch which possesses fibre like qualities and aids in digestion, reducing blood sugar and cholesterol levels. The soluble solid of the plantain flour supplemented muffins and the whole wheat flour muffins range between 6.98 and 9.01%, with the wheat flour muffins recording the highest value.Muffins made with 100% wheat flour contained 16.27, 94.58, 1.30 and 153.56 mg/100g for calcium, potassium, iron and phosphorus respectively. Meanwhile, at the level of 30% of replacement, they increased to 29.87, 124.2, 2.52 and 181.7 respectively.

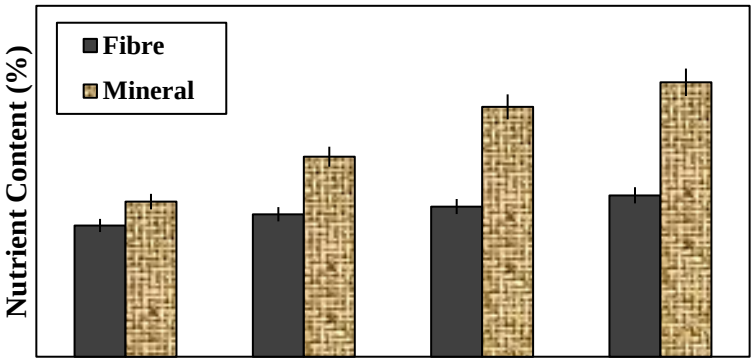

Figure: 1 Fibre and mineral content of the muffins made from Plantain-Wheat composite flours

T_1– Muffin produced from flour of 100% wheat; **T_2** – Muffin produced from composite flours of 90% wheat and 10% Plantain; **T_3** – Muffin produced from composite flours of 70% wheat and 30% Plantain; **T_4** – Muffin produced from composite flours of 50% wheat and 50% Plantain

ORGANOLEPTIC QUALITIES

The sensory scores of the muffins prepared from the different proportion of composite plantain – wheat flour are shown in Table: 2. Tukey's Studentized test was done to compare the means differences.

Table 2: Sensory scores of the muffins made from plantain – wheat composite flour

Treatments	Shape	Aroma	Internal Texture	Taste	Overall acceptability
T_1	8.85 ± 0.08^{a}	8.81 ± 0.3^{a}	8.70 ± 0.18^{a}	8.77 ± 0.28^{a}	8.75 ± 0.08^{a}
T_2	8.68 ± 0.02^{ab}	8.65 ± 0.2^{a}	8.59 ± 0.17^{a}	8.64 ± 0.26^{a}	8.63 ± 0.02^{ab}
T_3	8.51 ± 0.20^{b}	8.47 ± 0.1^{ab}	8.48 ± 0.01^{ab}	8.50 ± 0.22^{a}	8.58 ± 0.20^{ab}
T_4	8.25 ± 0.15^{c}	8.30 ± 0.2^{ab}	8.29 ± 0.01^{b}	8.29 ± 0.04^{a}	7.85 ± 0.15^{b}

The values are means of three replicates $\pm$ standard error. Means in the same column followed by different letters are significantly ($P \leq 0.05$) different.

The sensory evaluation showed that no significant ($p > 0.05$) differences were observed between the whole wheat flour muffins and the 30% plantain flour supplemented product in the sensory attributes of aroma, internal texture, taste and overall acceptability, but differences were significant ($p \leq 0.05$) in shape, appearance and crust texture.

Highly acceptable crust texture was obtained for whole wheat flour muffins while it was low for 50% plantain flour muffins. The importance of the protein level was due to its gluten fraction in that gluten was responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide generated during baking. When gluten coagulated under the influence of heat during baking, it served as the framework of the loaf, which became relatively rigid and did not collapse. Plantain flour contains no gluten and consequently cannot be used solely for muffins. When used, however, a limit of substitution level with wheat flour was necessarily imposed on the extent to which the flour could be used as a substitute for wheat flour for cakes and muffins. Similar findings were reported by

Nwaojigwa *et al* (2007) that the cake made from plantain- wheat flour was acceptable up to 30% supplementation level based on the sensory attributes.

CONCLUSIONS

This research was carried out to reduce wastage and improve the utilization of plantains. Wheat flour could be substituted with plantain flour in the manufacturing of nutritious muffins. Therefore, muffins with comparable nutritional level could be produced with plantain – wheat composite flour up to the substitution level of 30% plantain flour. The sensory qualities showed that the muffins supplemented with 30% plantain flour are well acceptable in terms of aroma, internal texture, taste and overall acceptability. Hence, the 30% plantain flour substituted muffins had comparable nutritional and sensory qualities to the whole wheat flour muffins. The plantain flour exists as a resistant starch which greatly lowers its glycemic index rating and contributes to digestive health and is helpful for diabetics or any others needing to choose low sugar foods. The broader economic benefits accruing from the processing of plantain fruit into flour and its use in bakery products include employment opportunity, savings in foreign exchange and stimulus to home agriculture.

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