Review of Cassava and Wheat Flour Composite in Bread Making: Prospects for Industrial Application

Tajudeen Adebayo Adeniji

ABSTRACT

Cassava is emerging as a dominant staple of primary importance in many developing countries of the humid and sub-humid tropics in Africa and elsewhere. Nigeria is the largest producer of cassava in the world, while production has also increased over the past two decades in many African countries. This formidable production potential demands for a strategy for the development of Africa through cassava industrialisation under the auspices of New Partnership for Africa’s Development (NEPAD). This can be achieved through the emergence of many strong cassava-based industries with opportunities in commercial flour production for baking and confectioneries. The habit of eating bread has spread from the Mediterranean Basin throughout the world, thus making bread available in many urban centres in developing countries. The demand for bread (the most popular yeast-leavened product) is increasing globally. It is one of the least expensive and yet most important staple foods in the world. Flour is an important raw material in bread making. Processing of fresh cassava roots into flour improves product palatability, reduces the cyanide content of the processed products and facilitates fortification with other food products. The International Institute of Tropical Agriculture has developed several varieties of disease-resistant and high-yielding cassava. The trend in cassava production in Africa cannot be sustained without corresponding improvements in the diversification of their processing technology. The utilisation of cassava flour in bakery and confectionery products therefore requires upgrading to exploit its industrial potentials. The application of cassava flour as a partial replacement for wheat flour in bread making, biscuits, pastries, and snack foods could constitute an intervention programme in support of NEPAD and Millennium Development Goals of the United Nations initiative in achieving food security.

Keywords: bread, disease resistant, diversification, flour, utilisation

INTRODUCTION

Cassava (Manihot esculenta L. Crantz) is one of the most important food crops in the humid tropics, being particularly suited to conditions of low nutrient availability and able to survive drought (Burrell 2003). It was introduced into Central Africa from South America in the latter half of the 16th century by the Portuguese settlers (Nweke 1994), and presently it is widely cultivated in sub-Saharan Africa, and is considered to be a major staple food crop in Africa. Cassava may sustain several millions of people around the tropics (FAO 2006) where people are highly dependent on cassava for their daily diet. In Nigeria, it is the most important root crop in terms of food security, employment creation, and income generation for crop producing households (Ugwu and Ukpabi 2002).

In the early 1960’s, Africa accounted for 42% of world cassava production, and in the early 1990’s Africa produced half of world output, primarily because Nigeria and Ghana increased their production in flour. Nigeria, with an estimated annual production rate of 34 million metric tonnes per annum replaced Brazil as the world’s leading producer (FAO 1994). Cassava production has increased in Nigeria over the past two decades (Ugwu 1996) and also in Angola, Côte d’Ivoire, Congo, Kenya, Madagascar, Mozambique, Rwanda, Uganda and Zaire over the last decade (Ekanayake et al. 1997). FAO (2005) projections indicated that cassava production in Africa, which already represents 53% of the world cassava output, will continue to increase while production will be relatively stagnant in Asia and Latin America. It is expected that the African cassava production will reach 115 million tons in 2005 and 168 to 184 million tons by the year 2020 (FAO 2000).

The agro-processing sub-sector is an important source...
of agricultural contribution to national economic growth. The formulation of effective policy for agro-processing development in Africa will encourage cassava transformation with increased production and processing for local industrial uses and export markets. Cassava transformation involves a shift from production as a low-yielding famine-reserve crop to a high-yielding cash crop with diversification of its processing technology, especially in form of flour for baking and the need to develop such findings for food security, industrial and economic growth in Africa.

Cassava mosaic disease (CMD) has been identified as a major constraint to cassava production, which has reduced tuber yields by up to 79% (Ranomenjanahary et al. 1994). CMD is caused by African cassava mosaic virus (ACMV), a plant pathogenic virus of the family Geminiviridae that is transmitted by the whitefly (Thrips palmi). The African Journal of Plant Science and Biotechnology (2001) reported that estimated industrial cassava use was approximately 16% of cassava root production and was utilised as an industrial raw material in 2001 in Nigeria. Ten percent was used as chips in animal feed, 5% was processed into syrup concentrate for soft drinks and less than 1% was processed into high quality cassava flour. Part of the 84% estimate left was used in food formulation, a portion of which was lost in post harvest and wastes.

Bread is defined as a food of any size, shape or form and consists of dough confectionery made from flour and water, with or without other ingredients, which have been fermented by yeast or otherwise leavened and subsequently baked or partly baked (Asselbergs 1973). Principally, high quality breads in terms of large volume, good crust and crumb texture is produced from wheat flour (Okaka 1997). Leavened wheat bread has become a favourite food of many households in developing countries which may be attributed to increasing populations, urbanisation and changing food habits (Onabolu et al. 2003). However, the Nigerian government policy of 10% cassava flour in bread, biscuits and other confectioneries could help to sustain the production of cassava and restrict fund outflow for wheat imports (RMRDC 2004). This present review aims to document some of the research findings in cassava transformation for baking and the need to develop such findings for food security, industrial and economic growth in Africa.

**TRENDS IN CASSAVA RESEARCH**

Cassava mosaic disease (CMD) has been identified as a major constraint to cassava production, which has reduced tuber yields by up to 79% (Ranomenjanahary et al. 1994). CMD is caused by African cassava mosaic virus (ACMV), a plant pathogenic virus of the family Geminiviridae that may cause either a mosaic appearance to plant leaves, or chlorosis, a loss of chlorophyll (Moses et al. 2001). ACMV is transmitted by the whitefly (Thresh et al. 1998c).

The International Institute of Tropical Agriculture (IITA) has developed extensive research programmes on cassava with a focus on generating high-yielding and disease-resistant genetic material and agronomic practices suitable for use in Africa (IITA 1984). Forty three improved cassava varieties have so far been developed by IITA which are disease, pest, and drought resistant, early maturing, high yielding and low in cyanide content. These high yielding varieties will ensure uninterrupted and adequate national and regional production of cassava for food and industrial applications. Among the cassava varieties released to farmers are those with high starch and dry matter content which are suitable for high quality flour production. IITA is also concerned with the development of a permanent production system to replace intermittent shifting cultivation. This multidisciplinary approach includes the improvement of traditional processing of cassava as well as non-traditional processing and utilisation. The development of high-yielding varieties has encouraged the large-scale cultivation of cassava by farmers through IITA and various national programmes in the tropics. IITA, the National Root Crops Research Institute (NRCRI), Umudike, Nigeria and the Federal Institute of Industrial Research (FIIRO), Oshodi, Nigeria has the national mandate to research the genetic improvement, production, processing and utilisation of cassava and other root and tuber crops of economic importance in Nigeria. Through its Cassava Enterprise Development Project, IITA in partnership with NRCRI and other stakeholders, is working to support micro- and small-scale agro-processing activities in Nigeria.

Research into cassava utilisation has been motivated by concern for malnutrition among poor families (rural and urban) who depend on cassava as their dietary staple. Research conducted at IITA and Katholieke Universiteit Leuven (KUL), Belgium demonstrated the possibility of baking bread using cassava flour in combination with locally available ingredients (Onabolu et al. 1998). Preemptive management of virulent CMD in Nigeria is documented in the Annual Report of IITA in 2005. New CMD-resistant varieties are being currently disseminated in Nigeria and many parts of West and Central Africa (WCA) and East and Southern Africa (ESA) to improve cassava production, rural income and generate raw materials for local industries. The status of this dissemination project and cassava production, which was funded by Nigeria, IITA, USAID and Shell Petroleum Development Company of Nigeria was documented in the report of Ezedinim et al. (2004), IITA and Shell Petroleum Development Company of Nigeria.

Presently, the utilisation of cassava flour in bakery products, confectionery, and other food products is relatively new and insignificant compared to its potentials and wide opportunities (Sanni et al. 2006a). Simple and appropriate technology now exists for the application of cassava flour as a partial replacement for wheat flour in bread making, biscuits, pastries, and snack foods (Eggleston and Omoosa 1994; Onabolu et al. 1998; FIIRO 2003; Ako bundu 2006; Sanni et al. 2006a; Ukpabi 2006). To this end, the Nigerian government inaugurated a Committee on Cassava Export Promotion with a mandate to ensure increased production, processing, packaging, and export of cassava and cassava products to satisfy both domestic and export markets. The ultimate objective was to make cassava a major non-oil foreign exchange earner, employment generator, import substitutor, poverty alleviator, and ultimately, a substantial contributor to national food security. The promulgation into law, effective 1st July, 2006 of the mandatory inclusion of 10% cassava flour in bread produced in Nigeria is an important initiative towards cassava industrialisation. This intervention is anticipated to enhance the industrial utilisation of cassava for income generation, capacity building and food security in line with NEPAD and Millennium Development Goals of the United Nations.

**CHEMICAL COMPOSITION AND NUTRITIONAL VALUE**

Cassava is a cheap source of carbohydrate from a nutritional point of view and its food value lies in the starch content (80-90% on dry wet basis) of its root. The roots of currently available varieties of cassava are relatively low in eba, although Eba production and utilisation in Africa are derived from the leaves, which are a popular vegetable (Berry 1993). Detailed chemical composition of raw and processed cassava products, including flour, gari, eba, fufu, lafun and abacha has been reported (Adepoju et al. 2010; Adeniji 2011). Cassava is always combined with other nutritious foodstuffs, which enhance their nutritional value in terms of protein. For instance, thick paste such as eba, amala, and fufu made from cassava and supplemented with vegetable soup in Nigeria, Ghana and other African countries. Cassava root also contain cyanide, which is released from cyanogenic compounds (Spencer 1999). Cyanogenicity of cassava varies widely among different varieties (Bokanga 1994). Boiled or roasted cassava is consumed as snack with roasted groundnut, coconut, fish or meat. Traditional cassava salads are very good combinations of highly nutritious foodstuffs, e.g. atunabo (cassava noodles) and wet chips of cassava including tapioca are more than snacks.
Thus, the emphasis usually laid on protein deficiency of cassava is due to ignorance of the food habits in regions where cassava is eaten as major food. In actual practice, protein sources (and other nutrient sources) are not eaten in isolation but in combination with other foods whose nutrients supplement one another (Ihekornoye and Ngoddy 1985).

Breeding and processing of cassava for increasing nutritional value has been given serious consideration about 20 years ago (IITA 1992) because cassava products are rarely eaten alone, but in combination with relatively protein rich food such as fish, meat, beans or peas, and vegetable soup. Certain processing procedures, however, may result in the reduction or in the enhancement of the protein, vitamin or mineral content of the cassava roots. Fermentation through heating/stacking has an advantage over soaking or water expressing methods, as most of the nutrients in the roots are retained. One other nutritional advantage of fermentation by heating is that mould growth associated with it increases the protein content of the end product. Palm oil, which is rich in β-carotene, is often added during the roasting stage of toasted granule production (Hahn 1989).

**PROCESSING AND UTILISATION**

Cassava roots are the most perishable of the major root crops and deteriorate in air at ambient temperature in 3-4 days (CCDN 2003). Postharvest storage is therefore a major problem militating against its production, which necessitates rapid conversion of fresh roots into various finished products immediately after harvest. This constitutes a means of preserving the roots from deterioration while adding value to the fresh roots and facilitating transportation.

Cassava processing also helps to detoxify the root from cyanide, a poisonous chemical, which binds to an enzyme called cytochrome oxidase and stops its action in respiration, which is a key energy conversion process in the body (CCDN 2003). Cyanogenicity of cassava varieties, risk of exposure to cyanide and processing methods to detoxify cyanide from cassava food in Nigerian communities was reported in a study carried out by Oluwole (2008). Processing cassava roots into flour in Latin America dated back to as early as 2000 B.C. (Hahn 1997). The major uses of cassava in Nigeria (Philip et al. 2005; Adeniji 2011) include flour, which involves several unit operations, resulting in flour of different properties, which are used for domestic and industrial purposes. Other products include gari (creamy white granular flour with a slightly fermented flavour and slightly sour taste), lafun, chips, noodles, fufu, abacha, and pupuru (FIRO 2006a). Gari can only be made regularly shaped granules, usually soaked or cooked in water with the addition of sugar and or milk. Fresh roots may also be boiled and pounded to obtain fufu, which is popular in Ghana, and to some extent in Nigeria and Cameroon (Hahn 1997).

Improvement of cassava processing and utilisation techniques would greatly increase labour efficiency, productivity, incomes, and improve the lives of cassava farmers and the urban poor. This would also enhance the shelf life of products, facilitate transportation, raise marketing opportunities, and provide better nutrition. Processing is also anticipated to increase the efficiency of land use by releasing land after harvest for other crops or for fallow to sustain soil productivity. Processing reduces food losses and stabilises seasonal fluctuations in supply of the crop. Expansion of cassava processing is necessary to consolidate farmer's efforts and to create avenues for industrial production.

The numerous advantages of industrial utilisation of cassava (Barimalaa 1994; FIRO 2003) over traditional methods have been documented. Industrial production is adequate for Africa's teeming population and it is a time-saving venture, resulting in hygienic products, uniform in quality, with a longer shelf life and fairly lower level of cyanide. The high demand for calories in Nigeria and a strategic reserve in flour throughout the year enables industrialisation of the processes involved in flour production.

The diversification of cassava in various food processing and utilisation routes has been extensively documented (Onabolu et al. 1998; Sanni et al. 2006a). Some of the newly developed products include high quality flour (HQF), which is used in the formulation of bakery products and fritters. Cassava starch obtained from fresh roots has applications in salads, cream, flacks and buns. Cassava has been used successfully in the production of fritters, croquettes and doughnuts, while the leaves and tender shoots are consumed as a vegetable in the Democratic Republic of Congo, Sierra Leone, Nigeria and some other African countries. Cassava leaves contain about 7% protein on a fresh weight basis and a high level of lysine (Ekanyake et al. 1997) and are used in the preparation of different traditional dishes (Sanni et al. 2006).

**PRODUCTION OF HIGH QUALITY CASSAVA FLOUR**

A flow chart for the production of high quality cassava flour is presented in Fig. 1 based on the method described by Sanni et al. (2006a). In the processing of high quality cassava flour, there should be no fermentation. The production process should be completed within 24 h in order to obtain...
Fresh cassava root
↓
Washing
↓
Peeling
↓
Washing
↓
Grating
↓
Cassava mash
↓
Dewatering by pressing in clean bag
↓
Cake breaking
↓
Drying
↓
Milling
↓
Packaging

Fig. 1 A flow chart demonstrating the processing of High Quality Cassava Flour (HQCF) production.

In the past, bread was seldom made from any other crop other than wheat flour hence the term ‘wheaten bread’ has fallen out of use due to the emergence of composite bread technology. Composite can be regarded as two or more materials that are brought together to make a new product which is better than the individual component: better may mean improved properties or performance, or in some cases, improved economics. Composite flour technology refers to the process of mixing wheat flour with cereals and legumes to make economic use of local raw materials to produce high quality food products (Shahzadi et al. 2005). Composite flours are quite different from the ready-mixed flours familiar to millers and bakers. Whereas ready-mixed flours contain all the non-perishable constituents of the recipe for a certain baked product, composite flours are only a mixture of different flours rich in starch or protein, with or without wheat flour, for certain groups of bakery products. Composite flour can be regarded as mixtures of flours from tubers rich in starch (e.g. cassava, yam, sweet potato) and/or protein-rich flours (e.g. soy, peanut) and/or cereals (e.g. maize, rice, millet, buckwheat), with or without wheat flour. The goal of earlier research into composite flours was to save the largest possible percentage of wheat flour in the production of certain baked products, including bread. The major advantages that can be derived from this technology by developing countries is in the savings of hard currency, job creation, capacity building, shelf life extension of fresh produce and diversification of agricultural produce in food processing.

CONSTRAINTS TO CASSAVA-WHEAT COMPOSITE BREADMAKING IN NIGERIA

Unavailability of locally fabricated equipment is one of the factors militating against commercial production of cassava flour in Nigeria, which consequently affects commercial composite bread-making using wheat-cassava flour. Importation of the equipment may outweigh the savings in imported wheat flour, hence ruling out any justification for such an approach. Eggleston and Omoaka (1994) and Defloor (1995) reported that getting quality cassava flour that will meet the need of the mills has remained a problem due to poor processing methods, varietal age, and environmental growth conditions of cassava. Also, only few gluten substitute additives are available locally in Nigeria. Worst still, most flour millers were adding only 0.1 to 2% taking advantage of the shortage of cassava flour. By mid-2007, most governments to encourage small-scale business operators to identify with cassava producers in the utilisation of cassava by helping them to establish cottage industries. Such assistance can be in the form of granting soft loans to enable them to establish industries that will process cassava from the raw stage to intermediate raw materials for the bigger industries to process for finished products. Such a process would lead to increased production of raw materials and industrial products like bread and confectionery products. In Nigeria, President Goodluck Ebele Jonathan, in his 2012 Budget Speech to the joint session of the National Assembly on December 13, 2011, announced that the government will introduce policies to encourage the substitution of high quality cassava flour for wheat flour in bread baking. The government was determined to commence implementation in March 2012, starting with 10% cassava flour inclusion in wheat flour, which is expected to increase steadily to 40% by 2015. The National Agency for Food and Drug Administration and Control (NAFDAC) is expected to monitor compliance. Part of the policy included the implementation of a zero percent import duty on cassava processing facilities, implementation of 65% and 15% levy on wheat flour and wheat grain, respectively. In addition, bakeries that attain 40% blending would be granted a corporate tax incentive of 12% rebate, and prohibition of cassava flour importation so as to further support the programme (GAIN 2012).

COMPOSITE FLOUR

Presently, the utilisation of cassava flour in bakery products, confectionery, and other food products is relatively new and insignificant, compared to its potentials and wide opportunities. However, simple and appropriate technology now exists for the application of cassava flour as a partial replacement for wheat flour in bread making, biscuits, pastries, and snack foods. To this end, the Nigerian government inaugurated a Committee on Cassava Export Promotion with a mandate to ensure increased production, processing, packaging, and export of cassava and cassava products to satisfy both domestic and export markets. The ultimate objective was to make cassava a major non-oil foreign exchange earner, employment generator, import substitutor, poverty alleviator, and ultimately, a substantial contributor to national food security.

The promulgation into law, effective 1 July 2006 of the mandatory inclusion of 10% cassava in bread produced in Nigeria is an important drive towards cassava industrialisation and valorisation. The non-enforcement on the flour millers to comply with the mandate as contained in the initiative has brought a negative effect on cassava processing plants. Most flour millers in Nigeria have poor responses to the initiative to include cassava in their products because of the lapses in its implementation. This development had led to the under-utilisation of cassava for industrial products thereby causing glut in the face of the increasing production of cassava by farmers. There is need for various African governments to encourage small-scale business operators to

NIGERIAN GOVERNMENT INITIATIVE ON CASSAVA

The Nigerian industrial standard for edible cassava flour. In a present study conducted by Adeniji (2011) on the chemical composition and flour yield potentials of new Nigerian plantain and banana and cassava cultivars for adoption in human nutrition, a Retch Muhle, 2850 RPM Hammer Mill fitted with a sieve of 150-850 microns mesh size was used. This method yielded flour of 0.5 mm particle size, which is also applicable to flours produced from other root and tuber crops.

The highest quality, unfermented flour suitable for baking. Also, cassava flour should pass through a fine mesh to meet the Nigerian industrial standard for edible cassava flour. In a study conducted by Adeniji (2011) on the chemical composition and flour yield potentials of new Nigerian plantain and banana and cassava cultivars for adoption in human nutrition, a Retch Muhle, 2850 RPM Hammer Mill fitted with a sieve of 150-850 microns mesh size was used. This method yielded flour of 0.5 mm particle size, which is also applicable to flours produced from other root and tuber crops.

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flour millers in Nigeria practically stopped consuming cassava flour, thus reverting to the status quo. Moreover, there are persistent rumours that many institutions profit financially from wheat imports, which would not be the case if locally grown raw materials were used. However, the achievements of local manufacturers in the design and fabrication of machinery needed for cassava flour production will help to solve the problem of machinery importation. For instance, Sanmi et al. (2007) provided a catalogue of postharvest equipment and information on cassava postharvest requirements for cassava processing, including high quality flour at commercial quantities. Prototypes of these various equipment are being currently utilised in the production of flour in commercial quantities in many parts of Nigeria. FIRO (2003) also researched into various equipments for industrial processing of cassava into raw and finished products. The Nigerian government has a policy on raw materials and products standardisation to guide local investors. For example, the Standards Organisation of Nigeria (SON) is charged with the responsibility of standardizing processing methodology and finished products quality in Nigeria. In accordance with their mandate, SON has established standards that could result into effective implementation of cassava-wheat bread initiative as follows:

1. Nigerian Industrial Standard for wheat flour
2. Nigerian Industrial Standard for white bread
3. Nigerian Industrial Standard for biscuit
4. Nigerian Industrial Standard for composite flour
5. Nigerian Industrial Standard for cassava starch
6. Nigerian Industrial Standard for granulated sugar
7. Nigerian Industrial Standard for cassava flour

Apart from SON, the National Agency for Food and Drug Administration and Control (NAFDAC) was established to protect and promote public health by ensuring wholesomeness, quality and safety of food, drugs and cosmetics in Nigeria. For example, raw materials and ingredients for the baking industry must be approved and Registered. A ban on the use of potassium bromate in bread-making is a good example.

PROSPECTS FOR INDUSTRIAL APPLICATION OF CASSAVA COMPOSITE IN BREADMAKING

Wheat is one of the world’s primary food sources, and remarkable improvement in yield has been recorded by breeders. It is produced in commercial quantities in temperate countries such as Canada, Australia and sometimes the USSR and it contains a protein, gluten, which by suitable development imparts to bread its unique and much-desired texture (Dendy et al. 1970). Conventionally, a flour suitably milled from strong wheat of fairly high protein (and hence gluten) content is required for bread-making. A suitable substitute for the gluten is therefore required to make bread without wheat. Nigeria and most developing countries import red winter wheat from the USA to meet their industrial needs (Edema et al. 2005; David 2006). Importing countries could take advantage of locally produced raw materials such as cassava for partial substitution of wheat in the baking and confectionery industries. The major problem with bread consumption in Africa is that most countries cannot produce sufficient quantities of wheat required by the baking industry. In Angola, Cameroon, Côte d’Ivoire, Ghana, Guinea, Madagascar, Mozambique, Nigeria, Tanzania, Uganda and Zaire, about 2 million tonnes of wheat is imported for the baking industry annually, and local wheat production is less than 7% of wheat imports (FAO 1991b). In contrast, these countries produce 90% of Africa’s cassava (FAO 1992). In 1964, FAO, through its Composite Flour Programme, spearheaded the first attempts to effectively safe foreign exchange through partial substitution of wheat flour with flours from indigenous crops such as cassava, sorghum and millet. This was intended to reduce the importation of wheat by third world countries.

In Nigeria, several attempts have been made to produce wheatless bread or gluten-free bread, especially in the 1960s and early 1970s. The ban placed on importation of wheat into Nigeria by the Nigerian Government in 1987 was aimed to conserve currency, but this effort was not sustained in the subsequent years (Bokanga and Tewe 1998). The obvious problem in the supplementation of wheat with non-wheat flours is the replacement of the unique functional viscoelastic properties of the wheat protein gluten (Eggleston et al. 1992). Such composite bread usually requires at least 70% of wheat flour to be able to rise (Dendy and Trotter 1988; Satin 1988). Tables 1 and 2 present recipes for 100% and 10% cassava bread production, respectively.

In broad terms, there are three major new markets opportunities in cassava enterprise. Firstly, higher quality cassava flour as a partial replacement for wheat flour, cassava starch as a raw material for food and non-food industries, and cassava chips for either the domestic livestock feed sector or for export (Bokanga 1995). Ouraga-Djoussou and Bokanga (1998) showed that with a 15% substitution rate of wheat flour with cassava, Nigeria could save up to US$14.8 million in foreign exchange annually: US$12.7 would go to cassava processors and US$4.2 million to farmers. Bokanga (1998) summarises the use of cassava flour in bread by citing a survey in Nigeria and Côte d’Ivoire where it was shown that the majority of the bread consumed in the survey area was made from composite flour (wheat mixed with cassava, sorghum or maize flour). In order to address a need to diversify the range of cassava products in Tanzania, bakery products made from cassava flour instead of wheat (doughnuts, cakes, biscuits, croquettes and chin-chin) developed at IITA (Onabolu et al. 1998) were evaluated. This evaluation shows that there are potential for some of these new products in consonance with the recipes shown in Tables 3 and 4 for bread/small baked products with 70% wheat and those without wheat, respectively. In Table 3 the flour mixture is supplemented with 25% maize or cassava flour or flour and 5% soy flour. The emulsifier used is CSL in the amount of 0.5% of the total flour. For the recipe in Table 4, the emulsifier used was glyceryl monostearate at a dose of 1% of the total amount of flour. Although it is well known that no other crop can achieve the baking properties of wheat, composite flour became the subject of numerous studies to provide the following benefits for developing countries: a savings of hard currency, promotion of the domestic production of local food species; a bulk supply of protein for human nutrition and better overall use of domestic agriculture production (Berghofer 2000; Bugusu et al. 2001).

Jongh et al. (1968) used the surface active emulsifier GMS (glycerol monostearate) to improve gas retention and bread qualities of starches. He suggested that any ingredient capable of improving coherence between starch granules without impairing the capacity of dough or rise would be a suitable binder during bread-making. Kim and de Ruiter (1968) reported that fat, egg white, and gliadin could also be employed as wheat starch granule binders, apart from GMS. These authors further the use of gums and pre-gelatinised starches as gluten substitutes, and finally developed bread from cassava and soya flours using GMS. Owuamanam (2007) utilised cassava var. ‘TMS 30572’ developed by IITA to study the quality of wheat-cassava bread composite as affected by strength and steeping dura-

Table 2 Recipes for 10% cassava bread production.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Quantity 1</th>
<th>Quantity 2</th>
<th>Quantity 3</th>
<th>Quantity 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava flour</td>
<td>50 g</td>
<td>50 g</td>
<td>50 g</td>
<td>1 cup (100 g)</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>450 g</td>
<td>450 g</td>
<td>450 g</td>
<td>9 cups (900 g)</td>
</tr>
<tr>
<td>Sugar</td>
<td>50 g</td>
<td>50 g</td>
<td>50 g</td>
<td>10 tsps (50 g)</td>
</tr>
<tr>
<td>Margarine</td>
<td>38 g</td>
<td>50 g</td>
<td>50 g</td>
<td>5.tsps (100 g)</td>
</tr>
<tr>
<td>Yeast (instant)</td>
<td>20 g</td>
<td>20 g</td>
<td>20 g</td>
<td>5 tsps (25 g)</td>
</tr>
<tr>
<td>Salt</td>
<td>½ tbsp</td>
<td>11 tbsp</td>
<td>11 tbsp</td>
<td>2½ tsps (12.5 g)</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>-</td>
<td>0.25 g</td>
<td>-</td>
<td>2 cups</td>
</tr>
<tr>
<td>Water</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2 cups (2-3 cups (500-750 ml))</td>
</tr>
</tbody>
</table>

Key: tsp = teaspoon; tbsp = tablespoon; lbsp = level tablespoon; 2lbsp = level teaspoon
Quantity 1 = Denton et al. (2003); Quantity 2 = Oti and Aniedu (2006); Quantity 4 = Sanni et al. (2006)
Method (Sanni et al. 2006)
1. Weigh all ingredients, except water into a mixing bowl.
2. Mix thoroughly.
3. Add water and mix until soft dough, which can easily be handled is obtained.
5. Cut into desired sizes and shape and put in a well-greased bread pan.
6. Allow to rise until size doubles.
7. Bake at 200°C (395°F) for 15-20 minutes or until the crust is brown.
8. Remove from oven and remove the bread from the pan, and allow to cool before slicing or wrapping.

Table 3 Recipe for bread/small baked products with 70% wheat flour.

<table>
<thead>
<tr>
<th>Component</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour</td>
<td>70</td>
</tr>
<tr>
<td>Maize and cassava starch/flour</td>
<td>25</td>
</tr>
<tr>
<td>Soy flour</td>
<td>5</td>
</tr>
<tr>
<td>Sugar</td>
<td>4</td>
</tr>
<tr>
<td>Yeast</td>
<td>2</td>
</tr>
<tr>
<td>Salt</td>
<td>2</td>
</tr>
<tr>
<td>CSL</td>
<td>0.5</td>
</tr>
<tr>
<td>Water</td>
<td>50-60</td>
</tr>
</tbody>
</table>

Source: Bugusu et al. 2001; Anon 2000

Table 4 Recipe for bread/small baked products without wheat flour.

<table>
<thead>
<tr>
<th>Component</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava starch/flour</td>
<td>80</td>
</tr>
<tr>
<td>Deoiled soil flour</td>
<td>20</td>
</tr>
<tr>
<td>Yeast</td>
<td>2</td>
</tr>
<tr>
<td>Salt</td>
<td>2</td>
</tr>
<tr>
<td>Sugar</td>
<td>2</td>
</tr>
<tr>
<td>Glyceryl monoestearate</td>
<td>1</td>
</tr>
<tr>
<td>Water</td>
<td>55-65</td>
</tr>
</tbody>
</table>

Source: Bugusu et al. 2001; Anon 2000

The authors observed that there was uniformity in the scores between labelled and unlabelled samples, indicating that nutrition information on percentage composition of cassava flour did not significantly lower acceptability and preference of the samples. This suggests that the 10 and 20% cassava flour in a bread recipe could be a viable alternative to achieve the desired economic, food security and health of bread consumers. However, bread packaging with detailed nutritional information is required for commercial cassava-wheat composite bread.

Special nutrition studies were carried out parallel to the development of various types of bread from composite flours. A typical example is an investigation by Kim and de Rui (1968, 1973) from TNO Wageningen, Netherlands. They compared conventional white Dutch bread (100% wheat flour), cassava (80%) and soy (20%) bread, and cassava (80) and peanut 20% bread in feed trials with rats. Among other things, they recorded the net protein utilisation (NPU), digestibility (D) and the protein efficiency ratio (PER). From the NPU and D, the biological value (BV) was calculated as presented in Table 5, showing only the most important results. The NPU and D values of the cassava-peanut bread correlated well with a typical white Dutch bread. The cassava-soy bread was superior to both white Dutch bread and cassava-peanut bread due to the better protein quality of the soybean as compared to peanuts and wheat. The PER was also highest for the cassava-soy bread.
Concluding remarks and practical implications

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Table 5 Nutritional evaluation of various bread types made from wheat and composite flour.

<table>
<thead>
<tr>
<th>Product</th>
<th>Protein (%)</th>
<th>NPU (%)</th>
<th>BV (%)</th>
<th>PER (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Dutch bread</td>
<td>10.2</td>
<td>48</td>
<td>94</td>
<td>51</td>
</tr>
<tr>
<td>Cassava/soy</td>
<td>10.3</td>
<td>60</td>
<td>92</td>
<td>65</td>
</tr>
<tr>
<td>Cassava/peanut</td>
<td>12.4</td>
<td>49</td>
<td>91</td>
<td>54</td>
</tr>
</tbody>
</table>

Wet basis; net protein utilisation; digestibility; biological value; protein efficiency ratio.

Source: Kim and de Ruiter (1963, 1973)

resulting to the highest weight gain by rats fed with this bread. This leads to the conclusion that the protein quality of bread made from composite flours is superior to that of conventional Dutch whole bread. The best values were achieved by the cassava-soy bread.

Europe and North America produce sufﬁcient quantities of bread cereals, so theoretically they have no need to mar-
ket and use composite ﬂours in their baking industries. But constantly widening ranges of bread and small baked goods and the emergence of certain types of bread as “functional food” have led to an interest in mixtures of wheaﬁlour with other agricultural raw materials (Kim and de Ruiter 1969; Abdel-Kader 2000).

In their studies, Uzomah and Ibe (2011) fermented and chemically modiﬁed starches obtained from different vari-
eties of cassava. The aim of this study was to investigate the functional and pasting properties of the starches and possible contribution of these properties to the explanations of the baking potentials of the starches. The acetylated starches were found to possess remarkable functional properties and it gave highest expansion volume compared to that ob-
tained from lactic acid treated cassava starch. Although, the different modiﬁcation showed different effect on the sens-
ory properties of the wheat/starch bread, highest score for the overall acceptability was associated with the unfermen-
ted acetylated starches.

Jolaqho (2010) investigated the effect of bromate on the speciﬁc volume of bread baked from cassava-wheat, maize-wheat, soy-wheat composite ﬂour and wheat ﬂour. It was concluded that the use of potassium bromate has a detrimental effect on the loaf volume of cassava-wheat bread in that it causes reduction in the speciﬁc volume of the bread, which decreases as the bromate level increases. The author therefore recommended that government should ensure effective implementation of the inclusion of 10% cassava-wheat ﬂour into wheat formulation by ﬂour manu-
facturers so as to improve the commercial feasibility of composite cassava-wheat ﬂour.