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

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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

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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

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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 the baking and confectionery industries. Cassava processing, like other fresh produce, offers a means of adding value to the crop, while extending the shelf life, expanding the market, and facilitating transportation. Processing also improves product palatability, reduces the cyanide content of the processed product and facilitates fortification with other food products (Hahn 1983; Nweke 1994). The FAO (2007) 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 feed 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 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 about the level of malnutrition and under-nutrition 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 Ezedinma *et al.* (2004), IITA (2005) and Ezedinma *et al.* (2007).

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 Omoaka 1994; Onabolu *et al*. 1998; FIIRO 2003; Akobundu 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 protein, although in Central Africa, substantial amounts of protein 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 are always served 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. *abacha* (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 (Ihekoronye and Ngoddy 1985).

Breeding and processing of cassava for increasing nutrition was 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 heaping/ 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 heaping 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 (FIIRO 2003; Okoro and Isa 2008; Ekwu and Ehirim 2008; Adepoju *et al*. 2010; Oyegbami *et al*. 2010). Gari and flour forms account for the bulk of cassava used for human food in the tropics, while chips and starch are mainly used as industrial raw materials, which are traded internationally. Cassava flour is called *lafun* in Nigeria, *kokonte* in Ghana, *cossete* or *unga* in Zaire, *ugali* in Tanzania and *ajobo* or *malwa* in Uganda (Nweke 1994). Chips and flour are made following different technological pathways, depending on whether the flour is fermented or not, and in the case of fermented chips or flour, it also depends on the method of fermentation i.e., soaking or heaping. The drying process is a unit operation common to the processing of all chips or flour, irrespective of the technological pathway. Fresh roots also find considerable use as a feed for livestock such as goat, sheep, cattle, and pigs (Ihekoronye and Ngoddy 1985).

The various traditional processing of cassava methods used in Africa probably originated in tropical America, particularly Northeastern Brazil, and or have been adapted from indigenous techniques for processing yams (Hahn 1997). In Brazil, cassava is broadly used in industry in the processing of typical cassava flour named *farinha de tapioca* as well as in starch extraction, and at homes for culinary purposes (Cereda 1994). Traditional processing of cassava does not require sophisticated equipment, but storage requirements of the processed products are critical. The processing method involves a combination of activities such as peeling, boiling, steaming, slicing, grating, soaking or steeping, fermenting, pounding, roasting, pressing and milling (Hahn 1997). Cassava is playing a major role in African food crisis alleviation because of its efficient production of food energy, year-round availability, tolerance to extreme stress conditions, and suitability for present farming and food systems in Africa (Burrell 2003). *Gari* is often consumed as a drink with sugar, milk and sometimes groundnut in many parts of Nigeria, and can store for more than six months. *Gari* may also be reconstituted in boiled water to form a thick paste called *eba*, which is usually eaten with vegetable soup. *Abacha* is commonly produced in south-eastern Nigeria, and it is made by boiling flat pieces of fresh cassava roots and soaked overnight to make wet *abacha*, or sun-dried to produce dried *abacha*. *Fufu* is a fermented wet paste from cassava and it is next to *gari* as an indigenous food of most Nigerians in the south. Cassava starch is an important product for domestic and industrial application. In domestic terms, it is used as a thickener, filler, binder and stabilizer in cooking. Industrially, starch is an important raw material in the pharmaceuticals, textile and paper industry. Tapioca is an important meal commonly eaten in many parts of southern Nigeria. It is a partly gelatinised, dried cassava starch, which appears as flakes or irregularly 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; FIIRO 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 can only be met through 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 included high quality flour (HQF), which is used in the formulation of bakery products and fries. Cassava starch obtained from fresh roots has application in salads, cream, flakes 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 (Ekanayake *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.

high 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.

NIGERIAN GOVERNMENT INITIATIVE ON CASSAVA

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 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

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 flout 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 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, Sanni *et al*. (2006b) and Sanni (2007) provide 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 equipments are being currently utilised in the production of flour in commercial quantities in many parts of Nigeria. FIIRO (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 breadmaking 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.

Table 1 Recipes for 100% cassava bread production.

Ingredients	Quantity	Equivalent
Cassava flour	2 cups	200 g
Sugar	2 teaspoons	10 g
Salt	½ teaspoon	2.5 g
Yeast	1 teaspoon	5 g
Margarine	1 heaped tablespoon	20 g
Eggs	2 small	52.6 g
Water	¾ - ½ cup	85-125 ml

Source: Sanni *et al*. (2006)

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 starch 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 monoestearate 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 high yielding, native plant species; a better 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 batter to 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.

Ingredients	Quantity 1	Quantity 2	Quantity 3	Quantity 4
Cassava flour	50 g	50 g	50 g	1 cup (100 g)
Wheat flour	450 g	450 g	450 g	9 cups (900 g)
Sugar	50 g	50 g	50 g	10 tsps (50 g)
Margarine	38 g	50 g	50 g	5 tbsps (100 g)
Yeast (instant)	20 g	20 g	20 g	5 tsps (25 g)
Salt	½ tbsp	1l tbsp	1l tbsp	$2^1/_2$ ltsps (12.5 g)
Ascorbic acid	-	0.25 g	-	-
Water	2 cups	2 cups	2 cups	2-3 cups (500-750 ml)

Key: tsp = teaspoon; tbsp = tablespoon; ltbsp = level tablespoon; ltsp = 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.
4. Knead until smooth.
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.

Component	%
Wheat flour	70
Maize and/cassava starch/flour	25
Soy flour	5
Sugar	4
Yeast	2
Salt	2
CSL	0.5
Water	50-60

Source: Bugusu *et al.* 2001; Anon 2000

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

Component	%
Cassava starch/flour	80
Deoiled soil flour	20
Yeast	2
Salt	2
Sugar	2
Glyceryl monoestearate	1
Water	55-65

Source: Bugusu *et al.* 2001; Anon 2000

tion of cassava in citric acid. The cassava-wheat composite was formulated in 90:10, 80:20 and 70:30 ratios. The loaf volume of the resultant bread increased with a corresponding increase in concentration of the steeping solution, which suggests that citric acid solution modified the functional properties of cassava flour. Also, the absorbed citric acid might enhance the activity of gluten in the wheat flour portion in the blend. Citric acid is regarded as a raising agent and its role as a flour improver has been reported by Smith (1991). Citric acid also influenced the taste of wheat-cassava bread in consonance with the report of Macrae *et al.* (1993) on the use of citric acid as a flavour enhancer in food systems. There was an increase in crumb texture with corresponding increase in steeping solution concentration due to citric acid absorbed in cassava flour, which enhanced the development of the texture of the bread. Citric acid has long been employed in the development of textural properties of food (Macrae *et al.* 1993). Expectedly, the ratio of flour composites influenced the sensory properties wheat-cassava bread. The highest loaf volume was obtained in 90:10 wheat: cassava, reflecting the high content of gluten in the wheat flour portion, in line with Nigerian government policy of wheat-cassava bread.

Defloor *et al.* (1993) substituted wheat flour at 0, 15, and 30% by wheat starch, cassava starch and cassava flour to study the impact of the substitutes on the mixing requirements and on the gas retention capacity during the fermentation and baking stages of the composite flour dough. The authors reported that the bread-making potential of substituted wheat flour is determined by the degree of substitution and the type of substitute. The differentiation in bread qualities including loaf volume was more pronounced at a 30% substitution than with a 15% substitution.

The application of various additives to improve the baking potential of cassava flour has been investigated (Eggleston *et al.* 1992). In their studies, small amounts of xanthan gum or whisked egg white with table margarine produced loaves with increased volumes and improved crumb characteristics. The resultant bread was very acceptable to local African taste panellists and had good keeping qualities. Egg whites and table margarine are locally available in developing countries and are therefore more economical compared to xanthan gum, which has to be imported. Wheat-cassava composite bread can be consumed by Nigerians with stews and soups or sauces in the same manner wheaten bread are eaten.

In their studies, the performance of 10, 20 and 30% cassava-wheat composite bread was investigated (Eddy *et al.* 2007) using sensory evaluation parameters, including colour, aroma, texture, acceptability and purchasing preference. Although the proximate composition of the composite breads was slightly different from that of 100% wheat bread, the bread baked with 10 and 20% cassava composite flour was not significantly different in most sensory attributes, acceptability and readiness to buy compared to the control. 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 Ruiter (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

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

Product	Protein[a]	% NPU[b]	D[c]	BV[d]	PER[e]
White Dutch bread	10.2	48	94	51	2.50
Cassava/soy	10.3	60	92	65	1.26
Cassava/peanut	12.4	49	91	54	0.86

[a] wet basis; [b] net protein utilisation; [c] digestibility; [d] biological value; [e] protein efficiency ratio
Source: Kim and de Ruiter (1968, 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 white 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 market 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 wheat flour 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 varieties 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 obtained from lactic acid treated cassava starch. Although, the different modification showed different effect on the sensory properties of the wheat/starch bread, highest score for the overall acceptability was associated with the unfermented acetylated starches.

Jolaosho (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 manufacturers so as to improve the commercial feasibility of composite cassava-wheat flour.

CONCLUSION

Supplementation of high quality cassava flour with wheat in commercial bread making has become imperative for developing countries in order to reduce wheat importation, and further increase cassava production, thereby saving foreign exchange and consequently improving the economy. Developments in the agricultural sector through new products development, processing and utilisation will activate the emergence and growth of small- and medium-scale agro-enterprises. This could constitute a means of foreign exchange, capacity building, employment creation, diversification of cassava products and food security in line with the new global trends. This review provides information that furthers composite bread-making ventures in developing countries.

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