REVIEW OF NEW PRODUCT DEVELOPMENT WITH HIGH QUALITY CASSAVA FLOUR (HQCF)

1.0 Introduction

Cassava serves as food for many the world over. It is a dicotyledonous perennial plant belonging to the family Euphorbiaceae, grown primarily for its starchy roots, although its leaves are also consumed a protein-rich leafy vegetable. The crop is widely valued as a low-cost carbohydrate source for urban consumers (Hillocks, 2002) and the food security that it provides (Siritunga and Sayre, 2003). Cassava is the most important source of calories in the tropics after rice and corn, providing energy nourishment for more than half a billion people worldwide (Murugan et al., 2012). More than 160 million tons of cassava is produced globally per annum, making it the fourth widely produced crop after rice, wheat and maize (Ugwuanyi et al., 2007). In Ghana, the crop ranks first among its root and tuber contemporaries in-terms of production (12,230.6 MT in 2009) and has an estimated per capita consumption of 152.9 kg/year (MOFA, 2010). Cassava is largely consumed locally; hence it does not play a significant foreign exchange role even though Ghana has succeeded in exporting significant amounts of cassava chips to the European Union market (Lebot, 2009). In spite of its nutritional and economic benefits, cassava is mostly grown by small scale farmers on small plots of land (Bokanga, 1999), with little or no inputs and this limits production levels and extent of commercialization.

1.1 Nutritional composition

According to Gil and Buitrago (2002) the nutrient composition of cassava varies depending on the variety, age of the plant, geographical location and environmental conditions. Both roots and leaves are nutritionally important parts of the cassava and make up 50% and 6% of the mature plant respectively (Tewe and Lutaladio, 2004). The root which is made up of the bark, peel and the edible cortex, principally serves as the energy storehouse for the plant and the most widely consumed part worldwide. The edible portion makes up about 80 – 90% of the root, with water forming its major component (Harris and Koomson, 2011). Cassava is energy dense and produces the highest amount of carbohydrates among plants after sugarcane (Charles et al., 2005) in the region of 80 – 90 % on dry matter basis (Gil and Buitrago, 2002). Cassava roots are deficient in proteins, fat, some mineral and vitamins (Charles et al., 2005). It contains 1-2% proteins, up to 0.5% fat and reasonably rich in calcium (16 – 35mg/100g) and vitamin C (15 – 45mg /100g) (Charles et al., 2004) but has low amounts of vitamin B (Gil and Buitrago, 2002).

1.2 Cassava utilization

Cassava is one of the most important root staple, serving as rich source of carbohydrates for more than half a billion people worldwide (Anhwage et al., 2011). Global utilization of the crop has advanced, from subsistence and household consumption to the processing of industrialized commodities, although, domestic/human food usage account for the greater percentage of the crop produced in Africa and Asia (UNIDO, 2006, Westby, 2002). In Latin America and the Caribbean, industrial processing into products such as starch and ethanol dominates traditional processing, while Europe, the most of cassava consumption is channeled into animal feed production (UNIDO, 2006). Indeed, global cassava use is expected to increase to 291 million tonnes by year 2020 (Scott et al., 2000). The cassava root, which an important source of energy, and its leaves, which contain commendable amounts of protein and minerals (Westby, 2002) are both suitable for human consumption and the roots widely employed as a raw material for industrial applications (Collares, et al., 2012). Much of the growth in the industrial usage of cassava has been seen in the markets for cassava starch, which is used as a raw material for a wide array of industrial products. Processing cassava into advanced forms enhances its value and hence increases its economic potential.

1.3 Production/processing

Producing HQCF is based on the method developed by the IITA (Onabolu et al., 1998). This method is suitable for processing both cassava of high and low cyanogenic potential. The production requires a strict adherence to good manufacturing practices in order to obtain a final product with desirable qualities. Cassava roots for this process must be of high quality, in good state of health, without signs of rot and must have been harvested 9–12 months after planting (Dziedzoave et al., 2006). Roots older than 12 months reduce yield of flour (Apea-Bah et al., 2011) and fail to meet industrial standards for starch and fiber when used for the production of HQCF (Oti et al., 2010). Production of HQCF must be done within 24 hrs after harvesting cassava roots and begins with sorting and peeling of roots. Subsequent unit operations must follow one another immediately in order to eliminate the likelihood of fermentation.

1.4 Unit operations involved

Only healthy roots should be selected for processing. Once peeled, the roots must immediately be transferred into wash water in order not to overexpose them to air and cause discolouration. Washing follows peeling and must be thoroughly done with clean potable water to rid roots of dirt, mud and offensive odour. The washed roots are then grated or chipped/sliced, depending raw material type, intended use of final product and equipment available. Chipping/slicing is used as a substitute for grating if low cyanogen potential cassava is used. This however, cannot replace grating when high cyanogen potential cassava is used for the production of food grade HQCF. This is because chipping/slicing may not adequately detoxify high cyanogenic potential cassava as endogenous enzymes do not have enough contact time with the cyanogenic compounds (Oti et al., 2010). Size reduction is followed by dewatering. The grated or chipped/sliced cassava is packed in sacks and pressed to remove water before sifting and drying. While screw presses or simple hydraulic systems are used on small scale production, centrifuges are used on large scale processing. After pressing, moisture content of cake ranges between 45-50%. The pressed cake is then broken down into smaller bits by hand-sifting or using a mechanical grater. This step makes drying of the grated or chipped faster and more uniform. Drying immediately follows sifting to reduce the moisture content of the mass/grits to a range of 10 – 12 % (Abass et al., 1998; Bechoff et al. , Graffham et al., 2000). This can be achieved using a solar dryer, mechanical dryer or flash dryer. Once desired moisture content is attained, the grits are milled in a hammer mill to fine HQCF of required particle size that ranges between 250 – 500 µ. Sifting may become necessary if a disc attrition mill is used to mill the dried grits. The HQCF obtained from the process is then packaged in sacks lined with polyethylene bags with good moisture barrier properties, sealed and stored. A flow diagram of the production process is shown in Figure 1 below.

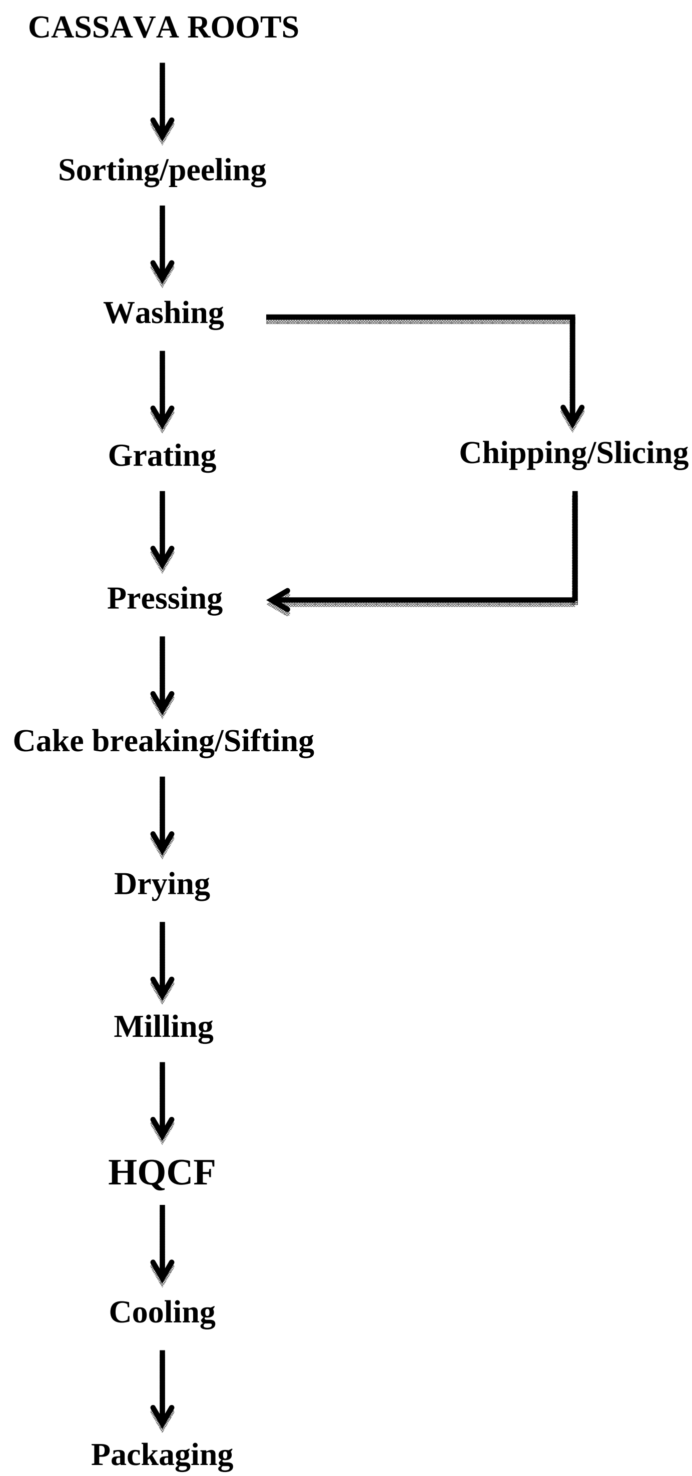

Figure 1: Flow diagram for processing cassava roots into HQCF

1.5 Quality of HQCF

In order to obtain HQCF of recommended quality, healthy raw materials of good maturity must be processed within 24 hours after harvesting. Recommended characteristics of HQCF are documented in Abass et al., 1998 and Graffham et al., 2000. Generally, HQCF is unfermented and practically free from extraneous material and foreign matter, without odor and flavor, must have a colour characteristic of the cassava variety used for processing and particle size of 250 - 500µ. Particle size depends on the cell structure and the degree of processing and affects the functional properties of flour and the quality of products it is used for (Sahin and Sumnu, 2006). Table 1 presents some quality properties of HQCF

Characteristics	Quality level		
Moisture content	≤10%	12	
Starch content, min	65 – 70%	60	
Total ash DM	3%		
Acid insoluble ash	0.15%	0.35	
Total titratable acidity (as lactic acid)	<0.25%	0.25	
Crude fiber DM	2%	0.2	
Pasting temperature	< 74C	<75C	
Cook paste viscosity	740 BU		
Total cyanogens (CNP)	≤10mg/kg HCN	10	
pH	>5.8	5.5 – 7.0	
Particle size	250 – 500 µ or at least 95% by mass shall pass through 0.6mm sieve	At least 95% by mass shall pass through 250µ sieve	
Extraneous matter		≤10 specks/100cm^2	

Color is a property of product visual appearance and greatly influences the market quality, consumer acceptability and preference of food products (Maskan, 2001). The colour of HQCF gives an indication of deterioration or contamination (Bainbridge et al., 1996). The extent of drying and age at harvest greatly affects the moisture content of the final flour (Apea-Bah et al., 2011). Moisture plays a prominent role in the storage of flours such that levels greater than 12 % aid the growth of microbes and subsequent spoilage while lower levels ensure relatively longer shelf-life. Changes in flour moisture can enhance acidity alterations through enzyme breakdown of certain inherent compounds (Hansen and Rose, 1996). Recommended pH for HQCF is set between low acid to neutral range because flours with low pH and high titratable acidity have a quality limitation when used in a composite for certain application in industries such as bakeries and adhesive production. Flour pH of 4 or less indicates substantial level of fermentation and hence starch breakdown. Cyanide is the most toxic factor that limits the consumption of cassava and its products. Even though the recommended limit is within the recommendation set by WHO (1990), cassava flour products have been found to contain cyanide in excess of these specifications (Carlsson et al., 1999; Cumbana et al., 2007; Yeoh and Sun, 2001). Indeed, variety (Aryee et al, 2006) and processing play a pivotal role in detoxifying cassava for culinary applications (Westby, 2002). Other quality parameters of consideration include heavy metal ( ), microbial and pesticide residue contamination (EAS, 2012). These concerns are critical if the intended use of the HQCF is for food and food-related purposes

2.0 Overview of utilization

Cassava flour is processed into a wide array of products, ranging from food and feed to industrial products of commercial importance. The crop is increasingly gaining popularity for use in the production of low-cost, high-quality raw materials for both small scale and large scale manufacturing of many products for growing national markets and for export (Bokanga, 1999). In Africa, 70% of the root crop is processed into a variety of food products, including cooked pastes, beverages, roasted chips as well as flour and starch (Bokanga, 1999), which serves as starting materials for the other value added products. In the recent past, some industries have begun using cassava as a substitute for other starchy cereals. This has been used to meet industrial needs such as the production of bio-fuel, starch and flour for use in paper and drug manufacturing.

Cassava flour has been applied in several kinds of dishes, especially in countries where cassava is grown. This is seen as a less expensive means of adding value to the root crop. Processing cassava into flour differs from one locality to another (Falade and Akingbala, 2008), however, in most of these methods, the cassava undergoes fermentation. The low pH and high acidity of the resulting flour makes it inappropriate for industrial applications (Dziedzoave *et al*., 2006). An improvement on this system of production yields a better quality product that is most suitable for serving as industrial raw material called High Quality Cassava Flour (HQCF). This is produced in a manner that reduces or eliminates fermentation, thus resulting in a product that has a pH of 5.5 – 7 and an acidity of up to 0.25 % (EAC, 2012)

HQCF is one of the numerous cassava products for which use has been found as raw or starting material for industrial applications. HQCF is produced from freshly harvested cassava and rapidly processed roots (Oti et al., 2010). The flour is unfermented, smooth, odourless, white/creamy, and bland with no gluten and has been used in composite flours and has even been proposed as for substitute wheat flour in countries where wheat is imported. It is easy to produce and has a high income generation potential (Abass et al., 1998) among small scale producers. Application of cassava flour creates and avenue for the betterment of food and livelihood security for a lot of people (Falade and Akingbala, 2008), especially, small scale cassava growers.

2.1 Products development with HQCF

HQCF is a major intermediate product and its development has come as a key success in cassava processing (Sanni et al., 2009). Its development is a relatively new concept in cassava utilization even though some other forms of cassava flour have existed and have been used globally in a wide variety of food-based products. In Vietnam, about 60% of cassava is processed into flour mainly for the feed industry (Dang et al., 1996). The following are some of the products developed from HQCF.

a. Formulation of composite flour for bread

HQCF and wheat flour has been used in the proportion of 1:4 to obtain 20% HQCF and 80% wheat flour composite bread. Other ingredients like milk, sugar, egg, margarine, salt, nutmeg, baking powder etc were added as in normal wheat bread preparation. The results showed that wheat/cassava composite flour bread was acceptable to most consumers (The recipes prepared have shown to be viable alternatives to 100% wheat bread which is consumed in large quantities. Tests conducted in Nigeria shows that replacing between 20 to 40 per cent of wheat flour with cassava flour produces bread acceptable to Nigerian consumers.

b. Pastries

Cassava flour can replace 75% of wheat flour in sponge cakes and chiffon cakes, 50% in butter cakes and cookies, 25% in doughnuts and spaghetti, and 20% in bread.

c. Noodles

Cassava flour has been shown to be able to replace 25-50% of the rice starch in noodles, and makes the noodles softer and more elastic. Locally produced High Quality Cassava Flour (HQCF) can replace expensive wheat flour in macaroni and spaghetti production, improving the overall taste and texture.

d. Glucose Syrup

Several industries in Ghana use Glucose syrup in their manufacturing operations with the bulk of the syrup being imported. In an attempt to increase use of HQCF, a technology was developed and modified to process glucose syrup from HQCF and rice malt (Training manual for production of Glucose syrup) The process was found to be successful in providing a local supply source for glucose syrup to substitute for the imported product . DADTCO's HQCF, consisting of 95 per cent starch can efficiently be further processed into sugar substances like commercial Glucose and Sorbitol– a sugar substitute used in toothpaste production, chewing gum, and cough syrups.

e. Application of HQCF in the brewery Industry

DADTCO's cassava cake serves as a significant cost effective substitute for imported glucose syrup and starch from barley for the brewing industry. SABMiller, the second largest brewer in the World has opted to replace a large part of its imported raw materials with cassava cake produced by DADTCO in up to 13 African countries. The cooperation between SABMiller and DADTCO will provide a guaranteed income and a good fortune for thousands of smallholder cassava farmers in Rivers State.

f. Use of HQCF as a food binder

HQCF serves as a binding agent for food and other industrial uses and provides increased market opportunities through its use in the manufacture of Bouillon cooking cubes such as Knorr and Maggi (both consisting of approximately 20 per cent starch).

g. Industrial alcohols Production

Ethanol and methanol production from HQCF has been proved to be another viable way of increasing utilization of cassava flour. The technology of producing alcohols from cassava involves fermentation of cassava flour syrup to convert into a sugar solution which is then distilled into alcohol. Alcohol of high yield is produced during the fermentation of cassava flour hydrolysate. The conversion efficiency of sugars to alcohols have been found to be high for cassava flour hydrolysate (Ocloo and Ayernor, 2010).

h. Paperboard adhesives

Laboratory and factory trials have shown that locally produced cassava flour can be used to replace 50 to 100% of maize starch in starch-based adhesives. Cassava starch has the added advantage of reducing the amount of sodium hydroxide (gelatinisation modifier) and borax (viscosity enhancer) required to prepare a suitable adhesive for paperboard manufacture, thus further reducing costs. The paperboard and plywood industries of Ghana are significant users of starch, flour and starch-based products. In 1996 the paperboard industry used 420 tonnes of starch-based adhesives in the manufacture of corrugated board. In the same period the plywood industry used 1,134 tonnes of starch and 1,200 tonnes of food grade wheat flour as extenders for synthetic wood glues. The paperboard and plywood industries account for 37% (excluding wheat flour) of the market for starch and starch-based products in Ghana (Graffham et al. 1997).

Three out of the four-paperboard factories use local as well as imported adhesives. The local product is favoured because of its low price and ready availability. However, all users commented unfavourably on the quality of the local product. Locally produced SBAs form weaker bonds, have a short shelf life, contain too many contaminants, and are not finely milled. Users overcome bonding problems by blending local and imported products together (Day et al. 1996).

i. Other Uses of HQCF

Cassava flour has been applied as binding agents in mosquito coil manufacturing and in producing pharmaceutical products. The market for HQCF comprises a number of end users who use maize, cassava and potato starch, in textiles for desizing. (CPHP R6505 Report)

References

Tewe, O.O. and Lutaladio, N. (2004). Cassava for livestock feed in Sub-Sahara Africa, FAO, Rome Italy.

Dang, T.H., Tru, L.C. and Henry, G. (1996). Prospects for cassava starch in Vietnam. Cassava Flour and Starch: Progress in Research and development. Pp 48 – 54. Dufour, D., O'Brien, G.M. and Best, R. (eds). Centre de Cooperation Internationale de Recherche Agronomique pour le Development (CIRAD). Montpellier, France. Centro Internacional de Agriculture Tropical (CIAT) Cali, Columbia.

Amoa-Awua, W.K., Owusu, M. and Feglo, P. (2005). Utilization of unfermented cassava flour for the production of an indigenous African fermented food, agbelima. World Journal of Microbiology and Biotechnology, 21:1202 – 1207.

Sanni, L.O., Onadipe, O.O., Ilona, P., Mussagy, M.D., Abass, A. and Dixon, A.G.O. (2009). Successes and challenges of cassava enterprise in west Africa: A case study of Nigeria , Benin and Sierra Leone. Internationa Institute of Tropical Agriculture (IITA), Ibadan and Common Fund for Commodities (CFC), Amsterdam, pp 1 – 19.

Sahin, S. and Sumnu, G.S. (2006) Physical properties of food. Springer science and business media, New York. pp 1 – 36.

Hansen, L. and Rose, M.S. (1996). Sensory acceptability is inversely related to development of fat rancidity made from stored flour. Journal of American Dietetic Association, 96:792 – 793.

Carlsson, L., Mlingi, N., Juma, A., Ronquist, G. and Rosling, H. (1999). Metabolic fates in humans of linamarin in cassava flour ingested as stiff porridge. Food and Chemical Toxicology, 37:307 – 312

Cumbana, A., Mirione, E., Cliff, J. and Bradbury, J.H. (2007). Reduction of cyanide content of cassava flour in mozambique by the wetting method. Food Chemistry, 101:894 – 897.

Aryee, F.N.A., Oduro, I., Ellis, W.O. and Afuakwa, J.J. (2006). The physicochemical properties of flour samples from the roots of 31 varieties of cassava. Food control, 17: 916 – 922.

Apea-Bah, F.B., Oduro, I., Ellis, W.O. and Safo-Katanka, O. (2011). Factor analysis and age at harvest effect on the quality of flour from four cassava varieties. World journal of dairy and food science, 6:43 – 54.

Charles, A.L., Sriroth, K. and Huang, T.C. (2005). Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. Food chemistry, 92:615 – 620.

Abass, A.B., Onabolu, A.O. and Bokanga, M. (1998). Impact of the high quality cassava flour technology in Nigeria. In root crops in the 21st century. Compiled by Akoroda, M.O. and Ngeve, J.M. Proceedings of the 7th triennial Symposium of the International Society for Tropical Root crops-Africa Branch (ISTRAC – AB). Centre International des conferences, cotonou, Benin, 11 – 17, October, 1998.

Gil, J.L. and Buitrago, A.J.A. (2002). La yucca en la alimentacion animal. In: Ospina, B. and Ceballos, H. (eds). La yuca en el tercer milenio: sistemas modernos de producci´on, procesamiento, utilizaci ´on y comercializaci ´on. Cali, Colombia: Centro Internacional de Agricultura Tropical. p 527–69. Available from: http://www.clayuca.org/PDF/libro_yuca/capitulo28.pdf. Accessed Jun 29, 2008.

Maskan, M. (2001). Kinetics of colour change of kiwifruits during hot air and microwave drying. Journal of Food Engineering, 48:169 – 175.

Charles, A.L., Chang, Y.H., Ko, W.C., Sriroth, K. and Huang, T.C. (2004). Some physical and chemical properties of starch isolates of cassava genotypes. Starch/Starke, 56:413 – 418.

Yeoh, H.H. and Sun, F. (2001). Assessing cyanogen content of cassava based food using the enzyme-dipstick method. Food and chemical toxicology, 39:649 – 653.

Ocloo F. and Ayernor, G. Production of alcohol from cassava flour hydrolysate. Journal of Brewing and Distilling Vol. 1(2) pp. 15-21, June 2010

Oti, E., Olapeju, O., Dohou, S., Moutairou, E., Nankagninou, D., Komlaga, G.A. and Loueke, G.M. (2010). Processing of cassava into gari and high quality cassava flour in west Africa. Training manual (draft). USAID/CORAF/SONGHAI.

Gleadow, R.M. and Woodrow, I.E. (2002). Constraints on the effectiveness of cyanogenic glycosides in herbivore defence. Journal of chemical ecology, 28:1301-1313.

Bainbridge, Z., Tomlins, K., Wellings, K. and Westby, A. (1996). Methods for Assessing quality characteristics of Non-grain starch samples, Part 2 field methods. Natural Resources Institute.

Falade, K.O. and Akingbala, J.O. (2008). Improved nutrition and national development through the utilization of cassava in baked foods. In: Robertson, G.L. and Lupien, J.L. (eds) Using Food science and technology to improve nutrition and promote national development: select case studies. International Union of Food science and technology.

MOFA (2010). Agriculture in Ghana, Facts and Figures (2009). Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Ghana. Buck Press, Accra.

Bokanga, M. (1999). Cassava: Postharvest operations. International institute of tropical agriculture

Hillocks, R.J. (2002). Cassava in Africa. In: Hillocks, R.J., Thresh, J.M. and Bellotti, A.C. (eds) Cassava: Biology, Production and Utilization. CAB International, pp 41 – 54.

Siritunga, D. and Sayre, R.T. (2003). Generation of cyanogen-free transgenic cassava. Plants, 217: 367 – 373.

Lebot, V. (2009). Tropical root and tuber crops. Cassava, sweet potato, yams and aroids. CAB International, Oxfordshire, UK, pp

Ugwuanyi, J.O., Harvey, L.M. and McNeil, B. (2007). Linamarase activities in Bacillus spp. Responsible for thermophilic aerobic digestion of agricultural waste for animal nutrition. Waste Management, 27:1501 – 1508.

Murugan, K., Yashitha, Kuppusamy, S. and Al-Sohaibani, S. (2012). Detoxification of cyanides in cassava flour by linamarase of Bacillus subtilis KM05 isolaed from cassava peels. African journal of biotechnology, 11:7232 – 7237.

UNIDO (2006). Nigerian Cassava master plan: A strategic action plan for the development of the Nigerian cassava industry. Report prepared by United Nations Industrial Development Organization in Cooperation with the Ministry of Trade and Industry and the Presidential Initiative on Cassava.

Scott, G.J., Rosegrant, M.W. and Ringler, M.W. (2000). Roots and tuber for the 21st century: trends, projections and policy options. Food, agriculture and the Environmenr Discussion Paper 31. International Food Policy Research Institute.

Westby, A. (2002). Cassava Utilization, Storage and Small-scale Processing. In: Hillocks, R.J., Thresh, J.M. and Bellotti, A.C. (eds) Cassava: Biology, Production and Utilization. CAB International, pp 41 – 54.

Collares, R. M., Miklasevicius, V.S.L., Bassaco, M.M., Salau, P.G.N., Mazutti, M.A., Bisognin, D.A. and Terra, L.M. (2012). Optimization of enzymatic hydrolysis of cassava to obtain fermentable sugars. Journal of Zhejiang University-Science B (Biomedicine and Biotechnology), 13:579 – 586.

Bokanga, M. (1999) Cassava: Post-harvest Operations.

Dziedzoave, N.T., Abass, A. B., Amoa-Awua, W.K.A. and Sablah, M. (2006). Quality Management manual for production of high quality cassava flour. (Adegoke, G.O. and Brimer, L. eds). International Institute of Tropical Agriculture (IITA).

Graffham, A.J. Dziedzoave, N.T. and Ayenor, G.S. (2000). Final Technical report of the CPHP project entitled “Expanding markets for cassava starches and flours in Ghana” Report of the Natural Resources Institute (R6504).