POTENTIALS OF CASSAVA, BAMBARA GROUNDNUT AND TIGERNUT IN BISCUIT PRODUCTION: A REVIEW

ABSTRACT

With various changes in lifestyle and urbanization in the developing countries, the consumption of biscuit and the development of food products using composite flour have increased and are attracting much attention from researchers in bakery and pastry productions. This work reviewed the potentials of cassava, bambara groundnut and tigernut composite flours in biscuit production**.** Studies on the substitution of wheat flour with flours from different sources of tubers, legumes, cereals and fruit in different percentages to produce variety of food products are also reported in this review. It was revealed that composite flour from cassava, bambara groundnut and tigernut used to produce biscuit products is capable of maintaining similar characteristics to products made from full-wheat flour. The positive effects of the use of composite flour is observed in the final product in terms of its functional and physicochemical properties and health benefits of raw blended flour along with percentage blending. Finally, composite flour is a good new approach to utilizing uncommon food products as the application of composite flour produced products with different characteristics and quality, depending on the types and percentage of wheat flour used in the formulation. Some possible challenges likely to be encountered in case Nigeria changes from use of wheat flour to composite flours and blends of non-wheat flours are also discussed.

Keywords: Composite flour, products, challenges, potential, biscuit, cassava, bambara groundnut and tigernut

INTRODUCTION

Consumption of biscuit and other baked aerated wheat flour products has spread in Nigeria and other developing countries of the world (Milligan *et al*., 2011). Wheat which is popular and unique among other cereals for making biscuit and other aerated baked products can only grow in very few developing countries (Robertson *et al*., 2005). In the bid to lower wheat flour importation in Nigeria, the government has encouraged the use of composite flours and blends of non-wheat flours for the production of aerated products such as bread, biscuit, cake and doughnut. It is therefore of economic importance if wheat importation is reduced by substitution with other locally available raw materials such as cassava, maize, potato, millet, and other legume flours like soy bean, Bambara groundnut, and pigeon pea (Milligan *et al*., 2011).

(Robertson *et al*., 2005) defined composite flour as a mixture of flours, starches and other ingredients intended to replace wheat flour totally or partially in bakery and pastry products. The use of composite flours had advantages in terms of saving 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 (Robertson *et al*., 2003). Composite flour is made by blending or mixing varying proportion of more than one non-wheat flour with or without wheat flour and used for production of leavened or unleavened baked or snack products that are traditionally made from wheat flour and increase the essential nutrients in human diet composite flour (Robertson *et al*., 2005).

Composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the use of locally grown crops as flour. Local raw materials substitution for wheat flour is increasing due to the growing market for confectioneries (Eleazu *et al.*, 2011). Thus, several developing countries have encouraged the initiation of programmes to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour (Abdelghafor *et al*., 2011).

Cassava or manioc is a woody shrub of the Euphorbiaceous (Spurge) family. The root crop is a source of livelihood for at least 300 million people. Virtually all cassava (90%) produced in Africa is used as a staple food for human consumption, providing calories for 500 million people and constituting 37% of the population’s dietary energy requirements (IITA, 2015).

Bambara groundnut (also spelt Bambarra) groundnut originated in West Africa and is still a traditional food plant in Africa. As an indigenous tropical crop, **b**ambara groundnut is cultivated in Nigeria. It is grown in areas such as Enugu state, many northern states and some parts of South West Nigeria. Bambara groundnut is a very important crop, but it is not a lucrative cash crop despite being the third most important legume in most of Africa after peanuts and cowpeas. The seed is a balanced food because when compared to most food legumes, it is rich in iron, the protein contains high lysine and methionine (Hasmadi, 2014).

Tigernut (*Cyperusesculentus*), an underutilized crop, was reported to be high in dietary fibre content, which could be effective in the treatment and prevention of many diseases including colon cancer, coronary heart diseases, obesity, diabetics and gastro intestinal disorders (Fadeyibi, 2012). Tigernut flour has been demonstrated to be a rich source of quality oil and contains moderate amount of protein. It is also an excellent source of some useful minerals such as iron and calcium which are essential for body growth and development. Its tubers are also said to be aphrodisiac, carminative, diuretic, emmenagogue, stimulant and tonic (Fadeyibi, 2012).

Effective processing and utilization of flour blends of locally grown crops based on nutrient complementary will be one of the ways of addressing the world food problem and insecurity. This will also help to combat the high rate of post harvest losses experienced in the country (Alakali *et al*., 2012).

Composite flour is innovative flour that has attracted much attention in research as well as food product development (Alakali *et al*., 2012). It is defined as a mixture of flours obtained from tubers which are rich in starch such as cassava, yam, potato, and protein-rich flour and cereals, with or without wheat flour. For example, wheat and cassava (El-Sharkawy, 2014; Nwodo and

Obinna, 2012), wheat and many legumes (Butt *et al*.,2011), millet (Abass *et al*., 2017) or without wheat flour and other composites (Zhao *et al*., 2005). Composite flour has better nutritional value been reported to have in terms of minerals, vitamins, fibres and proteins than flour milled from any specific cereal alone (Butt *et al*.,2011). (Dendy, 1993) reported that the composite flour mixture could provide a balanced nutrient in a few years. Recently, composite flour became the subject of numerous studies. There has been increasing interest in replacing conventional gluten-free formulations made from refined gluten-free flour, starch, and hydrocolloids with those enriched with functional gluten-free ingredients (Ogunbawo, 2018). The use of composite flour to produce baked goods, if feasible, would help to lessen total dependence on imported wheat.

In 1964, the FAO (Food and Agriculture Organization of the United Nations) introduced the Composite Flour Programme that aimed at the development of bakery products from locally available materials. In developing countries such as Africa and other parts of the world. The use of composite flours had many benefits in saving of hard currency and as a promotion of high yielding of native plant species. Besides that, (Mepba and Nwaojigwa, 2007) also stated that the use of composite flour would promote better overall use of domestic agricultural production. According to (Odedeji and Adeleke, 2010), there are two significant reasons for mixing the wheat flour with other flours; economic and nutritional. The capability, availability, and cost at the point of use are the most important things overlooked in selecting the raw material to produce good flour blends in terms of preference, variety, nutrition, and low cost as to fulfill consumer demands (Odedeji and Adeleke, 2010).

Protein is believed to be mostly responsible for functional properties, such as foaming, emulsification, nitrogen solubility, oil, and water absorption (Begum *et al*., 2013). These properties are affected by the intrinsic factors of protein, such as molecular structure and size, and many environmental factors, including the method of protein separation or production (Adeloye, 2012). The low protein content and absence of gluten in some composite flours are considered disadvantageous for its exclusive use in food products, especially in those where the elasticity of the dough is essential for product quality. The percentage of wheat flour required to achieve a specific effect in composite flours depends heavily on the quality and quantity of wheat gluten and the nature of the product involved (Adeniyi, 2012).

Potentials of Cassava flour in baking

Efforts are being made to partially replace wheat flour in commercial food products with non-wheat flours, as a promising means to increase utilization of indigenous crops. In view of this, physicochemical and functional properties of Cassava Flour (CF) have been studied to maximize its industrial use. The functional properties of cassava and soy flour blends were studied by (Marti *et al*., 2010) It was observed that Cassava Flour (CF) had less capacity than soy flour (SF) to bind and retain water as well as oil. The high water and oil absorption capacity of SF was explained by the high protein content of soybeans.(Ahmed *et al*.,2010) reported that soy protein absorbs water up to 200% its weight whereas carbohydrate absorbs only 15% of its weight in water.

(Marti *et al*., 2010) further reported that the water and oil absorption capacities of the SF:CF blends increased with increasing levels of SF. The flour blends had greater water and oil absorption capacities than the CF alone. The properties may give an advantage to the blends comparative to CF in baked doughs where hydration to improve handling characteristics is required. Dough rheology studies showed that the dough development times for cassava and wheat flour blends were shorter than for the 100% wheat flour (WF), and decreased as the extent of substitution with CF increased (Marti *et al*., 2010).

This was correlated with dilution of gluten caused by the addition of the CF, and also indicated that water uptake by the various components present in the CF was faster. Dough stability, which indicates how much additional mixing can be applied to a dough sample before it begins to break down, was much lower for 12 doughs made with the flour blends than with 100% WF, suggesting an overall weakening of the doughs with increased substitution of CF (Marti *et al*., 2010).

Evaluation of the physicochemical properties of biscuits made from wheat-cassava flour blends showed that increase in the levels of CF resulted in decrease in protein content from 13.04% in 100% WF biscuits to 8.4% in 40% CF: 60% WF biscuits (Ahmed *et al*.,2010). This was attributed to the low protein content of the CF (1-2%) which would have lowered the protein content of the wheat-cassava flour blend. Addition of 10% soy flour (SF) to CF resulted in increase in protein and fat contents of cookies thus improving the nutritive value of the cassava cookies (Marti *et al*., 2010).

For example, the 100% CF biscuits contained 1.6% protein and 10.7% fat. These values increased to 32.2% protein and 30.5% fat respectively for the 20:80 (CF: SF) biscuits which had the highest level of SF incorporation (Marti *et al*., 2010). Addition of CF to SF resulted in reduced color, crispiness, taste and flavor of biscuits, but increases in diameter, spread ratio and height of the biscuits were observed as cassava level was increased (Marti *et al*., 2010).. The increase in diameter and spread ratio was due to the starch polymer of cassava whose molecules is loosely connected and expands more when heated (Yetunde *et al*., 2009)

Notably, there was no significant difference in the overall acceptability between biscuits made with 100% WF and those made with the wheatcassava-soy flour blend. The findings strengthen the possibility of using cassava flour in biscuit making. Loaf volume of biscuit largely depends on the gluten content of wheat flour. This is the reason why wheat is the unique raw material for bread making. When gluten is hydrated, it forms a viscoelastic network that retains more gas during baking, hence yielding an increased biscuit loaf volume (Zuwariah and Noor, 2009).

Also, the use of composite flour, like cassava and wheat flour blend has resulted in reduced loaf volume. The reason for the reduced volume was the dilution of gluten protein as more cassava flour was added. Despite the reduced volume, differences in consumer preference for wheat biscuit and composite flour biscuit were not significant, thus acceptable biscuit can be made from composite wheat-cassava flour (Ferial, 2011).Unfortunately, Hydrogen cyanide is a poisonous substance that is found in cassava roots and therefore its content in baked products made from cassava must be assessed to avoid food poisoning (Ferial, 2011).

(Etejer and Bhat ,1985) reported that the hydrocyanic acid content (HCN) of the biscuits increased as the level of cassava flour increased in the formulation. With 70% CF biscuits having the highest HCN value of 0.02 mg/kg of product. The observed HCN content is below the maximum allowable level of 1 mg/100 g of flour recommended by the Codex Alimentarius Commission thus making the biscuits safe for human consumption.

Potentials of Bambara groundnut flour in baking

Different snack products have been produced from flour blends of bambara groundnut and other ingredients with bambara groundnut as the major source of protein. (Falade and Akingbala, 2010) produced *akpekpa* (similar to *okpa*) from flour blends of bambara groundnut, cassava, and soybean at different levels (100:0:0, 80:20:0, 80:0:20, and 70:15:15) and reported protein content varying between 14.25% and 16.25%; the high protein content of the product is as a result of bambara groundnut and soybean but more from bambara groundnut due to its high proportion in the product. Based on sensory scores, the most acceptable product (80:20:0) was that containing 80% bambara groundnut.

(Balagopalan, 2002) produced snacks from composite flours of unripe plantain, bambara groundnut and turmeric. The ratio of bambara groundnut in the different formulations ranged from 35% to 100%. The protein content from the different formulations ranged from 4.23% to 14.81%. This implied that the increase in protein content was dependent on the quantity of bambara groundnut in the formulation.

(Anderson *et al*., 2009) produced deep fried snacks from bambara groundnut flour and paste and reported protein content of 23.41 and 19.35 g/100 g respectively in the products. The decrease in the protein content of the flour after snack production was attributed to heat and Maillard browning.

Doughnut is a wheat-based snack that has been produced by substitution of wheat flour with bambara groundnut flour. (Weickert and Pfeiffer, 2008) prepared doughnuts from composite flour blends of wheat and bambara groundnut mixed at different ratios (90:10, 80:20, 70:30, and 0:100) and reported a protein content of 10.88–11.78%. The protein content increased with the increase in the quantity of bambara groundnut flour. On sensory evaluation, the product with 10% bambara groundnut flour was most acceptable.

Bread is a commonly consumed staple food, which is produced from wheat flour. Many researchers have substituted wheat flour with bambara groundnut flour in bread production.

(Masood *et al*.,2011) produced bread by replacing wheat flour with different proportions of *acha* and bambara groundnut sourdough flours (0, 5:5, 10:10, and 15:15) and reported protein content of 14.0–16.48%. Improvement of amino acids content compared with white bread was reported (contribution of dietary reference intakes of 50.29–71.65 for protein in male and female was also reported). The sourdough flours' substitution (10%) in bread significantly increased sensory properties (taste and flavour). (Mahala and Mohammed, 2015) incorporated bambara groundnut flour at different levels (10%, 20%, and 30%) in *kissra* bread production. The control *kissra* (13.37 g/100 g) had lower protein content compared with the fortified *kissra* with the different levels (17.93%, 19.38%, and 20.23%, respectively) of bambara groundnut flour fortification, which could be associated with the high protein content (24.53 g/100 g) of the bambara groundnut flour used for the fortification. This result is in agreement with (Martin-Esparza *et al*., 2013), who found significant improvement in the protein content of bread fortified with bambara groundnut. According to these authors, bread fortified with 15% of bambara groundnut flour inclusion was the most acceptable.

(Baljeet *et al*., 2014) also produced bread from composite flour blends of whole wheat and bambara groundnut at different proportions (100:0, 90:10, 80:20, 70:30, and 60:40). The increase in protein content (8.65–18.41%) was attributed to the increase in the quantity of bambara groundnut flour in the blend. The sample with the highest quantity (40%) of bambara groundnut was least acceptable compared with the sample with the least quantity (10%) of bambara groundnut.

(Best *et al*., 1988) produced extruded snacks from flours of bambara groundnut seeds that have been given different treatments (germination and roasting). The raw bambara groundnut had the least protein content (21.85%) compared with the roasted (23.09%) and germinated–roasted (23.20%). Roasting improved sensory properties such as taste and flavour.

Bambara groundnut has also been used in enriching breakfast cereal and extruded products.

(Mongi *et al*., 2011) prepared pasta from composite flour blends of partially gelatinized wheat, cassava, and bambara groundnut in different proportions (100:0:0, 64:10:26, 60:12:28, 56:14:30, 52:16:32, and 48:18:34). The protein content (16.20–17.85%) of the pasta was found to increase with increasing quantity of bambara groundnut flour. Although the protein content increased, the sensory properties of the pasta containing high quantity (30%, 32%, and 34%) of bambara groundnut were less acceptable compared with blends containing low quantity (26% and 28%) of bambara groundnut. The blends containing lesser quantity of bambara groundnut compared well with the blend containing 100% wheat flour (control). Bambara groundnut flour has also been reportedly used in enriching breakfast cereal produced from sorghum malt, which could be used in combating protein-energy malnutrition in children (Moore *et al*., 2006).

(Venho *et al*., 2020) also produced a protein-rich extruded product from the flour blend of sorghum and bambara groundnut in different proportions (90:10, 80:20, and 70:30) and reported that increase in quantity of bambara groundnut flour resulted in increase in protein content.

Use of bambara groundnut in enriching traditional foods

Traditional foods are highly relished by rural dwellers as well as people living in urban areas especially when the food is prepared under hygienic conditions. These foods have become part of the diet of many, and efforts have been made to improve their nutritional value either through fermentation or the addition of protein-rich grain such as bambara groundnut. For example, *fura* (millet flour-based food) was fortified with bambara groundnut and the fortified product showed adequate quantities of essential amino acids with higher lysine content compared with the control sample (Defloor *et al*., 1994). Some authors reported marginal increase (~8%) in protein content for *fura* fortified with 30% bambara groundnut (Olanipekun *et al*., 2012). Another important traditionally fermented food that is commonly consumed in Africa is *fufu*. *Fufu*, a staple food is a fermented cassava product, which is usually boiled before consumption (Wardlaw and Kessel, 2012; Basman and Koksel, 2003; Shogren, 2007).

(Ferial, 2011) supplemented *fufu* with bambara groundnut flour at different levels (10%, 20%, 30%, 40%, and 50%) and reported increased protein content (13.35–18.87%). The protein content increased with the increase in the quantity of bambara groundnut flour. However, based on sensory evaluation, the sample with 10% substitution of bambara groundnut was the most preferred.

(Kweon *et al*., 2010)) prepared meat analogue from flour blends of bambara groundnut flour or bambara groundnut protein isolate and African yam bean at different proportions (50:50, 60:40, and 40:60). Meat analogue was also prepared from 100% bambara groundnut flour, bambara groundnut protein isolate, and African yam bean. The sample with 100% bambara groundnut protein isolate had the highest protein content (36.4%) whereas other samples had lower protein content (20.0% to 34.3%). However, on sensory evaluation, the samples with bambara groundnut flour had higher mean scores compared with samples containing bambara groundnut protein isolate.

(Faridi and Faubion, 2015) improved *acha*-based biscuit with bambara groundnut and unripe plantain (100:0:0, 80:10:10, 70:20:10, 60:30:10, and 50:40:10) and reported acceptable sensory properties (colour, taste, flavour, texture, and crispness) of the product. The protein content ranged between 5.30% and 7.51%. The product was also suitable for diabetic patients.

(Perez *et al.,* 2013)fermented bambara groundnut flour using *Rhizopus oligosporus* and *Rhizopus nigricans* and reported that fermentation within 3 days improved the nutritive value (the protein increased from 18.66–22.60%). Bambara groundnut flour was recommended as a supplement in the diet. It was concluded that it could play a role in preventing cardiovascular diseases and obesity.

(Perez *et al.,* 2013) produced composite flour blends from wheat, cocoyam, and bambara groundnut (60:30:10 and 72:19:9). The protein content ranged from 11.11% to 20.35%. Addition of bambara groundnut improved the protein content of the composite flour blends. (Slade *et al*., 2013) produced extruded food product from a blend of white yam meal and bambara groundnut meal at a ratio of 80:20. (Slade *et al*., 2013) prepared extruded snack from composite flour blends of bambara groundnut, corn bran, and cassava starch and reported protein content of 3.26—17.62%, which was attributed to bambara groundnut. It was concluded that bambara groundnut is a nutritious legume because it resulted in a protein dense product. (Bukusu *et al*., 2021) produced extruded products from orange-fleshed sweet potato and bambara groundnut and reported that an increase in quantity of bambara groundnut resulted in an increase in the protein content (4.08—15.03%) of the product. (Brites *et al*., 2007) produced biscuits from different ratios (100:0:0, 0:100:0, 0:0:100, 40:30:30, 30:30:40, and 50:40:10) of flour blends of wheat, bambara groundnut, and aerial yam and reported protein content of 7.90–17.08%. The protein content increased with the increase in the quantity of bambara groundnut flour. The sample with the ratio 40:30:30 was moderately accepted.

Potentials of Tigernut flour in baking

Tigernut flour has a unique sweet taste, which is ideal for different uses. It is a good alternative to many other flours like wheat flour, as it is gluten free and good for people who cannot take gluten in their diets. It is also used in the confectionery industry (Mepba *et al*., 2007; Martin-esparza *et al*., 2013). It is considered good flour or additive for the bakery industry, as its natural sugar content is fairly high, avoiding the necessity of adding too much extra sugar (Martin-esparza et al., 2013). Also, it can be used as a flavoring agent for ice cream and biscuits (Martin-esparza et al., 2013). In the Keta area of Ghana, the sun-dried tubers are ground to a fine powder to which sugar can be added to be stored till required.

Roasted tubers may be similarly ground to a powder known in Vhe (Awlan) as fie-dzowe. These meals may be eaten alone or with water added to make a beverage (Falade and Omojola, 2010). In addition, tigernut has been demonstrated to contain higher essential amino acids than those proposed in the protein standard by the FAO/WHO (Ferial, 2011) for satisfying adult needs. Therefore, tigernut, with its inherent nutritional and therapeutic advantage, could serve as good alternative to cassava in the baking industry (Falade and Akingbala, 2010).

Furthermore, tigernut flour does not lose any of its nutritious properties in the milling process. The fine ground tigernut flour gives baits a smooth, creamy texture with a distinctive taste and can be incorporated into any mix as base ingredient, allowing baits to retain moisture (Venho et al.,2020) . Incidentally, cutting part or all of the skins off tigernut hook baits makes them more effective. Part of tigernuts' attraction is that they are rich in lysine, a major fish feeding stimulant though tigernuts also contain many other extremely important and stimulatory dietary essential amino acids for fish, including methionine, cystine, arginine and histidine (Anderson *et al*., 2009; Weickert and Pfeiffer, 2008).

The composition of tigernut is characterized by high contents of insoluble fiber and unsaturated fat and with relatively low concentration of starch (Zanoni et al., 2020). (Watson, 2019) used a combination of tigernut and chickpea flour to replace emulsifier and/or shortening partially or totally in GF batters or doughs and breads formulations, and reported acceptable specific volume and darker crust in the GF products. (Wanatabe, 2019) reported that tigernut flour added up to 25% to the rice flour increased the gelatinization temperatures in GF bread, while a significant reduction of the onset gelatinization temperature and peak temperature was observed when tigernut flour was added to corn-based biscuits. (Aluko and Olugbemi, 2018) reported the effect of a selection of hydrocolloids on the dough rheology, texture properties and cooking performances of GF noodles made by tigernut. Only one study has reported using tigernut as food ingredient to produce extrudates. The authors found the mixes of TN-cassava used in their study difficult to extrude as the TN concentration increased in the mixes, due to the high content of insoluble fiber and fat present in tigernut, that caused pressure drop in the extruder barrel and reduced expansion. Moreover, focusing on the sensory quality of GF cereal-based foodstuffs, TN incorporation (20%) produced the highest overall acceptability scores of corn-made biscuits. It is known that insoluble fiber reduce expansion, while soluble fiber tends to increase the expansion of the extrudate, and that fat content can cause slippage of melt into the barrel with consequent low pressure at the die exit (Andrae, 2015).

Relationship between flour quality and baked-product quality

For analyzing the relationship between flour quality and baked-product quality, dough rheology methods (farinography, mixography, extensography, alveography) and baking tests (bread, cookies, cakes) have been used widely and traditionally. Among the dough rheology methods, farinography and mixography are typically used to obtain information on a flour's water absorption and the mixing time of a dough, as related to gluten development (Weipert and Lindhauer, 2021).

In these two methods, different amounts of water were added to achieve constant dough consistency. In contrast, in extensography and conventional alveography, a constant amount of water is added, regardless of the actual water absorption of a given flour, in order to obtain information on the flour's dough-forming properties and gluten strength (Wood, 2019). In order to evaluate the biscuit-baking quality of soft wheat flours, cookie-baking analyses are often used. Although traditional sugar-snap cookie-baking benchtop methods [AACC Methods 10-50D and 10-52 have been used in most previously published research studies on cookie-baking.

(Slade *et al.*, 2013) reported that wire-cut cookie-baking showed a much more sensitive response to changing ingredients (e.g., trans-fat and zero-trans-fat shortening) compared with sugar-snap cookie-baking. That is, the wire-cut cookie method is more capable of discriminating between different flours, as they respond to the operating environment of the cookie dough, and of demonstrating the effects of contributions from non-flour ingredients to that environment. The AACC sugar-snap and wire-cut cookie formulas differ significantly and importantly with respect to sugar concentration [%S = formula level of sugar/(sugar + water), baker's % (100 parts-by-weight flour) basis] and amount of total solvent (TS = formula levels of sugar + water, baker's % basis). The sugar-snap cookie formula ordinarily contains 73%S and 82 TS, while the wire-cut cookie formula ordinarily contains 66%S and 64 TS (Baljeet *et al.*,2020)

Compared with the above-described cookie-baking methods, a benchtop cracker-baking method has not been widely explored or implemented as an Official Method, due to hurdles, including the difficulty in finding ideal diagnostic flours and the absence of suitable benchtop equipment (e.g., powerful dough mixer, dough sheeter, multizone oven).

In general, there are three major types of crackers: saltine, chemically leavened, and savory (Ayodele and Aladesanmi, 2013). Most previous publications on crackers have dealt with saltine and soda crackers, which are typically prepared by sponge-and-dough processes (Slade *et al.*, 2013). Typical sponge- ´ and-dough processes for preparing saltine and savory crackers usually require about 24 hours, due to the need for a prolonged (19-hour sponge) fermentation time. In comparison, chemically leavened crackers ordinarily do not require a fermentation step, and their processing is relatively easy and simple to manage. Development of a benchtop method for chemically leavened crackers would enable one to use such a method as a predictive tool for evaluating gluten functionality in flours for crackers. Thus, to satisfy a longstanding demand from academia and industry for a benchtop baking method to predict the contribution of gluten functionality/performance to overall flour performance for cracker-baking,

(Aniedu and Omodamiro, 2012) recently identified and reported a diagnostic formula and procedure for a benchtop method for producing chemically leavened crackers, and validated the method using different flours. Through future planned collaborative studies by the Soft Wheat Flour and Product Technical Committee of AACC International, this method will hopefully be implemented as an Official AACC Method. Even though empirical rheological and baking tests are so widely used, they all measure, in one way or another, only the combined contributions of the major flour functional components, which include damaged starch, gluten proteins, and arabinoxylans (i.e., "pentosans"), rather than the individual functional contribution of each of those components. The ability to analyze the individual functional contribution of each functional component of flour would enable end-users to better predict flour functionality and improve biscuit quality, through a deeper understanding of dough mixing and cookie/cracker-baking mechanisms (Ali *et al*, 2020).

As a valuable tool for measuring flour functionality for soft wheat applications, the solvent retention capacity (SRC) method was conceived and developed by (Watson, 2019) and then implemented as an Official AACC Method. The SRC test is a solvation assay for flours, based on the enhanced swelling behavior of individual polymer networks in selected single diagnostic solvents—water, 5% weight/weight lactic acid in water (for gluten), 5% w/w sodium carbonate in water (for damaged starch), and 50% w/w sucrose in water (for pentosans)—which are used to predict the functional contribution of each individual flour component. The SRC method is increasingly used by wheat breeders, millers, and bakers, and the relationships between flour SRC profiles, cookie and cracker quality have recently been widely reported (Menon *et al*., 2014).

COMPOSITIONAL EFFECT ON QUALITY CHARACTERISTICS OF BISCUIT.

(Ali *et al*., 2020) studied the effect of baking on protein quality of high protein biscuits made from wheat and groundnut flour supplemented with lysine rich flour such as soybean, wheat germ and pea. They found baking caused 13-35.3% loss in protein efficiency ratio (PER) in various type of biscuits. They developed high protein biscuits using wheat, groundnut and soybean flour in ratio of 55:20:25. The percentage of moisture, crude fibre, ash, protein (N × 6.25) and reducing sugar were found to be 7.5, 3.33, 5.58 and 0.52,.Calcium and phosphorous content of biscuit were 439 and 228g/100g, respectively. Calcium and phosphorous content ion baked and unbaked biscuit was 4.8 and 4.8g/100g protein, respectively. Whereas the available lysine in biscuit was 3.44g/100g (Ahmed *et al*.,2012)

Scientist also evaluated the high protein cookies prepared by adding 33% defatted soy flour and 27% peanut butter. The proximate composition of protein was 1.5%, fat 22.4%, moisture 4.7%, ash 2.4%, fibres 1.5% and carbohydrates 54.21%. The calculated energy content of cookies was 48 kcal/100g. Addition of soy and peanut butter substantially improved the micronutrient except thiamine, which were 5.25 times higher than those in wheat flour. The Ca, P and Fe, content of cookies were 49.1, 1.82 and 2.76mg/100g, respectively (Aluko *et al.*, 2018).

(Andrae and Beckman, 2015) prepared biscuits containing wheat, breadfruit flour, soy protein, whey and found that biscuits containing 10% breadfruit flour, soy protein were judged more acceptable in flavor, color and texture. (Weipert amd Lindhauer, 2021) in the study on biscuit baking properties of composite flours containing varying levels of 0, 5, 10, 15, 20 and 25% untreated, heat-treated and germinated black gram flour (BGF) separately indicated that the diameter and thickness of biscuits gradually reduced with increasing quantity of BGFs. The hardness values significantly increased on incorporation of 25% of all the three differently processed BGFs.

The organoleptic studies inferred that 10% of untreated, 15% of heat-treated and 10% of germinated BGFs were optimum acceptable levels for fortification. Use of 35% sugar, 22.5% fat and 0.5% sodium stearoyal-2 lactylate improved significantly the biscuit baking quality. In general, biscuits made from composite flour containing 15% heat treated BGF, and optimized biscuit formulation were better than those made from 10% of untreated or germinated BGFs (Andrae and Beckman, 2015).

(Ahmed et al., 2012) evaluated the wheat flour and soy-fortified biscuits prepared with standardized levels of ingredients and emulsifiers (SSL and/or GMS) for chemical composition, *in vitro* digestibility and PER. Addition of 20% defatted soy flour in the recipe increased the protein, ash, crude fibre, calcium, phosphorus, iron, sugar (reducing and non-reducing) and available calcium, phosphorus, iron, sugar (reducing and non-reducing) and available lysine contents of biscuits. No trypsin inhibitor activity was found in soy biscuits but had marginally higher non-enzymatic browning than the control samples. The *in vitro* digestibility values of control and soy biscuits were found to be 68.46% and 83.82% respectively. The PER of soy biscuits (1.41) had improved to a greater extent, which could be attributed to the higher levels of protein and available lysine content in defatted soy flour.

(Adebayo, 2012) evaluated replacement of wheat flour up to 40% level with defatted soy flour in the standard sweet biscuits recipe, which increased the protein content from 6.02 to 14.8%, bending hardness from 3.60 to 9.80 N and cutting hardness from 6.02 to 23.04 N of the biscuits. Sensory evaluation showed that all of the biscuits from various blends were acceptable with no significant difference among them.

(Wang *et al*., 2010) studied on biscuits containing finger millet flour indicated that a moisture content of 5% equilibrating to 32% Rh was critical with respect to storage stability of the product. Shelf life of biscuits were 75 and 50 days at 90% Rh, 38°C, when packed in double pack of polypropylene/pearlized BOPP and metalized polyester/poly laminate pack, respectively and over 120 days at 60% Rh, 27^{o}C in both types of packs. Their sorption characteristics and shelf life were comparable to that of conventional glucose biscuits.

(Akanbi *et al*., 2021) evaluated the nutritional quality of biscuits enriched with spray dried egg powder, before and after storage for 6 months under ambient temperature (20-30^{o}C). The food intake, weight gain of rats and PER of the biscuits enriched with spray dried egg powder were evaluated by rat feeding trails and compared with those from popular brand biscuits. Protein enrichment resulted in a 3-fold increase in the PER value compared to control. Egg although being an excellent source of protein, the PER value was not found to be at par with casein because of the fortification being done at low levels, to maintain acceptable sensory attributes.

Possible challenges of the use of composite flour and blends of wheat less flours

Several challenges could be encountered in the implementation of cassava-wheat composite biscuit policy. One of them is the policy itself. The Nigerian wheat policies have changed at least five times since 1979. The policy has changed from successive Government during this period.

Hence, stakeholders are skeptical of the stability of the current policy. Cassava milling is quite different from wheat milling. The implementation of the policy will require major modification of the mills, which could be costly. It will also require the training of millers and bakers, which the government has already started (Amnar *et al*., 2019)

The full implementation of the Nigerian cassava biscuit policy will require 1200 metric tonnes of HQCF per annum. The country had failed to implement 5-10% cassava inclusion policy in the past. It is therefore inconceivable that such a country will attempt to implement 40%. Studies have shown that at 10% inclusion, biscuit of adequate quality can be produced without the need of improvers. But at 40%, improvers will be required. These improvers are not produced in Nigeria, but will have to be imported at high costs (Singh *et al*.,2020)

The Nigerian biscuit policy was specific on the use of cassava for the production of composite bread. But as part of the agricultural transformation agenda (ATA) of the present and immediate past government, cassava have been used mostly for food (85 – 90% of total production), feed composition (mostly fish and poultry) and for manufacturing purposes such as textile, paper, beverages, glue/gum industry. Also, the same government have implemented the Nigeria biofuel policy, which selected cassava for the production of fuel ethanol for transportation (Ohimain, 2012) and cooking purposes. With all these multiple uses of cassava, it is doubtful if the quality of flour required by the millers could be met. In Nigeria, HQCF is mostly supplied by smallholders (Nti and Plahar, 2016). These smallholders were unable to supply the 200,000 – 300,000 tonnes of HQCF needed for 10% cassava flour inclusion in composite flour(Heller *et al*., 2017) . Hence, 40% will present a greater challenge. Other local alternative crops such as yam, maize, sweet potatoes and cowpea are also in short supply (FAO, 2019). In addition, most of the Nigerian mills are controlled by wheat traders and others with negative views on composite flour (Dendy, 1993)

(Aboaba and Obakpolor, 2020) summarized some of the major problems threatening the cassava biscuit policy to include weak HQCF supply chains, strong consumer preference for 100% wheat bread, and the reluctance of millers to use composite flour. Some bakeries that have used composite flour in the past had reported some quality challenges including high sand content, foul odour, shorter product shelf life, gradual discoloration, unreliable supply, brittleness and poor final product quality due to the use of partially fermented cassava flour (Aboaba and Obakpolor, 2020).

These are possible challenges that may likely arise if the use of composite and wheatless flours are enforced for making of leavened and unleavened baked products in Nigeria.

1. There may not be adequate and ready availability of the non-wheat crops (e.g. cassava) for the production of composite flours.
2. Unwillingness of multinational companies operating in Nigeria to incorporate non-wheat flours for composite flour production, as this will reduce the quantity of wheat they import and the profit their parent companies make from sale of wheat.
3. Acceptability of the products baked with composite flours and blends of wheatless flours by Nigerians will be difficult. Most Nigerians have a penchant for imported items or foreign made products. They may find it difficult to accept composite flour and blends of wheatless flours for baked products unless adequate and vigorous sensitization is carried out.

4. Infrastructural problem such as lack of reliable power supply from Power Holding Company of Nigeria (PHCN) and public water supply especially for small and medium scale would- be operators who will like to venture into non-wheat flour milling business.
5. Detoxification to low and safe levels of the cyanide content of cassava if this crop flour is to be used as a component of the composite flour.
6. Competition between the consumers and processors of the non-wheat crop if the crop is consumed as a staple food. This would no doubt increase the cost of the staple food.
7. Possible sabotage from multinational flour milling companies through importation of low-quality wheat for their mills since the percentage of non-wheat flour incorporated with wheat flour to form composite flour suitable for biscuit making depends on the quantity and quality of gluten protein[79].

Conclusion

In order to reduce the impact on the economy, Nigeria released policy mandating the flour mills to partially substitute wheat flour with 40% cassava flour for bread making. The potential benefits of the policy include Savings of the Nigeria's foreign exchange earnings of N 254 billion per annum, reduction in the severity of coeliac disease, utilization of locally available crops and creation of employment and wealth. Studies have shown that cassava, other root crops/tubers (yam, coco-yam, sweat potato), grains (maize, rice, sorghum, and millet), legumes (soya, chick- pea, and cowpea, peanut) and some underutilized crops (bread fruit, bread nut, and tigernut) can be used to partially substitute wheat in bread making. Most of the studies revealed that wheat can be substituted by 5 – 10% without significant detrimental effects on bread making and quality. Though, wheat can be substituted at higher levels, but beyond 20%, additives may be required to maintain bread quality such as emulsifiers, enzymes, hydrocolloids and other improvers. The use of these additives could increase the cost of bread production; it would require installation of new equipment and training of bakers and millers. Other potential challenges of the policy include poor quality of the bread, weak cassava flour supply chains, strong consumer preference for 100% wheat bread, and the reluctance of millers to use composite flour. Except the aforementioned challenges are adequately addressed, the 40% wheat flour substitution may fail like previous attempts.

Also, it is possible to bake good quality biscuits and cakes from composite flour having equal blends of wheat flour and local food flour as wheat flour containing as low as 6 – 7%. Protein could be used for making them. High quality wheat flour of 13% or above protein content when blended with local food flour such as cassava or cocoyam flour will give a composite flour containing at least 6% wheat protein.Hence, if high quality wheat is imported and the flour blended with local food flours to produce composite flours, more than 20% and 50% of foreign exchange spent respectively for importation of wheat for biscuit making flour and importation of wheat for biscuit and cake making flours can be saved. This on one hand will create jobs for our teeming youths in agriculture and food processing industry and on the other hand save some foreign exchange which could be used to develop other areas of the economy.

Recommendations

Since composite flour shows good potential for use as functional ingredients in bakery products, therefore the evaluation of the functionality of composite flour in test baking should be performed to ensure an increase in the use of composite flour made from many different raw materials in future.

At the same time, development and consumption of such functional foods not only improves the nutritional status of the general population but also helps those suffering from degenerative diseases associated with today's changing lifestyles and environment.

There is also the need to adjust the mixing ingredients and baking techniques in order to improve the composite bakery qualities.

Much effort is needed to find the optimization of composite flour used for any bakery products by mixing different types of crop flours to maximize the composite bakery quality using the mixture response surface methodology.

In addition, the effects of the method of processing, such as toasting, boiling and fermentation of flour, could be used to improve rheology properties of composite bakery products. New discoveries can be made in the future, based on the data obtained, and more food products can be developed for domestic markets

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