ARID ZONE JOURNAL OF ENGINEERING, TECHNOLOGY & ENVIRONMENT
AZOJETE - CIGR Section VI Special Issue:
Innovation & Technologies for Sustainable Agricultural Production & Food Sufficiency
AZOJETE, December, 2018. Vol. 14(SP.i4): 208-218
Published by the Faculty of Engineering, University of Maidiguri, Maidiguri, Nigeria.

Print ISSN: 1596-2490, Electronic ISSN: 2545-5818
www.azojete.com.ng

ORIGINAL RESEARCH ARTICLE

A REVIEW OF RHEOLOGICAL PROPERTIES OF HIGH QUALITY CASSAVA FLOUR (HQCF) COMPOSITES

J. U. Okoko*, A. F. Alonge and P. O. Ngoddy.

Department of Agricultural and Food Engineering, University of Uyo, Uyo, Nigeria.

ARTICLE INFORMATION

Received: October, 2018
Accepted: December, 2018

Keywords:
Rheological properties
Composite flour
Cassava
High quality flour
Products

ABSTRACT

Food products development by means of composite flour technology is experiencing a remarkable upsurge globally with the ticking of the clock; thereby inviting a great deal of researchers' consideration, particularly in bakery foodstuffs and pastries making. The world population is increasing and is projected to be well over eight billion people in the year 2030, with attendant imports of an increased consumption, hence higher demands for processed foods such as bread. In view of the climb in consumption of bread, a higher demand for wheat should be in anticipation. Thus, shrinkage in the global supply of wheat as a resource in the immediate future should be anticipated. This development gives emphasis to the necessity for alternative sources of flour and starch. The attention of this review is directed at the studies of rheological characteristics of composite flour vis-à-vis its consumptions via food products such as bread, biscuits, and pasta. Emphasis is on blends which have high quality cassava flour (HQCF) or just cassava flour as one of the compositing flours with its influence on the sensory and nutritional qualities in addition to its universal approval. In this work, a report has also been given of a study on wheat flour blended in varying proportions with other flours such as those from rhizomes, legumes, fruits and cereals (other than wheat) to create diverse food products. Cassava flour in bread making has been found to be a suitable substitute for encouraging the utilization of a local produce besides reduction of wheat flour imports and upholding the production of high quality cassava flour (HQCF). The development of gluten-free products and fortification of foods have also turned out to be a possibility. Several researchers have developed a range of breads using cassava flour whose properties are akin to those of wheat flour breads. It is promising that the capability of composite flour in bakery and pastry products to retain similar properties to products made from pure wheat flour has been reported. It has also been testified that the use of composite flours has acceptable impacts on the finishing products from the standpoint of functional and physicochemical characteristics as well as healthiness of the end users. Generally, composite flour technology is being regarded as a noble new method for harnessing the benefits in flours that may not unfold unless in composites, which of course, as a matter of fact, will be contingent upon the proportions of blending.

*Corresponding author Email address: josephokoko@uniuyo.edu.ng

1.0 Introduction

The global population is increasing and is estimated to reach nine billion people in no distant time (Jensen *et al*., 2015). A critical aspect of the imports of this increase in population will be an increased consumption, hence higher demands, for processed foods such as bread (Godfray *et al.,* 2010). In view of the escalation in consumption of bread, a higher demand for wheat should be in anticipation. To this end, the global supply of wheat as a resource should be expected to diminish in the immediate future. This development underscores the necessity for alternative sources of starch and flour (Jensen *et al.* 2015). Although Falade and Akingbala (2011) and Ukwuru and Egbonu (2013) would see the challenges in the emerging industry as it has to do with the type of food to be processed, consumption habits, raw materials supply and equipment availability. Onyango *et al*. (2011), however, is optimistic that in Africa and Latin America, cassava flour possesses an abundant potential as a substitute for wheat flour in bread making; the consistency, which is an offshoot of rheological properties, in flour quality being a foremost challenge, nevertheless (Hershey *et al.,* 2000). Noorfarahzilah *et al.,* (2014) maintains that the development of foodstuffs by means of composite flour has increased and is inviting considerable attention from researchers, particularly in the making of bakery products and pastries.

The enlarged root (tuber) of cassava plant (*Manihot esculenta Crantz*) is an essential foodstuff in the tropical regions of the world, namely; Africa, Asia, and in the Caribbean (Okafor *et al.,* 1999). Cassava is reported by Collares *et al.,* (2012) to be the world's sixth most important crop grown in these countries. According to IFAD and FAO (2001), cassava has outstanding features which include; its great potential for the production of starch, drought tolerance and adaptation to difficult ecosystems such as acid soils of low fertility. In 2014, Colombia produced 2.1 million tons of cassava, as compared with Brazil's 23.2 million tons and Paraguay's 3.0 million tons (FAO, 2016). The roots and leaves of cassava are both suitable for human consumption; the former, as a source of carbohydrates and the latter as a source of protein, minerals and vitamins, particularly carotene, calcium and phosphorus (IFAD and FAO, 2004).

It is a known fact that carbohydrates provide the prime source of fuel for the body. Cassava happens to be a dependable source of dietary carbohydrate – mainly starch. According to Dziedzoave *et al* (2010), cassava roots have up to 60% starch content. Thus exploring avenues for increased value chain of the cassava is a worthwhile venture. The increased demand for wheat-based convenient foods in Nigeria and other countries of the world vis-à-vis the challenges of climate in cultivation of wheat in the tropical regions demands an alternative food ingredient for baking and confectionery products with at least a partial substitution of wheat. An interesting attraction, as reported by (Abass *et al*., 1998), is that cassava flour is one of derivatives from cassava roots whose processing technology, not only requires less consumption of water and energy, is more economical and easier than its other products like starch; besides, and produces lesser amount of by-products and waste.

Eriksson (2013) disclosed that High Quality Cassava Flour has the prospective to swap part of the wheat flour in bakery foods as there has been an inclusive approval among users; even as he presented the proximate composition of cassava as shown in Table 1 below;

Table 1: Proximate composition of fresh cassava roots

Component	Value
Moisture (g/100 g)	59.4
Carbohydrates (g/100g)	38.1
Protein (g/100 g)	0.7
Fat (g/100 g)	0.2
Crude fiber (g/100 g)	0.6
Ash (g/100 g)	1.0
Calcium (mg/100 g)	50.0
Vitamin C (mg/100 g)	25.2
Energy (kcal/100 g)	157

Source: Eriksson (2013)

Although gluten, whose good source is wheat, has been reported to be responsible for the rheological characteristics of bakery foodstuffs (Sciarini, *et al*., 2010), the same gluten has been indicted in the report of Aguilera and Park (2016) as being a source of serious worry in diets for elderly people – people aged over 65 years - whom they had described as being the fastest increasing section of global population. Even though studies such as Defloor *et al*., (1993) and Jensen *et al*., (2015); have shown that bread quality is impaired when large quantities of cassava flour are used in the bread formulations, there is still room for less emphasis on pure wheat bread.

According to Akinlonu (2011), Falade and Akingbala (2009) and Oyewole (2002), inclusion of cassava flour as composite for production of foods such as noodles, breakfast cereals, cookies, breads, cakes, pastries, muffins and doughnuts inter alia could lessen costs and increase the production of these products locally. Thus wheat flour supplementation provides an excellent means of improving the dietary worth (protein, minerals, vitamins, and bioactive compounds) of foods. The incorporation of less expensive non-wheat flour for food product enrichment would be a desirable vehicle for nutritional improvement, Okafor, *et al*., (2002) opined.

1.1 Objective

The main objective of this work was to look into the studies of rheological properties of composite flour products with special emphasis on blends which have high quality cassava flour (HQCF) or just cassava flour as one of the compositing flours.

2.0 The Review

2.1 Composite flour

Composite flours may be considered chiefly as amalgams of wheat and other flours for the making of baked products, leavened or unleavened and pastas (Riley-Mitchell *et al.,* 2012). Also composite flour can be looked upon as a product created from a combination of two or more materials. Such amalgam may be different in characteristics from the individual components and/or may be an enhancement of their properties and overall acceptance; in some circumstances, value may be added to the financial aspects of its production. In the preceding age, it was uncommon to have bread prepared from any other material than wheat flour. However, the emergence of composite flour technology has conveyed innovative dimensions upon the production of bread and other bakery foodstuffs.

Composite flour technology denotes the development of bakery products by a combination of two or more flours which may be cereals and/or legumes. According to Adeniji (2013), composite flours can be considered as blends of flours from tubers rich in starch (e.g. cassava, yam, sweet potato) and/or protein-rich flours (e.g. soybeans, peanut) and/or cereals (e.g. maize, rice, millet, buckwheat) with or without wheat flour. This development creates an avenue for economic utilization of indigenous raw materials to manufacture high quality food products (Shahzadi, 2005). Composite flours should not be perceived in the light of ready-mixed flours which millers and bakers are accustomed to. While ready-mixed flours contain all the non-perishable constituents of the formula for a certain bakery 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.

The foremost objective of the previous study of composite flours was to lessen, to the largest imaginable extent, the emphasis on wheat flour usage in the manufacture of certain baked products, as well as bread. The key benefit derivable from this technology by emerging economies is in the amelioration of savings of hard foreign currencies. Job creation, capacity building, products shelf-life extension and diversification of food products utilization are other benefits in anticipation.

Sanful and Danko (2010) had observed that there is a possibility of making composite flour from locally available starchy crops. Bamidele *et al.* (2014) suggested that a composite of cassava and cocoyam flours produced a nutritive gari, which was hihgly acceptable. Kareem *et al*., 2015 worked on blends of tigernut and high quality cassava flours, and unmasked the fact that an acceptable extruded snacks can be produced from tigernut-HQCF composite. Wronkowska, Haros, and Soral-Śmietana (2013) reported that when starch was substituted by buckwheat flour on gluten-free bread quality, a decrease in whiteness and increase in redness and yellowness of crumb was noticed. Composite flour in baking performance using plantain flour substituted with wheat flour had been studied by Onwuka and Onwuka (2005), plantain, cassava/soybean flour blends for snacks and corresponding food preparations (2004). These efforts again were aimed at improving the protein content in particular and the overall nutritional value of the product (Kiin-Kabari *et al.,* 2015).

Composite flours, according to Chandra *et al.,* (2015) may be considered firstly as blends of wheat and other flours for the production of leavened breads, unleavened baked products, pastas, porridges and snack foods. Secondly, wholly non-wheat blends of flours or meals, for the same purpose. They also noted that there are two reasons for mixing the wheat with other flours namely; economic and nutritional; like adding soy flour is to increase the protein content of the +baked products. Increasing the quantity of buckwheat flour in gluten-free bread formulation caused a decrease in crumb hardness during storage. Haros and Soral-Śmietana (2013) also suggested that buckwheat flour incorporated into a gluten-free formula could improve bread texture and shelf-life. Bread made with seaweed composite flour exhibited higher values of firmness (Mamat, *et al* 2014).

Moreover, modified starchy flours from other sources such as tubers, cereals, pseudo-cereals, legumes and oil seeds have been used as alternatives1 in bread making (Ohimain, 2015). Mannuramath *et al.,* (2015) reported that combination of little millet flour (LMF) at 30% level in bread can be considered as a functional dietetic food option for the management of diet-related metabolic maladies. Boz and Karaoğlu (2013) showed that the value of whole wheat bread could be enhanced by adding various materials of plant origin.

2.2 High Quality Cassava Flour (HQCF)

High Quality Cassava Flour (HQCF) is sometimes produced from High Quality Cassava Cake (HQCC) and conveyed to and flash dried in a flash dryer at temperatures of between 165 and 180 degrees Celsius. The dried flour is milled in an industrial pin mill to less than 200 microns and subsequently the flour is cooled down to ambient temperature, sieved on tumbler sieves and bagged automatically or manually. The amicable features of this type of HQCF include; at least 98% of the flour will pass a sieve of 200 microns and a standard homogenous sizing for every batch; all cyanide, nearly all proteins and dissolvable matter have been removed, and there is no risk at all for public healthiness; starch granules are completely released and gelatinized totally at 57 - 65 degrees Celsius; low Total Viable Count (less than the 10,000 cfu/g limit), low yeasts, low moulds, no coliforms and no entero bacteriae; and there is standard and consistent quality between all batches as regards moisture content and all other parameters; i.e. batches do not differ or if they do, it is very marginally from each other. A standard HQCF producing unit comprises a flash dryer and 2-3 AMPUs. The flour production of a flash drier is 12,000 – 15,000 metric tonnes per annum. HQCF is a wheat flour substitute and is used in bread-making, pastas, cookies, various fast-food snacks, wood-board/plywood, adhesives and mosquito coils.

2.3 Rheological Properties

Rheological properties, with reference to food materials, are those characteristics which influence the consistency and flow of food under tightly specified conditions. These properties affect the deformation and flow of matter. The texture of any food material depends on its rheological properties. According to Berk (2009), most of the textural properties are largely rheological in nature; and most rheological tests involve applying a force to a material and measuring its flow or change in shape. However rheological considerations do not cover all the elements that establish the texture of a food (Urbicain and Lozano, 1997). Production of food products such as buns, bread, cake, etc., depends on the functional properties of the flour (Julianti *et al*., 2016; Ekwu *et al*., 2011). The rheological properties of dough are significant base for the process of manufacture of quality food products (Létang *et al*., 1999; Moreira *et al.,* 2010), which allows for the development of new materials (Ibarz and Barbosa-Canovas, 2014). There have been several studies, such as Kokse *et al.* (2001); Moreira *et al.* (2010) and Sabovics *et al.* (2011) on rheological properties of food materials and flour dough from different crops.

Flours from other raw resources replacing wheat flour will adjust the rheological properties of dough, as well as the feature of baked product. It is well known that proteins encountered in non-wheat flours do not have the capacity to form the gluten network responsible for holding the gas produced during the fermentation (Hadnadev *et al*., 2011). In determining the rheological behaviour of different raw materials using Chopin Mixolab, they reported that blends of rice and buckwheat flours would give the finest rheological profile.

The Mixolab technique as reported by Collar *et al*., (2007); Kahraman *et al*., (2008), allows the complete characterization of the flours in terms of proteins' quality by determining their water absorption, stability, elasticity, and weakening properties; starch behaviour during gelatinization and retro gradation; consistency modification when adding additives and enzymatic activity of the proteases, amylases, etc. The technique was also applied by Stoenescu *et al.* (2012) to study the rheological properties of augmented wheat flour. Mixolab analyses were carried out on composite flour with 30% of cassava flour by Jensen *et al.,* (2015). This team reported that the amount of incorporated cassava flour in bread was decidedly a function of the variety of cassava flour. Eriksson (2013) used a Rapid Visco Analyzer (RVA) from Newport Scientific (Warriewood, Australia) to analyze pasting properties of cassava flours upon heating and subsequent cooling with application of RVA General Pasting Method (STD1). The researcher concluded that cassava flours were characterized by a premature gelatinization (pasting temperature between 70 and 71°C), high peak viscosity, large paste breakdown and low retro-gradation propensity compared to wheat flour. In an analogous development, Ekwu *et al.* (2011) determined the rheological characteristics of traditionally processed cassava flour with the same apparatus, but a method after Sanni *et al*., (2008) and established that the pasting properties of the flour showed peak viscosity range from 157.35 to 399.58RVU, trough 90.08-206.50 RVU, breakdown viscosity 67.23-193.09 RVU, final viscosity 123.58 -300.41 RVU, setback 33.40 - 93.93 RVU.

Kareem *et al*., 2015 worked on blends of tigernut and high quality cassava flours, and unmasked the fact that and acceptable extruded snacks can be produced from tigernut-HQCF composite. Eduardo *et al.* (2013) investigated into some textural cum rheological characteristics of cassava – wheat – maize bread types. In that report, loaf slices of 2.5 cm were taken for study of the crumb firmness, six (6) hours after baking using an Instron Universal Testing Machine (UTM, model 5542). The loaf volume was measured one (1) hour after the end of the baking procedure by the displacement method in which alfalfa seed was used. It was shown that pectin interacts with wheat starch bringing about an increased paste viscosity during heating. Both the increased viscosity and the gel network were believed to have strengthened the gas-holding properties of the expanding cells in the dough and subsequently resulting in a greater loaf volume. Bread with fermented cassava flour resulted in firmer bread crumb when cassava level and pectin content were both low, and softer bread types were obtained with roasted flour.

The viscosity of a suspension of wheat flour supplemented with high quality cassava and pigeon pea flours was measured by Chilungo (2013) using the Brookfield viscometer. It was remarked that as the levels of supplementation were increased, the viscosity of flour blends slightly increased. This was construed to be due to addition of cassava flour at increased levels. The low viscosities of wheat and pigeon pea flours were related to the cohesiveness of the starch molecules of these flours.

Nwokocha *et al.* (2009) measured some rheological properties of the starch pastes using a controlled stress Rheometer (AR 2000, TA Instruments Ltd) with cone and plate geometry (40 mm, 2 cone and 52 lm gap). The measurements were carried out at 25ºC and shear rates of 10^{-1} to 120/s. They used TA Data Analysis software (version VI.2.5) to fit shear stress versus shear rate models viz; Newtonian, Power law, Bingham, Casson and Herschel–Bulkley to the experimental data and estimated the goodness of fit for each model using the standard error of estimate. In that report, a model was considered acceptable if the standard error was about 20 or less, and the model that had the lowest standard error was considered, best suited for the description of the shear stress–shear rate profile of the starch pastes.

Where rheological properties are viewed as textural, they are such characteristics of a food material that portray physical features of the material when it comes in contact with the senses of feel or touch. Food texture from this standpoint refers to those qualities of a food that can be felt with the fingers, tongue, palate, or teeth. Texture is distinctive of the surface of a material and is an indication of quality. Davies (2007) described texture as relating to characteristic intensity variation that typically originates from roughness of an object's surface. It may be regarded as what constitutes the macroscopic region of the object. Its structure is basically ascribed to the repetitive patterns in which elements or primitives are arranged according to an order rule (Tuceryan and Jain, 1998).

Textural characteristics refer, but are not limited to the following; consistency, hardness, brittleness, firmness, crispiness, springiness, combablilty, crunchiness, coarseness, fineness, cohesiveness, adhesiveness, gumminess, resilience, chewiness, fracturability. Fellows (2000) gave further delineation of textural properties as shown on Table 2 below. Korczyk–Szabó and Lacko–Bartošová (2013) described texture analysis as one of the most helpful analytical methods of product development.

Evaluation of texture involves measuring the response of a food when it is subjected to forces such as cutting, shearing, chewing, compressing or stretching. Many studies have been carried out on textural properties of dough obtained from composite flours blends such as wheat-pitaya flour (Ho and Abdul-Latif (2016); wheat-soy composite, wheat-cassava composite bread (Komlaga, Clover-Amengor, Dziedzoave, and Hagan, 2012). Starch has been identified by Miyazaki et al., (2006) as a major component that plays a major role in texture and quality of dough and bread. Cassava of course, is a good source of starch.

Table 2: Textural characteristics of food

Primary Characteristics	Secondary Characteristics	Popular Terms
Mechanical Characteristics		
Hardness	Brittleness	Soft → firm → hard
Cohesiveness	Chewiness	Crumbly, crunchy, brittle
	Gumminess	Tender, chewy, tough
		Short, mealy, pasty, gummy
Viscosity		Thin, viscous
Elasticity		Plastic, elastic
Adhesiveness		Sticky, tacky, gooey
Geometrical Characteristics		
Particle Size and Shape		Gritty, grainy, coarse
Particle Shape and Orientation		Fibrous, cellular, crystalline
Others		
Moisture Content		Dry →moist→ wet→ watery
Fat Content	Oiliness	Oily
	Greasiness	Greasy

Source: Fellows (2000)

Alvarez-Jubete *et al.,* (2009) evaluated the pasting properties of pseudo-cereal flours using a rapid visco analyzer. They carried out standard baking tests and texture profile analysis on the gluten-free control and pseudo-cereal samples of gluten-free breads. They obtained Confocal Laser Scanning Microscopy (CLSM) images from the baked breads. In addition, they conducted digital image analysis on the resulting bread slices. From these studies, they found that bread volume significantly increased for the buckwheat and quinoa breads compared with the control. Furthermore, breads with pseudo-cereal content were characterized by a considerably softer crumb texture effect that was ascribed to the presence of natural emulsifiers in the pseudo-cereal flours and confirmed by the confocal images.

Shittu *et al.* (2008) determined the textural analysis of bread from cassava-wheat composite four with the aid of a cone penetrometer to measure bread crumb softness. In this study, 6-cm thick bread slice was placed on the base of the penetrometer for the measurement. Higher penetration units were indicators of increased crumb softness.

3.0 Conclusion

It is a matter of fact that with the use of composite flour, at any percentage level of inclusion, the resulting recipe will certainly exhibit properties markedly different from those of the individual component flours. The determination of dough properties, including rheological was found to be essential for the estimation of dough processing, handling behavior and future bread properties (Tietze, Jekle, & Becker, 2016). Several studies carried out to use cassava flour in bread making have shown that wheat flour can be substituted by 5 to 10 % cassava flour without significant effects on processing and the quality of bread (Aristizábal *et al.* 2017).

References

Abass, A., Onabolu, AO. and Bokanga, M. 1998. Impact of the High Quality Cassava Flour Technology in Nigeria. In Akoroda, MO. and Ngve, JM. (Eds). Root Crops in the 21th Century. Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops Africa Branch (ISTRC- AB). Cotonou, Benin, 11-17

Aguilera, JM., and Park, DJ. 2016. Texture-modifiied Foods for the Elderly: Status, Technology and Opportunities. Trends in Food Science and Technology, 57: 156-164.

Akinlonu, EO. 2011. Nutritional and Sensory Qualities of Novel Dishes from Cassava. Dissertation submitted to the Department of Nutrition and Dietetics. University of Agriculture, Abeokuta, Nigeria.

Alvarez-Jubete, L., Auty, M., Arendt, EK. and Gallagher, E. 2009. Baking properties and microstructure of pseudocereal flours in gluten-free bread formulations. *European Food Research and Technology*, 437.

Aristizábal, J., García, A. and Ospina, B. 2017. Refined Cassava Flour in Bread Making: A Review. Ingeniería e Investigación, 37(1), 25-33.

Berk, Z. 2009. *Food Process Engineering and Technology*. Elservier Academic Press, New York.

Chilungo, S. 2013. Physicochemical Properties and Baking Qualities of Baked Wheat Products Supplemented with Cassava and Pigeon Pea Flours. A Thesis Submitted to Michigan State University in Partial Fulfillment of the Requirements for the Degree of Food Science - Master of Science.

Collar, C., Bollain, C. and Rosell, CM. 2007. Rheological behaviour of formulated breaddoughs during mixing and heating. *Food Science and Technology International*, 13, 99–107

Collares, RM., Miklasevicius, LVS., Bassaco, MM., Salau, Nina, PG., Mazutti, MA., Bisognin, DA. and Terral, LM. 2012. Optimization of Enzymatic Hydrolysis of Cassava to Obtain Fermentable Sugars. *J Zhejiang Univ Sci B*. 13(7): 579–586.

Defloor, I., Nys, M. and Delcour, JA. 1993. Wheat Starch, Cassava Starch, and Cassava Flour Impairment of the Bread Making Potential of Wheat Flour. *Cereal Chem. 78*, 525-30.

Dziedzoave, NT., Abass, A., Amoa-Awua, W., and Sabiah, M. 2010. *Quality Management Manual for Production of High Quality Cassava Flour.* Ibadan, Nigeria: International Institute for Tropical Agriculture.

Eduardo, M., Svanberg, U., Oliveira, J. and Ahrné, L. 2013. Effect of Cassava Flour Characteristics on Properties of Cassava-Wheat-Maize Composite Bread Types. *International Journal of Food Science*. Volume 2013, Article ID 305407, 10 pages

Ekwu, FC., Ngoddy, PO., and Uvere, P. 2011. Functional and Rheological Properties of Cassava Flour Processed by Adaptation of Traditional 'Abacha' Processing Technology. *JORMAR*, 6(1):17-30.

Eriksson, E. 2013. Flour from Three Local Varieties of Cassava (*Manihot Esculenta Crantz*): Physico-chemical Properties, Bread Making Quality and Sensory Evaluation (Master Degree Thesis). *Publikation/Sveriges lantbruksuniversitet, Institutionen för livsmedelsvetenskap, serie no 371 Uppsala*, http://stud.epsilon.slu.se.

Godfray, HCJ., Beddington, JR., Crute, IR., Haddad, L., Lawrence, D. and Muir, JF. 2010. Food Security: the Challenge of Feeding 9 Billion People. Science, 327(5967). 812-818.

Hershey, C., Henry, G., Best, R., and Iglesias, C. 2000. Cassava in Latin America and the Caribbean Resources for Global Development (pp. 1-57).

Ho, LH. and Abdul-Latif, NW. 2016. Nutritional Composition, Physical Properties, and Sensory Evaluation of Cookies Prepared from Wheat Flour and Pitaya (*Hylocereus undatus*) Peel Flour Blends *Cogent Food & Agriculture* (2016), 2: 1136369.

Falade, KO. and Akingbala, JO. 2009. Improved Nutrition and National Development through the Utilization of Cassava. In Robertson, G .L. & Lupien, J. R. (Eds). *Using Food Science and Technology to Improve Nutrition and Promote National Development*. International Union of Food Science & Technology.

Falade, KO and Akingbala, JO. 2011. Utilization of Cassava. F*ood Reviews International*, 27, 51–83

FAO 2016. Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT).

Fellows, PJ. 2000. Food Processing Technology - Principles and Practice. second Edition. Woodhead Publishing Company Ltd. Cambridge, England.

Hadnadev, TD., Torbica, A. and Hadnadev M. 2011. Rheological Properties of Wheat Flour Substitutes/Alternative Crops Assessed by Mixolab. *Procedia Food Science* 1, 328 – 334.

Ibarz, A. and Barbosa-Canovas, GV. 2014. Introduction to Food Process Engineering. CRC Press, New York.

IFAD and FAO 2001. The Global Cassava Development Strategy and Implementation Plan Vol. 1. Proceedings of the Validation Forum on the Global Cassava Development Strategy. Roma: International Fund for Agricultural Development, Food and Agriculture Organization of the United Nations.

IFAD and FAO 2004. *Global cassava market study. Business opportunities for the use of cassava. Proceedings of the validation forum on the global cassava development strategy*. Vol 6. Roma: International Fund for Agricultural Development (IFAD), Food and Agriculture Organization of the United Nations.

Jensen, S., Skibsted, L. H., Kidmose, U. and Thybo, AK. 2015. Addition of cassava flours in bread-Making: Sensory and Textural Evaluation. *LWT. Food Science and Technology*, 60 (*1*), 292-299.

Julianti, E., Rusmarilin, H., and Yusraini, RA. 2016. Functional and rheological properties of composite flour from sweet potato, maize, soybean and xanthan gum. *Journal of the Saudi Society of Agricultural Sciences*.

Kahraman, K., Sakyyan, O., Ozturk, S., Koksel, H., Sumnu, G. and, Dubat, A. 2008.Utilization of mixolab to predict the suitability of flours in terms of cake quality.*European Food Research Technology*, 22**7**, 565–570.

Kareem, ST., Adebowale, AA., Sobukola, OP., Adebisi, MA., Obadina, OA. and Kajihausa, OE. 2015. Some Quality Attributes of High Quality Cassava - Tigernut Composite Flour and its Extruded Snacks. *Journal of Culinary Science and Technology*, Vol. 13 (3), 242 - 252.

Kokse, H., Sivri, D., Ng, PKW., Steffe, JF. 2001. Effects of Transglutaminase Enzyme on Fundamental Rheological Properties of Sound and Bug-damaged Wheat Flour Doughs. *Cereal Chemistry*, 78, pp. 26–30.

Komlaga, GA., Clover-Amengor, M., Dziedzoave, NT., and Hagan, LL. 2012. Consumer Acceptability of Wheat-Cassava Composite Bread. *World Rural Observations*, 4 (2): 79-81.

Korczyk – Szabó, J. and Lacko – Bartošová, M. 2013. Crumb Texture of Spelt Bread. *Journal of Central European Agriculture*, 14(4):1326-1335.

Letang, C., Piau, M. and Verdier, C. 1999. Characterization of Wheat Flour-water Doughs. *Part I, Rheometry and microstructure, Journal of Food Engineering*, 41, pp. 121–132.

Miyazaki, M., Hung, PV., Maeda, T. and Morita, N. 2006. Recent Advances in Application of Modified Starches for Bread Making. *Trends in Food Science and Technology*, 17: 591-599.

Moreira, R., Chenlo, F., Torres, MD. and Prieto, DM. 2010. Influence of the Particle Size on the Rheological Behavior of Chestnut Flour Dough. *Journal of Food Engineering*, 100, pp. 270–277.

Noorfarahzilah, M., Lee, JS., Sharifudin, MS., Mohd-Fadzelly, AB. and Hasmadi, M. 2014. Applications of Composite Flour in Development of Food Products. *International Food Research Journal* 21(6): 2061-2074.

Nwokocha, LM., Aviara, NA., Senan, C. and Williams, PA. 2009. A Comparative Study of Some Properties of Cassava (*Manihot esculenta, Crantz)* and Cocoyam (*Colocasia esculenta, Linn*) Starches.. Carbohydrate Polymers 76, 362–367.

Okafor, N., Azubike, C. and Ibenegbu, C. 1999. Carriers for Starter Cultures for the Production of Garri, a Fermented Food Derived from Cassava. *World Journal of Microbiology & Biotechnology*, 15: 231-234.

Okafor, JN., Ozumba, AU. and Solomon, HM. 2002. Production and Acceptability of Chinchin Fortified with Oyster Mushroom. *Nigeria Food Journal, 18*, 19–20.

Onyango, C., Mutungi, C., Unbehend, G. and Lindhauer, MG. 2011. Modification of Gluten-free Sorghum Batter and Bread Using Maize, Potato, Cassava or Rice Starch. LWT - Food Science and Technology, 44, 681-686.

Oyewole, OB. 2002. The Powers at the Roots: Food and Its Microbials Allies. 15th Inaugural lecture University of Agriculture, Abeokuta, Nigeria.

Riley-Mitchell, D., Badrie, N. and Yarde, J. 2012. Cassava *(Manihot esculenta Crantz)*-Wheat Flour Composite Muffins: Effects on Quality and Sensory Characteristics. Tropical Agriculture (Trinidad) Vol. 89 No. 2, 104 - 112.

Sabovics, M., Straumite, E. and Galoburda R. 2011. Assessment of the Rheological Properties of Flour Using the Mixolab. FOOTBALT . 2011 p33-38.

Sanni, LO., Adebowale, AA., Awoyale, W. and Fetuga, GO. 2008. Quality of Gari (Roasted Cassava Mash) in Lagos State, Nigeria. *Nigeria Food Journal*. 26(2) 125-134

Sciarini, LS., Ribotta, PD., Leon, AE. and Perez, GT. 2010. Influence of Gluten-free Flours and their Mixtures on Batter Properties and Bread Quality. *Food Bioprocess Technology*, 3: 577-585.

Shittu, TA., Dixon, A., Awonorin, SO., Sanni, LO. and Maziya-Dixon, B. 2008. Bread from Composite Cassava–Wheat Flour II: Effect of Cassava Genotype and Nitrogen Fertilizer on Bread Quality. *Food Research International* 41, 569–578

Stoenescu, G., Ionescu, VS. and Banu, I. 2012. Rheological Properties of the Wheat Flour Supplemented with Different Additives. *The Annals of the University Dunarea de Jos of Galati Fascicle VI – Food Technology* 35(1) 54-62.

Tietze, S., Jekle, M. and Becker, T. 2016. Possibilities to Derive Empirical Dough Characteristics from Fundamental Rheology. *Trends in Food Science and Technology*, doi: 10.1016/j.tifs.2016.08.016.

Tuceryan, M. and Jain, AK. 1998. Texture Analysis. In C. H. Chen, & L. F. Pau, *The Handbook of Pattern Recognition and Computer Vision (2nd Edition)* (pp. pp. 207-248). USA: World Scientific Publishing Company.

Urbicain, MJ. and Lozano, JE. 1997. Thermal and Rheological Properties of Foodstuffs in *Handbook of Food Engineerig Practice*. CRC Press New York.

Ukwuru, MU. and Egbonu, SE. 2013. Recent Development in Cassava-based Products Research. *Academic Journal of Food Research*, 1(1), 1-13.