



Review Article



Digitaria species (Acha): panacea for malnutrition and food insecurity in Nigeria.

Rukayat Queen Adegbola¹; Grace O. Otitodun¹; Medinat O. Jimoh²; Okparavero, N. F.;² Okunlade A. F.³; Ishola, T. D.³; Aaron Y. Isaac⁴; Haruna P.B⁴; Dada A. Olarenwaju⁴ and Adegbola J. Adetayo²
^{1,2,3} Durable Crop Research Department, Nigerian Stored Products Research Institute, P.M.B 1489, Ilorin, Kwara State, Nigeria.

²Research Outreach Department, Nigerian Stored Products Research Institute, P.M.B 1489, Ilorin, Kwara State, Nigeria.

⁴Perishable Crop Research Department, Nigerian Stored Products Research Institute, P.M.B 1489, Ilorin, Kwara State, Nigeria.

*Corresponding author e-mail: queensadegbola@gmail.com

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ABSTRACT

Acha (*Digitaria sp*) is a powerhouse of nutrient, filling, versatile, light, and delicious, yet the most underutilized food security crop in Nigeria. The value of the nutritional content (amino acids, protein, starch, crude fibre and ash) present in acha grain is higher than that reported for other cereals such as rice, maize and sorghum and as such, a panacea for malnutrition'. The grain is tolerated by even those with frail digestive systems, including small children, the elderly, and those who are health-conscious. More so, it is a very fast-growing cereal grain and it is considerably cheaper than most staple food crops. Acha is said to be a good food security crop as it blends well with other recipes. It has a texture similar to grits or couscous with a sand colour and due to the primitive conventional processing methods, it contains a load of gritty sand particles. These gritty sand particles can be prevented by threshing over a clean, hard, non-sandy surface. The consumption of acha daily brings you back to the prehistoric era of longevity and wellness.

Keywords: Glycemic Index, *Digitaria exilis* (white acha), *Digitaria iburua* (black or brown acha), EAA (Essential Amino Acid), Sauté, Daddawa (Locust Beans), Food security.

INTRODUCTION

Acha (*Digitaria spp*) is a tiny cereal grain crop, smaller than the grains of rice (Jideani 1999). It is also known by other names such as fonio, iburu, findi, fundi, pom and kabug in different West African countries. Alongside the common grains like maize and rice, the rural poor also consume acha, which is known in many West African communities as "Hungry Rice" or "Grain of Life" (Ibrahim, 2001; FAO, 2008). Acha grows well in the Northern part of Nigeria and it is either a staple food or a major part of the diet in some parts of Nigeria and across some Western and Northern African countries (Jideani, 1999). It is one of the world's fastest-growing cereals with the production of grains at 42 – 56 days after planting for the early-growing varieties (Ibrahim, 2001) and 150 days for late-growing varieties (CIRAD, 2006) and as such, it can be cultivated two to three times a year since it matures within an average of 120 days. The grain is easily accessible when barns are empty and the next harvest season is not ready, therefore a handy crop to ward off hunger (Dachi & Gana, 2008). Though, acha is one of the lost crops of Africa and is considered to have

been cultivated as far back as 7000 years (Cruz, 2004) or 5000 BC (NRC, 1996), making it the oldest cereal in West Africa. The leading producing countries of Acha among the West African countries are Nigeria, Guinea, Burkina Faso and Mali. Worldwide production of acha grain was 671,000t in 2007, with an average yield of about 0.7t/ha and it ranged from 0.4t/ha in Nigeria to 1.0t/ha in Ivory Coast (FAO, 2019). Food and Agricultural Organization (FAO, 2003) opined that a total area of 347,380 hectares was dedicated to acha production in Africa in 2002, with Nigeria alone producing half of the total area. In West Africa, acha is produced annually on an area of about 380,000 hectares with an estimated output of 250,000 tons (Cruz, 2004). Additionally, Abdullahi & Luka (2003), also reported an annual output of acha to be 3,098 –126,000 metric tons. Gyang & Wuyep (2005) report shows that acha is grown in commercial quantity in various parts of Nigeria, citing Plateau State as the largest producer with an estimated production of 20,000 tons per annum. Ayo *et al.* (2018) reported that acha grain contributes significantly to

people's wellbeing such as improving the health, financial situation, and food security of a country like Nigeria that is still developing economically. Acha grains can be used for several recipes such as grounding into fine flour, baked into bread, cooked in various forms with fish, meat, legumes or vegetables and used as a brewer's grain for preparing local beverages (Coda et al. 2010). The grains are also used to prepare feeds for domestic animals especially the brown acha (*Digitaria iburua*) while the husk is a source of domestic fuel for cooking (Koreissi et al. 2007). Furthermore, the protein from acha is reported to be unique because it has greater methionine content than other cereals (Jideani & Akingbala, 1993).

The production and processing of acha have been at a zero-mechanization level and no proper research effort has been carried out towards its mechanization in Nigeria. Also, there are no machines for planting, harvesting, threshing and de-hulling of the crop on Nigerian farms, hence, leading to underutilization of the acha grain (Philip & Isaac, 2012). The provision of appropriate information and technologies that can support the mass production of acha will be able to bring the crop to prominence (Philip & Isaac, 2012). Therefore, this review is aimed at providing a guide on the processing and handling of acha, several recipes from acha grains apart from its current staple food status and the nutritional content and health benefits of the grain.

Description and Production of Acha (*Digitaria Spp*) Grain

Acha belongs to the family *Graminae* and the genus *digitaria*. It closely resembles the wild *Digitaria longiflora* (Retz) and grows under varying conditions from poor dry upland soils to hydromorphic valleys suitable for rice production (Purseglove, 1988). Acha is a fast-growing husked cereal grain with slender, knee stems growing up to 80cm in height. The seed is very small (fig 1), and should not be buried deeper than 6cm which is a lethal depth for this species. A sowing depth of 2cm was reported to be optimal (Cruz et al., 2016). The leaves are alternate, simple and the leaf blade is glabrous, linear to lanceolate in shape; 5-15cm long x 0.3-0.9cm broad. After threshing, the grain is surrounded by cellulose-rich hulls also known as lemma, palea and glumes. These grains are ovoid and slightly flattened on the abaxial surface. They measure only 1.8 mm in length and 0.9 mm in width which is quite small (Cruz & Béavogui, 2011). The colour of the grains varies from white to pale brown (dark brown) or purplish (Vodouhe et al., 2006). Eliminating the hulls exposes the naked grain called a caryopsis. Caryopses are smaller in size ranging from 1.4 mm -1.5 mm in length and 0.8 to 0.9 in width (Cruz & Béavogui, 2011).

The report of Philip & Isaac, (2012) shows that there are over 300 *Digitaria* species but only three or four species are grown as cereals while most of the species are grown as fodder (CIRAD, 2004). The two main varieties majorly cultivated are *Digitaria exilis* (white acha) and *Digitaria iburua* (black or brown acha). More so, about

70% of farmers cultivate the white acha while 6% cultivate the black or brown acha and 24% grow both species. The white acha (*Digitaria exilis*) is widely cultivated around the West African sub-region, while the black or brown acha (*Digitaria iburua*) is restricted to Northern Nigeria, Benin and Togo (Adoukonou-Sagbadja et al., 2007). The preference to cultivate the white acha include high yield, easy de-hulling process, availability of planting materials, preference by consumers, early maturity and adaptation (Philip & Isaac, 2012). The low moisture content for the two types (14.8% for white acha and 22% for brown acha) in a study by Ogbonnaya & Aminat (2008), however, suggests that acha loses a significant quantity of water during storage, giving it a long shelf life. During planting, the soil can be lightly tilled or hoed before sowing, and the seeds can be broadcasted or, preferably, drilled in a single row because doing so makes weeding simpler and boosts grain output (Dachi et al., 2017; Cruz et al., 2016). The rate of seed sowing is high (20-40kg/ha) because there are many causes of seed mortality such as heavy rains which can remove the seeds since they are not planted too deep or burying the seeds too deep and also, birds eating the seeds. Although, acha's small grain size and weak stem makes its cultivation and processing cumbersome. Nonetheless, it has an important trait, that is, its resistance to drought, fast germination and adaptation to climate change (Cruz et al., 2016).

Being an annual cereal grain, acha can be harvested one month before other cereals like maize or millet and it is well adapted to harsh environments, requires low input for its cultivation and is able to grow on very poor soils (either sandy, loamy, stony and shallow soils) without fertilization. In times of drought, war, or food scarcity when the major staple food of any given community falls short, acha crop can always come to the rescue because of its good harvest only after a short period of cultivation compared to many other staple crops. It is virtually the sole crop that could grow on already depleted soils and acidic soils with high aluminum content that are lethal to other crops (NRC, 1996., Vodouche et al., 2003., Cruz et al 2016). Acha can thrive in lowland tropical climate where annual rainfall is between 600 and 1200mm with a marked dry season, and average temperatures ranging from 25 to 30°C. In the mountains of fouta-Djalou which has higher altitude of up to 1500m, acha is grown when annual rainfall is between 1500 and 2000mm with temperatures ranging from 15 to 25°C.



Fig 1. Acha plant, Glumes and grains
Source: Cruz *et al* (2016)

Methods of Processing Acha Grain

There are several methods involved in processing acha grain right from the field to the finished product.

Harvesting: Acha plant is lodging which makes mechanical harvesting difficult. In some regions, when maturity occurs at the beginning of the rainy season, harvesting must be done between rains. Acha is often harvested by hand; it is sickled, gathered into sheaves, and brought to the barn where it is left to dry in stacks in a well-ventilated area to avoid mould growth and scorching. In other areas where acha is harvested at the end of the rainy season, the cut plants can be left in stacks on the field before threshing (Cruz *et al.*, 2016). Furthermore, the upper third of the plant can be cut if the farmer intends to let animals graze the stubbles and then plough the remains into the ground to improve soil fertility. However, if the straw is meant to be used as feed, the plant is cut close to the ground to produce the most straw possible (Cruz *et al.*, 2016).

Threshing: Acha plant is threshed to separate the grain from the stems once it is dried. If the grain is delayed to

avert hunger, threshing might begin soon after harvest. However, it is most often threshed after 1 or 2 weeks in more food-secure places. Threshing can also be done further than a month after harvest in sub-humid regions. Traditionally, threshing is done manually with rods and the threshing area has to be very clean to prevent grain contamination with grits or pebbles. It can also be covered with mats or plastic sheets (Vall *et al.*, 2008). After threshing and winnowing, the grains can be kept for storage. Since the late 1990s, various mechanical threshers that have been modified and created from rice threshers have been put to use but it is not readily available (Cruz *et al.*, 2016).

Storage: If acha is adequately dried and stored, it can have a shelf life of several years (Cruz *et al.*, 2016). The grain is stored in its hulled form, sometimes called paddy acha. Optimal preservation of acha grain requires a lower level of moisture content than in other cereals; 11% vs. 13% in main cases.

De-hulling and polishing: De-hulling is the process of removing the paddy acha hulls from the grain. It is usually carried out by women who first crack the hulls open by crushing the grains with a pestle in a mortar and then winnow the grains several times to separate the grains from the hulls. De-hulling is a method of post-harvest operation that is very difficult, time-consuming, and labour-intensive and these processes add more sand to the grains which contributes to the decline in the demand of the 'wonder crop'. To achieve de-hulled grain or pre-whitened acha grain, the pounding/winnowing procedure is performed 4–5 times. However, the bran is eliminated during the final pounding/winnowing procedure to produce the "whitened" or polished acha. Although, machines to de-hull and whiten acha have been developed in the early 2000s but it is not readily available (Cruz *et al.*, 2016).

Cleaning: The whitened grain must be washed, sometimes several times after polishing to remove impurities such as dust and bran fragments, and then "de-gritted" to remove pebbles and grits in an operation similar to gold panning. These operations are difficult, time-consuming, and require up to 10litre of water to process 1kg of grain (Cruz *et al.*, 2016).

Acha Most Popular and Delicious Recipes

Acha grain is a high-end cuisine that tastes great like other cereal grains such as rice, wheat, couscous, barley, millet, sorghum, or quinoa. It is also a perfect substitute in recipes with a mild taste, and slightly nutty flavor which can be blended perfectly with any ingredients to prepare a delicious delicacy. It can be processed into flour for bread and baked goodies, steamed or cooked and eaten as a wholesome meal just like rice, couscous, and corn grits. Furthermore, acha grains can be eaten alone or mixed with any favourite ingredients to make recipes such as gruel, porridge, couscous, stir-fried, alcoholic, and non-alcoholic beverages. The nutty aroma, flavour and taste of acha dishes can only be enhanced by roasting or toasting the grain first before cooking. This will prevent the little grains from sticking

together, and absorbing water without becoming mushy and mashed-up. Acha grain if not properly processed, has a lot of gritty sand particles, however, using the right washing procedures can assist to get rid of the sand grits. This can be done by using two calabashes or bowls to wash the sandy grains and get rid of the sand grits and dust before using them in recipes (Koreissi 2015). The grain remains vital to the food security of millions of Africans who use acha in several ways.

Plain Cooking: Acha is typically prepared as loose, grainy couscous, much like rice. It can also be grounded into flour for use in baked goods and fried foods.

Ingredients: Acha grains, water, a pinch of salt and a drizzle of olive oil (optional)

Preparation/Method: (1)Boil the water in a deep saucepan, (2) Add salt and olive oil drops which is optional,(3)As soon as the water starts to boil, stir in the acha grains and mix in well, (4) Cook over low heat for 5 minutes, or as it is commonly known, "steam up" for 5 minutes, much like when cooking couscous; cover the pan with a lid and lower the heat, (5)Turn off heat and allow the boiled grains to finish cooking with the steam for another 10 minutes, (6) remove the lid to see if the mixture is light and evenly divided. If it is too soggy, steam the mixture on low heat until the liquid has completely evaporated, (7) serve with sauce, stews, and vegetable soup. (Coda *et al.* 2010)

Acha Swallow: Acha swallow is known as "tuwon" in Hausa and being a popular Northern Nigeria main meal, it is either prepared using the Acha flour or Acha grains. Ingredients: Acha grains or Acha flour and water.

Preparation/Method: For acha flour, (1) Put some water to boil on low heat, (2) Then gradually introduce the acha flour into the boiling water and continuously stir quickly to avoid lumps, just like when making a semolina meal, (3) Stir until the thick, cooked dough, then reduce the heat and cover to finish cooking slowly with the steam, (4) Check and stir into a smooth and soft morsel, scoop and mold into balls. For acha grain, (1) Place a pot with moderate water on low heat,(2) Bring water to boil and quickly stir in acha gradually into the boiling water to avoid lumps, (3) Cover and reduce heat to the lowest, cook acha until soft with no more water present, (4) Stir and turn continuously with a spatula or stirring stick until a smooth and thick dough is formed, (6) Scoop and mold into morsels, (5) Serve with soup of choice.(Koreissi *et al.* (2007)

Acha Pudding: Acha pudding can be prepared into an all-vegan delight. It requires the use of soy or coconut milk which is a healthier choice than the use of animal milk.

Ingredients: Acha grains, water, soy or coconut milk, fruits of choice (favorite nuts for a nutty crunchiness), a pinch of salt, sugar, or honey. Preparation/Method: (1) put water to boil or the plant-based liquid milk to boil on low heat, (2) add a pinch of salt to balance the taste, (3)stir in the raw acha cereals, turning it continuously to avoid the grains clumping and forming lumps, (4) cook until cereal thickens, soften and

turn creamy, (5) once cooked, the pudding will begin to bubble and splash hot tiny bubbles, quickly cover to avoid burns, (6) remove from heat, (7) sweeten with honey for a healthy sweetness and garnish with any fruits and nuts of choice, (8)serve hot to enjoy the pudding, if allow to completely cool off it turns into a thick solid, hardening like a hard boil egg (Koreissi *et al.* 2007).

Acha Jollof: Acha jollof has the same ingredients with jollof rice recipes but the only difference is the substitute of the rice with the acha grains and the water content is less because the grains are tender, tiny, and light. Mixed spices, peas, green pepper, and other vegetables are added for more beautiful color, taste, aroma, and more richness. Acha jollof can be served with any fresh vegetable salad, plantain or Irish chips, fried eggs, and other side dishes of choice. (Koreissi *et al.* (2007)

Acha Pancakes: This is a light meal serve for breakfast with beverages or eaten as snacks with fresh fruit juices. Ingredients: Acha flour, eggs, milk, sweetener and flavour of choice.

Preparation/Method: (1) sieve the acha flour into a mixing bowl, (2) add eggs, milk, flavor, and sweetener of choice; Honey is a great healthy choice, (3) Mix in all ingredients into a thick consistency and beat until fluffy light to avoid the pancake disintegrating and sticking to the pan while frying, (4) place a clean non-stick frying pan on low heat, add oil, and heat up,(5) add a scoop full of acha mixture, tilt the pan to evenly distribute the mixture, (6) watch closely to avoid burning, flip or turn over to fry the other side, (7) serve with a drizzle of honey, jam, cream, or fruit of choice. (Ayo *et al.*, 2010). **Acha Kunun-zaki:** This is a very popular drink served with snacks and if allowed to ferment for several more days; it then turns into a mildly alcoholic beverage known as "Pito" or "Burukutu" and in Hausa it is called giya.

Ingredients: Acha grain, ginger, chilli pepper, black pepper, cloves, raw sweet potatoes and malted rice.

Preparation/Method: (1) acha grains are steeped in warm water for 24-72 hours depending on the weather,(2) the grains are wet-milled with native spices such as ginger, chilli pepper, black pepper, cloves, raw sweet potatoes and malted rice, (3) milling machine is used to process the tiny grains into a smoother paste or fine flour, (4) the paste is sieved with a smooth mesh or cheese bag into a very thin free-flowing gruel just a little bit thicker than a popular juice drink known as "kunun Zaki", (5) if allowed to ferment for several more days; it then turns into a mildly alcoholic beverage known as "Pito" or "Burukutu",(6) served with snacks of choice. (Gaffa & Jideani., 2001; Singh & Raghuvanshi.,2012).

Gwate Acha: Gwate acha is Hausa cultural cuisine that is mixed with veggies making it into porridge. It is a super-rich, healthy, nutrient-dense dish with a great load of fresh, colourful, and mixed vegetables which gives a thrilling unique taste to savour. It is a salt-less and oil-less recipe; the seasoning cubes and the locust beans known as daddawa will enrich the taste of the mixed vegetable porridge.

Ingredients: Acha grains, meat, meat bones, meat brisket, smoked fish and daddawa (optional), mixed fresh vegetables of tomatoes, Scotch bonnets, and the green bitter eggplants or garden eggs known as Gauta in Hausa, onion bulbs and spring onions, fresh green leaves of cabbage, spinach, and the hibiscus known as Yakuwa in Hausa, seasoning cubes, local spices, and palm oil, or olive oil (optional).

Preparation/Method: (1) thoroughly wash meat, meat bones, and meat brisket and put all into a deep pot, (2) add water, chopped onions, spices, daddawa, and the seasoning cubes, (3) place on medium heat and cook until the meat is tender, (4) wash and dice the mixed vegetables of tomatoes, scotch bonnets, bitter garden eggs, and onion bulbs into a separate bowl. If preferred, roughly blend or pound the vegetables and add to the boiling meat, (5) wash acha grains, strain off water severally until the grain is clean (6) gradually stir in the grains quickly to avoid lump balls forming, (7) add the washed and chopped green leaves of spinach, hibiscus leaves known as yakuwa, spring onions, and some garden eggs quartered into chunks, (8) add diced carrots and this gives the meal more beautiful color and richness, (9) cover and allow to steam cook all the vegetables; (10) mix in all ingredients well and remove from heat, (11) serve hot or cold. (Lasekan *et al.* (2001),

Acha Stir-Fried: Acha stir fried is a meal of all shades of healthy, delicious delicacy that is so filling.

Ingredients: Acha grains, fresh tomatoes, onions, scotch bonnets, green, red, and yellow bell pepper, chicken, hardboiled eggs, smoked or fresh fish, olive oil, palm oil, or vegetable oil, seasoning cubes, salt, mixed spices of ginger, garlic, cloves, black pepper, thyme, or curry.

Preparation/Method: (1) wash acha grains, strain off water severally until the grain is clean, (2) turn the washed acha into a perforated bowl to drain off excess water, (3) place a deep saucepan on heat, add in oil of choice, (4) add chopped onions to the heated oil and sauté until translucent, (5) wash and dice mixed colorful vegetables, add to the onions, and stir, (6) add in the cooked chicken or de-boned smoked fish, (7) stir continuously to avoid sticking to the pan while adding in mixed spices, seasoning cubes, and salt, (8) remove from heat and turn the stir-fry vegetable sauce into a separate plate, (9) add oil into the used saucepan just enough to stir-fry, (10) add the washed and drained acha into the saucepan, then stir-fry on low heat while stirring constantly, (11) Mix in spices, salt, and seasoning cubes, (12) add the stir-fry veggies into the acha and mix in well to combine properly, (13) serve hot or cold with fresh juice of choice (Singh & Raghuvanshi, 2012).

Acha Pop-Up Snack: Acha pop-up snack is a snack eaten by a handful just like pop-corn; it can be toasted or roasted into a sweet or savory pop-acha depending on the addition of salt or sugar.

Ingredients: Acha grains, sugar or salt according to choice, flavor or plain according to taste.

Preparation/ Method: (1) wash acha thoroughly to get rid of dirt, dust, and sand residues, (2) drain all water,

sprinkle salt or sugar, and spread out to dry, (3) put a metal pot on low heat, then pour into the pot the dried acha grains, (4) gently swirl it over the fire and within a few seconds, the very tiny grains will begin to burst and bounce, (5) continue swirling on low heat until all grains are pop-up, (6) turn off the light and turn the puffy tiny version of a pop-corn known as a Pop Acha into a bowl (7) serve with any fruit juice of your choice. (Singh & Raghuvanshi, 2012).

Nutritional and Chemical Composition of Acha Grain

Acha is the most nutritious cereals which are very important to the health of humans. Idris *et al.* (2015) used established methods to analyze and compare the nutritional value of brown and white acha, and the results revealed that brown acha had higher amounts of protein, fat, crude fibre, and calories than white acha as shown in (table 1).

Jideani & Akingbala (1993) found an energy value of 19400 KJ/kg, which was greater than the values for other grains such rice (18091 KJ/kg), maize (16982 KJ/kg), and sorghum (16245 KJ/kg) (Saldivar 2003). In acha grains just like other cereals, starch is the most plentiful carbohydrate and the main source of calories. Cruz *et al.* (2011) reported a starch concentration of 68%, which was lower than the average recorded starch contents for sorghum (73.8%) and rice (77.2%) respectively. The average soluble sugar content of acha grains was 1%, and soluble sugars were typically present in very modest amounts. Some examples of these important sugars are saccharose, glucose, and fructose (Cruz *et al.*, 2011). Acha grains contain crude fibre in amounts ranging from 0.41 to 11.3%, with a mean value of 5.85%. The wide range in crude fibre content, which is made up of lignin and polysaccharides may be attributable to various analytical techniques on the one hand and environmental impacts, geographic location, agronomic, and genetic factors on the other. (Jideani & Akingbala, 1993; Saldivar, 2003).

The total ash value for acha is between the range of 36.0-42.0 gkgG and this is higher than the average range of 10.9-31.3 gkgG reported for millet, wheat, oats, sorghum and maize (Oyenuga, 1968; Temple & Bassa 1991). Furthermore, acha's protein content is high and on the average is more than 7% compared with rice, millet, maize and sorghum (Oyenuga, 1968; Temple & Bassa, 1991). The anti nutritional factors such as tannis, phytate, oxalate and cyanide are of low quantity ranging between 0.05-1.03mg/100g. These anti-nutritional factors restrict bioavailability of key nutrient that is, they block or interfere with how the body absorbs nutrient out of the gut into the bloodstream (Ukim *et al.*, 2013).

The mineral composition of acha (table 3) conducted by Ukim *et al.*, (2013), shows that potassium (K) was the most concentrated mineral element with value of 215.82mg/100g, followed by phosphorus (P) (131.00 mg/100g), while the least mineral was iron (Fe) (22.82ppm). Chukwu & Abdul-Kadir (2008) conducted a study on the proximate and chemical composition of

acha to determine its amino acid content and essential minerals and they discovered that, acha contained more methionine, some essential minerals, and trace elements like calcium, magnesium, iron, and copper than most cereals. Additionally, Ukim *et al.*, (2013) showed that acha grain is a rich source of essential amino acids and it is found to be rich in methionine, leucine, and valine, and this has made the grain to be regarded as best nutritious and tasty of all grains (Kuta *et al.*, 2005). The grains also contained non-essential amino acids with glutamic acid (5.63g/16gN) and alanine (4.16g/16N) having maximum amounts as observed in (table 4).

Table 1. Nutrient Composition (%) of White and Black Acha Grains (mg/100g)

Nutrients	White Acha	Black Acha
Protein	7.11	8.75
Fat	3.00	4.00
Crude fibre	0.79	1.03
Carbohydrate	79.72	76.91
Ash	2.13	2.31
Moisture	7.00	7.00
Gross energy (Kcal/100g)	374.32	378.64

Source: Idris *et al.* (2015)

Table 2. Proximate, Chemical, Nutrient and Anti-Nutritional Composition of Acha Grains (mg/100g)

Composition	Minimum value	Average value	Maximum value
Energy (kj/kg)	-	19400	-
Carbohydrates (%)	67.1	79.05	91
Starch (%)	-	68	-
Amylose (%)	22.1	22.05	28
Soluble sugars	-	1	-
Saccharose (%)	0.7	0.75	0.8
Crude fibre (%)	0.41	5.85	11.3
Protein (%)	5.1	8.05	11
Albumins	-	3.5	-
Globulins	-	1.8	-
Prolamins	-	5.5	-
Glutelins	-	14	-
Lipids (%)	1.3	3.25	5.2
Ash (%)	1	3.5	6
Thiamins(mg/100g)	0.3	0.39	0.48
Riboflavin(mg/100g)	0.05	0.07	0.1
Nicotinic acid(mg/100g)	-	3	-
Tannis	-	0.18	-
Phytate	-	1.03	-
Oxalate	-	0.90	-
Cyanide	-	0.05	-

Sources: Carbiner *et al.*, (1960), Temple & Bassa (1991), Jideani *et al.*, (1994b), Fliedel *et al.*, (2004), Chukwu & Abdul-Kadir (2008), Ukim *et al.*, (2013)

Table 3. Mineral Composition of Acha Grains (mg/100g)

Mineral Elements	(mg/100g)
Calcium	28.17
Potassium	215.82
Sodium	11.30
Phosphorus	131.00
Manganese (ppm)	21.73
Magnesium	46.02
Sulphur	32.40
Iron (ppm)	22.82

Source: Ukim *et al.* (2013)

Table 4. Essential and Non-Essential Amino Acid Profile of Acha grains (g/16gN)

Amino Acid Profile	Acha grains
Arginine	1.29
Lysine	1.96
Isoleucine	1.39
Leucine	4.26
Phenylalanine	2.34
Histidine	1.35
Valine	4.11
Tryptophan	0.98
Threonine	1.91
Methionine	5.19
Alanine*	4.16
Glycine*	1.96
Proline*	3.18
Glutamic acid*	5.63
Cystine*	2.85
Tyrosine*	0.87
Serine*	2.14

Source: Ukim *et al.*, (2013). *None EAA= Essential Amino Acid

Difference of Stored and Newly Harvested Acha Grain

In a research conducted by Wonang *et al.*, (2017), the result of their investigations showed that six (6) different species of fungi were connected with stored and newly harvested acha grains. *Aspergillus* species was seen to be high (table 5) in the grain especially when stored and this lead to mycotoxin production which is a major concern for food technologies (Ogbonna & Apeji 1992). *Rhizopus stolonifer* and *R. oryzae* which are known to produce metabolites (ergosinine) that are toxic to man are of great quantity when the grain is stored and this may also produce certain allergic reactions in man when consumed; they impart discolorations on the grains, thereby reducing the economic values (Wonang *et al.*, 2017). Marley (1996), reported that, the nutrient composition of acha grain (table 5) such as carbohydrates, fatty acids and protein contents have been reduced on stored acha grains by fungi. Proximate analysis further indicated that newly harvested acha grains contained slightly higher proportions of crude proteins, crude fats and ash compared to stored acha grains and there are no significant differences ($p > 0.05$) between stored and newly harvested acha grains in terms

of their biochemical composition. The very low moisture content shows that acha loses a large quantity of water during storage resulting in a prolonged shelf life.

Wonang *et al.*, (2017) in table (6) observed that, in the preliminary result of the essential amino acid profiles of stored and newly harvested acha grain in comparison with the Food and Agricultural Organization (FAO), the result shows that the amino acid profiles have higher concentrations of threonine, leucine, methionine and valine which are above the FAO reference values (FAO, 1970)

Table 5. Frequency of Occurrence of Fungi and Proximate Analysis of Newly Harvested and Stored Acha Grain

Micro Organism	Stored acha	NewlyHarvestedAcha
<i>Aspergillus oryzae</i>	+++	+
<i>Asp. Flavus</i>	++	-
<i>Asp. niger</i>	+	+++
<i>Rhizopus stolonifer</i>	+++	++
<i>R. oryzae</i>	+++	+
<i>R. oligosporus</i>	+	-
<i>Ulocladium species</i>	++	-
Bacteria	-	-
Crude proteins	6.06	7.91
Crude fibre	2.71	2.19
Crude fats	5.02	5.10
Carbohydrates	76.83	75.13
Ash	1.82	2.15
Moisture	7.56	7.52

Key: +++ 75% and above colonization, ++ 50-74%, 0-49%, - nil

Source: Wonang *et al.*, (2017), Marley (1996)

Table 6. Essential Amino Acid Profiles of Stored and Newly Harvested Acha Grains Compared with F.A.O. (1970) Preference.

Amino Acid	Stored Acha Grain	Newly harvested Acha Grain	F.A.O. Preference
Leucine	7.22	8.52	4.2
Lysine	2.5	2.56	4.2
Threonine	3.87	3.95	2.8
Methionine	4.29	4.85	2.2
Phenylalanine	4.24	4.59	4.2
Valine	4.72	4.84	2.8
Tyrosine	2.87	2.87	2.8
Tryptophan	-	-	1.4
Cystine	2.06	2.2	2

Source: Wonang *et al.*, (2017)

Health Benefit of Acha

Acha is one of the healthiest grains in the world, gluten-free, easy to digest, and it is tolerated by even those with the most delicate digestive systems, including young children, the elderly, and those who are health-conscious. The grain is a fantastic source of plant-based amino acids with a higher load of sulfur-containing methionine and cysteine that makes for a great addition to the diets of people who lack animal or protein-based foods. It is a wonderful grain that is packed full of vitamins and has higher protein loads than "Quinoa". Acha is an excellent source of minerals that reduce inflammation and lower the risk of cardiovascular problems including heart disease. The grain's great fiber content quickly fills the stomach and promotes a stable energy-yielding metabolism that lessens weariness and exhaustion while also preventing post-meal food cravings. Acha grains are light, sweet, and nutrient-dense with a great source of iron for those with anemia and iron deficiency. It is also high in calcium, niacin, and phosphorus, making it a great choice for everyone, especially pregnant women. Acha grain is ideal for people with hypertension, diabetes and high blood sugar levels because of its low GI (Glycemic Index), which helps to reduce fluctuations in blood glucose and insulin levels. The grain is a nutritional powerhouse for shedding pounds, achieving gorgeous, smooth skin, and growing out beautifully radiant hair. It is also rich in phyto-chemicals, including phytic acid, which is believed to lower cholesterol, and phytate, which is associated with reduced cancer risk (Coulibaly *et al.*, 2011).

Furthermore, acha grains are excellent animal feeds because of its good digestible rate by all animal species. The straw and chaff also make a valuable feed for animals. The straw from acha can also be mixed with clay for building huts, houses, walls, barns, burned to provide heat for cooking, and has an amazing potential for increasing the food supply in any given community.

Insect Pest and Post-Harvest Storage of Acha

Acha plants are hardy crop, not easily prone to attacks by insect pests and pathogenic diseases. Shoot flies (*Atheigona spp.*), stem borer (*C. partellus*), dipteran stem borer (*Diopsis longicornis* R), lepidopteran stem borer (*Sesamia species*) bugs, thrips, grasshoppers and white-black plant hoppers (*Sogatella furcifera*) are some insects pests reported to attack the crop in the field and they cause severe damage (Umaru *et al.*, 2013, Kaleisekar *et al.*, 2017).

Also, among the prominent weeds which affect the development of the plant is *Striga hermonthica*. *Striga* is a parasitic weed which causes wilting and stunting of acha plant; another most important challenge in acha production. It is notably abundant in the drier and less fertile soils of the Sahel and northern Sudan Savannah and because of its parasitic nature, it may be able to cause entire yield loss as is the case with other cereals if it becomes endemic. Furthermore, some species of birds such as Orange-checked waxbill, Black-rumped waxhill,

Broze manikin, Senegal fire finexh, Pin-tailed whydah and rodents (black rat, house mouse and multi-mammate rat) consume and damage maturing grains as well as stored grains. The use of systemic insecticide (quinalphos or phosphomidon) and practicing of crop rotation helps to prevent insect pest attack and parasitic weeds since the larvae of the stem borer that is responsible for the damage bore into the stem of the susceptible plants (Umaru et al., 2013).

Additionally, like other cereal grains, acha is usually stored in bulk, in traditional banco granaries. In some cases, particularly if it is to be sold in paddy or hulled form, the grain may be bagged either using polypropylene bag or PICS (Purdue Improved Crop Storage) bags (Bekele et al., 2019). If well dried (moisture content of 10-11%), acha can be stored for many months and even years. Though the crop's seed viability decreases with increasing storage time (about 2 years), and the threshed grains could be stored for about 5-10 years and remain in good conditions for consumption (Adoukonou Sagbadja, 2010; Meji & Imolehi, 2013). The flour from acha can be stored in an airtight container in a cool, dry place for up to six months or more.

CONCLUSIONS

Acha has great potential in health and medicine, and can improve the economic status of any community. The grain is treasured more highly than many other cereals for taste and its nutrients and it can serve as food security for the people of Nigeria and a wholesome feed for animals. It is plant-based and naturally vegan, making it an excellent organic crop, gluten-free for a healthier, energetic, and longer life. In today's world of fast foods and fast life with modernization taking over and cutting down the life span of humans, acha grain is the best choice. The nutritious acha grains are needed as substitute, especially during food scarcity, hike in food prices, the social, economic, and political climate of the nation is unstable, and healthcare costs are particularly high and demanding. To meet the demands of Nigeria's expanding population and ensure that everyone enjoys the amazing benefits of acha grains, it is essential to bring together the country's major stakeholders, including the government, research institutions, and food manufacturing industries. Also, the provision of appropriate information and technologies that can support mass production and reduce the gritty sand particles will bring the crop to prominence. The crop must be exported in order to generate foreign exchange for the growth of Nigeria's economy.

CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

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