# CARIBBEAN FOOD CROPS SOCIETY

# 45

## Forty Fifth

## Annual Meeting 2009

Frigate Bay
Federation of St. Kitts and Nevis

Vol. XLV
Number 2

PROCEEDINGS

OF THE

45th ANNUAL MEETING

Caribbean Food Crops Society
45th Annual Meeting
July 12 to 17, 2009

St. Kitts Marriot Resort and Royal Beach Casino
Federation of St. Kitts and Nevis

**"Reality and Potential of Food Security and Agricultural Diversification in Small Island Developing States"**

**"Realidad y Potencial de la Seguridad Alimentaria y la Diversificación Agrícola en Pequeños Estados Insulares en Desarollo"**

**"Securité alimentaire et diversification agricole dans les petits états insulaires en développement: realizations et perspectives"**

Edited by Wanda I. Lugo and Wilfredo Colón

Published by the Caribbean Food Crops Society

**ISSN 95-07-0410**

Copies of this publication may be obtained from:

Secretariat, CFCS
P.O. Box 40108
San Juan, Puerto Rico 00940

**Proceedings of the Caribbean Food Crops Society. 45: 128-135. 2009**

# EFFECT OF CULTIVAR AND MATURITY ON YIELD AND NUTRIENT COMPOSITION OF BREADFRUIT (*ARTOCARPUS ALTILIS*) FLOUR

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**ABSTRACT:** Breadfruit, a versatile tree crop predominately used for its nutritious and starchy fruit, is commonly consumed among West Indian people. Because of its seasonality and short-shelf life, there is a need for an economical method of extending its availability. One such process is through the production of breadfruit flour. However, detailed information is needed on the nutrient profile of the flour. More research is needed in order to determine whether there are cultivar differences; previous research has been limited to one un-named cultivar at one stage of maturity. The objective of this study was to determine the influence of cultivar and maturity on the yield and nutrient composition of breadfruit flour. Four breadfruit cultivars, Jackson Macca (JM), Kashee Bread (KB), Local White (LW) and Local Yellow (LY), growing in the germplasm collection of the University Field Station, Valsayn, Trinidad, were evaluated for flour yield and nutrient composition. The fruits were harvested at the immature and mature stages. The flesh was sliced 5 mm thick, dried at 60° C for 24 hours, milled and sieved (0.60 mm). Proximate analyses were done in triplicate and according to the AOAC methods (1990). There were no significant differences in the fresh weights of the four selected cultivars. However, there were significant differences ($p<0.05$) in yield, dry matter, ash, crude protein, ether extract, dietary fibre, carbohydrates, calcium, magnesium, and iron content of the breadfruit flours. Cultivar JM showed the highest yield (46.5±1.4%) in addition to the highest levels of crude protein (5.5±0.4 g/100 g), ether extract (1.6±0.1 g/100 g) and carbohydrates (71.7±0.3 g/100 g). There were significant differences between dry matter (91.8±0.3 g/100 g immature; 90.9±0.2 g/100 g mature) and carbohydrates (67.9±0.8 g/100 g immature; 69.9±0.4 g/100 g mature). This finding illustrates that as the fruit matures, there is an increase in moisture and in carbohydrate content. This increase may be partly due to metabolic water and the bulking up of starches and sugars within the fruit as it matures. The knowledge of the nutrient composition of breadfruit flour is necessary for the production of acceptable food products which satisfy the nutritional needs of consumers, leading to increased use of breadfruit and thereby contributing to sustainable agriculture and food security.

Keywords: Breadfruit, Flour, Nutrient composition

## INTRODUCTION

In the Caribbean and Latin America, there is escalating chronic disease due to an increasing reliance on nutrient-poor, imported, processed foods (Bermudez and Tucker, 2003). However, the region is home to a variety of local food crops, many of which have not yet been assessed for nutritional content (Dignan et al., 2004) but which could contribute to improved lifestyles and food security.

In 2006, breadfruit was one local crop that was recognized by the UN/FAO as a priority commodity for food security and was listed as a species to be covered by the International Treaty on Plant Genetic Resources, a treatise which aims at the conservation and sustainable use of genetic resources for food security and agriculture. It has been further described as an important staple food of a high economic value (Soetjipto and Lubis, 1981).

The breadfruit, *Artocarpus altilis* (Parkinson) Fosberg, originated in the Western Pacific, with New Guinea and associated islands such as the Bismarck Archipelago being the centre of diversity for wild-seeded forms of *Artocarpus altilis* (Parkinson) Fosberg. Other vernacular names of the breadfruit (English) include arbre á pain (French), árbol del pan (Spanish), uto/kulu (Fiji), ulu (Hawaii, Samoa) and uru (Tahiti). Few-seeded and seedless forms occur throughout the Pacific Islands, with the greatest diversity found in the eastern pacific in Polynesia (Ragone, 1997). The first major introduction of breadfruit to the Caribbean was made by Captain William Bligh who landed six hundred plants representing five cultivars as a carbohydrate staple into St. Vincent and Jamaica via the H.M.S Providence in 1793. Most plants were of the seedless variety and had been obtained from Tahiti (Powell, 1976). It was from St. Vincent and Jamaica that breadfruit subsequently spread throughout the remainder of the Caribbean.

Within the Caribbean region, breadfruit is widely grown as a versatile tree crop and is predominately used for its nutritious, starchy fruit (Ragone, 1997). Compared with other starch crops, breadfruit provides comparable levels of carbohydrates and is a better source of protein than cassava (*Manihot esculenta*) and equivalent to banana (*Musa* spp.) and sweet potato (*Ipomea batatas*) (Graham and Negron de Bravo, 1981). Since its introduction in the eighteenth century, it has gradually become an accepted food and important component of the daily diet (Powell, 1977). At present, breadfruit has a relatively high consumption rate among West Indian people, especially within rural areas (Roberts-Nkrumah, 1993). However, breadfruit usage is subject to several constraints, including:

1. Tree height
2. Seasonality of fruit (Ferguson, 1981)
3. Short shelf-life
4. Very limited germplasm (Roberts-Nkrumah, 1998)

Availability is therefore an issue and so there is a pressing need for an economical method of preservation. Within the Caribbean, breadfruit flour has been produced as one method of preservation but only on a single unidentified cultivar. It is recognized that the use of breadfruit flour as an alternative flour is by a general lack of information on the characteristics of the flour. To explore the end-use of breadfruit flour, there is a need for information on the effect of cultivar and maturity on yield of flour and nutrient composition. Therefore, the objectives of this study were to determine the influence of cultivar and maturity on the yield and nutrient composition of breadfruit flour.

## MATERIALS AND METHODS

*Harvesting and selection of breadfruit:* Fruits were harvested from UWI Field Station's breadfruit germplasm collection. Fruits were harvested in the early morning, allowed to cool off from remove field heat, and then transported directly to the laboratory for processing. Four cultivars were selected on the basis of availability: Jackson Macca (JM), Kashee Bread (KB), Local White (LW) and Local Yellow (LY). Two stages of maturity were utilized: immature and mature (Ragone and Wiseman, 2006). Immature fruit tends to be greener in colour with little or no latex stains on the skin; has no separation of sections; has a very thin layer of pale green directly under the skin and tends to produce abundant latex when cut. Flesh does not discolour easily. The mature fruit shows scabbing on skin, slight separation of the sections with splotches or streaks of dried latex. Skin may show some yellowing and does not give when pressed; the flesh is firm and tightly affixed to the stem and core. The pulp shows little or no discolouring when cut; very little sap exudes from detached stem (Ragone and Wiseman, 2007; Graham and Negron de Bravo, 1981).

*Production of breadfruit flour:* For the production of flour, the breadfruit was sliced 5 mm thick and dried in a 60º C oven for 24 hours. The dried breadfruit was then milled and sifted through a 0.60 mm sieve and stored (CODEX STAN 176-1995 for Cassava Flour).

*Determination of yield:* Yield was determined for edible portion, skin, core, peduncle and flour and was calculated as follows:

Yield = (weight of specified portion)/ weight of whole fruit) * 100

Flour yield (%) from edible portion and from whole fruit was also determined.

*Physicochemical Composition:* Proximate analyses were done in triplicate and according to the AOAC (1990) methods to determine dry matter, ash, protein (N*6.25), lipids, dietary fibre, carbohydrates (by difference) and selected minerals.

*Statistical Analyses:* Minitab 15 Statistical Software was used to analyze yields and physicochemical characteristics from the cultivars at two different maturities. ANOVA was used to determine differences.

**RESULTS**

Table 1 shows that the whole fruit yielded a high of 34.0% flour from JM and a low of 19.5% flour from KB. From the edible portion, the highest yield was obtained from JM (46.5%) whereas a low of 28.8% was obtained from the edible portion of the LY cultivar. Thus 1.0 kg fruit (edible portion only) is expected to yield a high of 465 g flour and a low of 288 g. This illustrates that there is a considerable amount of wastage from the whole breadfruit. However, most of the wastage is incurred from the inedible portions of the breadfruit. Mayaki et al. (2003) reported a 43.9% flour yield from the pulp of an unripe breadfruit (no cultivar stated).

Table 1: Effect of cultivar on yield of breadfruit flour

| | Cultivar | | | | |
|---|---|---|---|---|---|
| Parameter | JM | KB | LW | LY | P |
| Fresh fruit (g) | 1558.8±60.7 | 1354.5±90.6 | 1451.3±48.8 | 1502.4±116.1 | N.S |
| Edible portion (%) | 72.9±2.2 | 66.9±6.0 | 74.8±3.0 | 73.3±2.4 | N.S |
| Skin (%) | 17.8±1.3 | 22.0±2.9 | 17.5±1.4 | 16.8±1.8 | N.S |
| Core (%) | 7.5±0.5 | 6.8±0.4 | 6.4±0.8 | 6.9±0.4 | N.S |
| Flour–edible portion (%) | 46.5±1.4$^{a}$ | 30.0±2.5$^{b}$ | 32.2±2.9$^{b}$ | 28.0±1.6$^{b}$ | 0.000 |
| Flour–whole fruit (%) | 34.0±1.7$^{a}$ | 19.5±1.7$^{b}$ | 23.7±1.7$^{b}$ | 20.4±1.7$^{b}$ | 0.000 |

- Values with the same letter are not significantly different (P<0.05)

Table 2: Effect of cultivar on nutritional and mineral composition of breadfruit flour

| | Cultivar | | | | |
|---|---|---|---|---|---|
| Parameter (g/100 g) | JM | KB | LW | LY | P |
| Dry matter | 90.7±0.3$^{a}$ | 92.3±0.4$^{b}$ | 91.8±0.2$^{ab}$ | 90.6±0.4$^{a}$ | 0.004 |
| Ash | 4.5±0.2$^{ac}$ | 3.3±0.1$^{b}$ | 4.1±0.1$^{c}$ | 4.8±0.1$^{a}$ | 0.000 |
| Crude protein | 5.5±0.4$^{a}$ | 4.1±0.1$^{b}$ | 4.3±0.1$^{b}$ | 4.9±0.1$^{ab}$ | 0.001 |
| Ether extract | 1.6±0.1$^{a}$ | 0.7±0.1$^{b}$ | 1.5±0.1$^{a}$ | 1.4±0.04$^{a}$ | 0.000 |
| Dietary fibre | 4.7±0.5$^{a}$ | 11.0±2.0$^{b}$ | 8.4±0.5$^{ab}$ | 8.4±0.8$^{ab}$ | 0.016 |
| Carbohydrates | 71.7±0.3$^{a}$ | 67.3±1.0$^{b}$ | 69.3±0.6$^{ab}$ | 67.5±0.4$^{b}$ | 0.000 |
| Calcium | 0.5±0.04$^{a}$ | 0.3±0.01$^{b}$ | 0.4±0.03$^{ab}$ | 0.5±0.02$^{a}$ | 0.001 |
| Magnesium | 2.0±0.05$^{a}$ | 1.4±0.04$^{b}$ | 1.2±0.14$^{b}$ | 2.0±0.1$^{a}$ | 0.000 |
| Sodium | 2.4±0.4 | 2.2±0.5 | 2.1±0.3 | 2.9±0.3 | N.S |
| Iron | 0.2±0.01$^{a}$ | 0.2±0.01$^{a}$ | 0.3±0.02$^{b}$ | 0.2±0.01$^{ab}$ | 0.014 |
| Potassium | 22.8±4.1 | 15.3±2.6 | 22.0±2.1 | 22.3±2.4 | N.S |

- Values with the same letter are not significantly different (P<0.05)

The nutrient analysis showed significant cultivar differences for dry matter, ash, crude protein, lipids, dietary fibre and carbohydrates (P<0.05). Cultivar JM showed the highest percentage of crude protein, lipids and carbohydrates (5.5±0.4, 1.6±0.1 and 71.7±0.3 g/100 g). The crude protein of the JM flour exceeded that reported for breadfruit flour by Mayaki et al. (2003) who gave a value of 4.3 g of protein per 100 g of flour. The protein and lipid values of the JM flour are less than those reported by Rincon and Padilla (2004), who reported 15.1 and 29.0 g/100 g, respectively. Research indicates that protein content influences flour yield (Metho et al., 1999). That is, the higher the protein content of the commodity, the lower the yield of flour. While the protein content of breadfruit flour appears to be low, it carries substantial value. Golden and Williams (2001) reported 30% of breadfruit amino acids as being essential amino acids such as leucine and lysine. These amino acids are not synthesized by the human body and so must be supplied in the diet, usually through plant material such as grains and legumes (Young and Pellet, 1994). Graham and Negron de Bravo (1981) reported breadfruit protein as being as good as sweet potato and better than cassava protein. Table 2 also shows that cultivar KB has the highest dietary fibre at 11.0 g per 100 g. Dietary fibre is essential in the fight against heart disease, colon cancer, diabetes and obesity. The Caribbean Food and Nutrition Institute (2006) reported 3.5 g dietary fibre per 100 g of boiled and roasted breadfruit. It is difficult to make further comparisons as most research investigated crude fibre instead of dietary fibre. There were significant cultivar differences in calcium, magnesium and iron (highest values being 0.5, 2.0, 0.3 g/100 g, respectively). It has been suggested that breadfruit is a good source of minerals for products such as baby foods (Nelson-Quartey et al., 2006). Mineral content of a commodity is largely influenced by genetics and environment (White and Broadly, 2005).

Table 3: Effect of maturity on breadfruit flour yield

| | Maturity | | |
|---|---|---|---|
| Parameter | Immature | Mature | P |
| Fresh fruit (g) | 1402.0±55.0 | 1531.5±60.4 | N.S |
| Edible portion (%) | 69.5±3.4 | 74.5±1.4 | N.S |
| Skin (%) | 20.5±1.6 | 16.6±1.0 | 0.047 |
| Core (%) | 6.7±0.5 | 7.0±0.3 | N.S |
| Flour from Edible Portion (%) | 35.2±1.9 | 33.1±2.8 | N.S |
| Flour from Whole Fruit (%) | 24.1±1.5 | 24.7±2.1 | N.S |

Maturity has no effect upon edible portion percentage or the flour yield percentage as seen in Table 3. An increase in the edible portion may have gone undetected because of the immature and mature breadfruits being too close in age when harvested (13 to 16 and 14 to 18 weeks, respectively).

The water and starch accumulation within the fruit may not have been significantly different, thus showing no distinctions in the percentage of the flour. It is seen that as the fruits matured, skin percentage decreased from 20.5±1.6 to 16.6±1.0. This decrease occurred because cell growth within the breadfruit exceeds skin growth.

Table 4: Effect of maturity on nutritional and mineral composition of breadfruit flour

| | Maturity | | |
|---|---|---|---|
| Parameter (g/100 g) | Immature | Mature | P |
| Dry matter | 91.8±0.3 | 90.9±0.2 | 0.037 |
| Ash | 4.3±0.2 | 4.0±0.2 | N.S |
| Crude protein | 4.9±0.3 | 4.6±0.1 | N.S |
| Ether extract | 1.4±0.2 | 1.2±0.1 | N.S |
| Dietary fibre | 9.4±1.1 | 6.9±0.9 | N.S |
| Carbohydrates | 67.9±0.8 | 69.9±0.4 | 0.030 |
| Calcium | 0.4±0.03 | 0.04±0.03 | N.S |
| Magnesium | 1.8±0.1 | 1.5±0.04 | N.S |
| Sodium | 2.1±0.2 | 2.6±0.3 | N.S |
| Iron | 0.2±0.02 | 0.2±0.01 | N.S |
| Potassium | 18.6±2.1 | 22.6±2.0 | N.S |

Table 4 illustrates that as the breadfruit matures, dry matter decreases (91.8, 90.9 g/100 g). However, carbohydrates increase (67.9 to 69.9 g/100 g). The reduction in dry matter may be brought about by an increase in moisture due to metabolic water (Amusa, 1992). The carbohydrate increase would have been the result of assimilation where there is an accumulation of starches within the fruit (Neilson, 2002). However, there is a need to investigate whether these carbohydrates are simple or complex as this factor can impact on shelf-life. It can also be concluded that maturity has no effect upon the mineral composition of breadfruit flour. The closeness in age of the immature and mature fruits may have made it difficult to detect subtle changes in mineral content. In addition, as stated before, mineral content is primarily influenced by genetics and environment.

Table 5: Effect of cultivar and maturity interaction on nutritional composition of breadfruit flour

| Parameter | P |
|---|---|
| Dry matter | N.S |
| Ash | 0.000 |
| Crude protein | 0.000 |
| Ether extract | N.S |
| Dietary fibre | N.S |
| Carbohydrates | 0.000 |
| Calcium | N.S |
| Magnesium | N.S |
| Sodium | N.S |
| Iron | N.S |
| Potassium | N.S |

For the effect of cultivar and maturity interaction on nutritional composition, significant differences were detected only for ash, crude protein and carbohydrates (see Table 5 and Figure 1). From immaturity to maturity, ash and crude protein (g/100 g) decreased in the flour from cultivars JM and KB while increasing in LW and LY. For carbohydrates (g/100 g), there was a decrease in the flour from cultivar JM from immaturity to maturity. However, the carbohydrates increased for cultivars KB, LW and LY from immaturity to maturity as a result of the interaction between cultivar and maturity.

## CONCLUSIONS

Cultivar and maturity affect some parameters of yield and nutrient composition of breadfruit flour. Cultivars differ significantly in flour yield, dry matter, ash, crude protein, lipids, dietary fibre, carbohydrates, Ca, Mg and Fe. Maturity did not influence flour yield or nutritional composition but caused significant differences in dry matter and carbohydrates because of metabolic water and growth (starch accumulation).

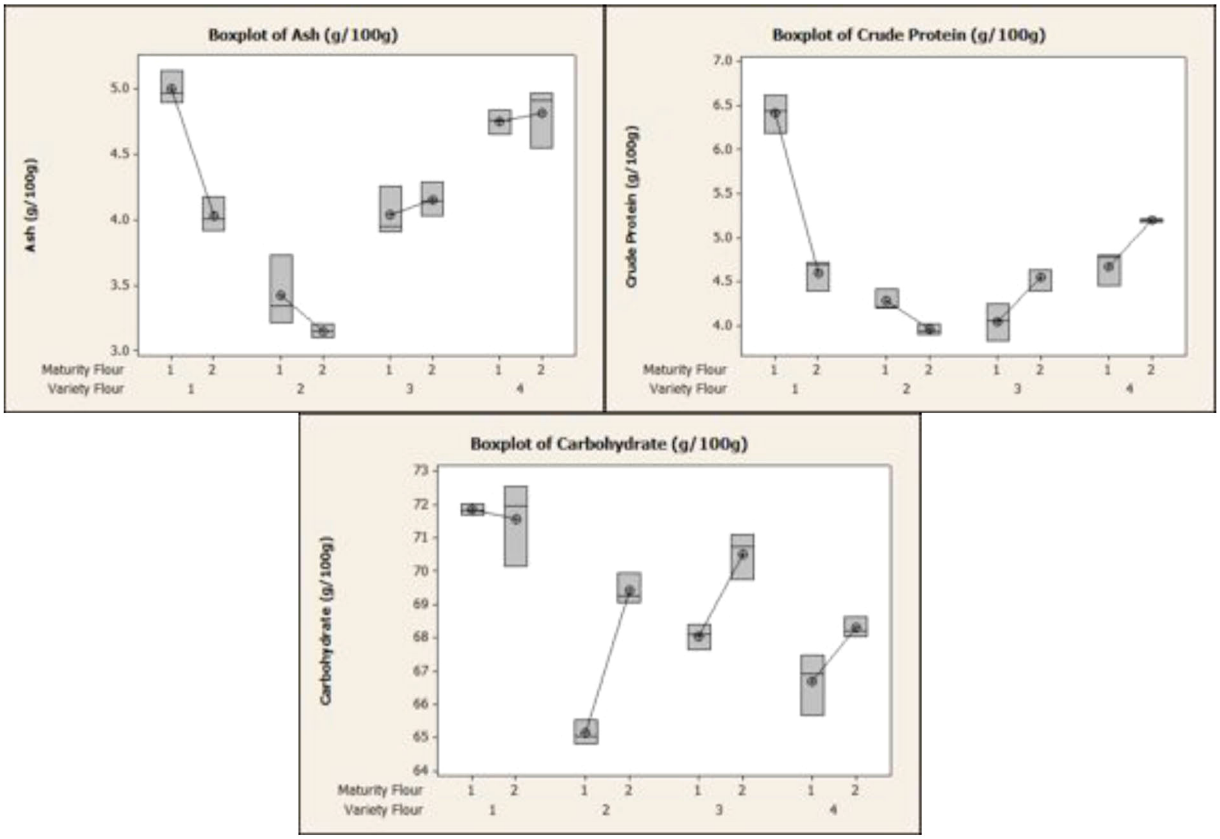


Figure 1: Box-plots illustrating the effect of interactions between cultivar and maturity on ash, protein and carbohydrates (g/100 g)
Note – Maturity: 1 = immature; 2 = mature; Cultivar: 1 = JM, 2 = KB, 3 = LW, 4 = LY

## ACKNOWLEDGEMENTS

The authors wish to thank Mrs. Radicka Seepersad and Mr. Erickson Bhudoo of the Department of Food Production, Faculty of Science and Agriculture, University of the West Indies, Trinidad and Tobago, for their technical support.

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