Fact about Pearl Millet (*Pennisetum Glaucum* (L.): A Review

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Abstract- ***Pearl Millet is highly valuable in semi-arid regions and the sixth most important cereal in the world, after rice, wheat, maize, barley and sorghum. It has a very high level of photosynthetic efficiency, a short duration, a higher capacity to produce dry matter, and a higher adaptation to drought, soil salinity, soil acidity, and high temperatures. Pearl millet is nutritionally comparable and even superior to major cereals with respect to protein, energy, vitamins, and minerals. It contained 10.0-60.0g calcium, 5.0g fat, 11.6g protein, 1.2g crude fibre, 67.5g carbohydrates, 2.3g mineral matter and 296g phosphorus. Dieticians and many health professionals recommended Pearl millet because of its various health benefits and good effect on the body.***

Indexed Terms- ATP (Adenosine Triphosphate), C4 (Carbon fixation), DNA (Deoxyribonucleic Acid), LDL (Low-density Lipoprotein), Pennisetum glaucum (pearl millet), pH (Potential of hydrogen)

I. INTRODUCTION

Pearl millet, commonly called millet (*Pennisetum glaucum* L. R. Br.), also known as *gero/maiwa/dauro*in Hausa language, is an annual cereal crop extensively cultivated in the arid and semi-arid regions of African (mainly grown in the Northern part of Nigeria) and the Indian sub-continent (Jika *et al*., 2017).It is the sixth most important cereal in the world, after rice, wheat, maize, barley and sorghum(Khairawal, Rai, Andrew &Harrnarayana, 1999; FAO, 2007; Anonymous, 2010**;** Jika *et al*., 2017) and grown in over 40 countries predominantly in Africa and Asia as a staple food grain and source of feed and fodder, fuel and construction material (FAO, 2007).

There are several species of millet but the pearl millet is notified as one of the millets under 'Nutri-Cereals' because of the nutrition value by the Agricultural ministry Government of India (GOI). It is a good source of energy, protein, vitamins, dietary fibers and minerals.It is a robust, quick growing cereal grass in the Poaceae family with large stems and leaves which are tall and vigorous, with outstanding grain and fodder yielding potential. Pearl millets were first cultivated and grown for human use and animal feed between 8700 and 10,300 years ago, making them one of the world's oldest crops. (Lu *et al.* 2009a, b).Food and Agricultural Organization (FAO) showed that millet production covers between 29 and 38 million hectares between 2003 and 2013, and the world millet production was 29.8 million tons in 2013 while 15 million ton (50.3%) were produced in Africa, followed by Asia with 13.7 million (45.9%) and other countries shared 1.1 million (3.7%) (Miller, 2020).Nigeria has moved from the third to the present second largest pearl millet producer in the world (Aminu, Ajayi, Ikwelle & Anaso, 1998) covering about 28% of the global production and the crop is cultivated on about 5.0 million hectares of land, with annual production of 3.4 million metric tons. More than 60% of crop lands in Borno and Adamawa states are dedicated to pearl millet production respectively (FAOSTAT, 2011). The crop thrives well in places where rainfall does not last long enough to deter its growth but in the north eastern part of Nigeria, millet is largely grown as a rainy season crop, using open-pollinated varieties (local landraces or improved cultivars).Though, the crop is grown where rainfall ranges from 200-1500 mm, and mostly occurs in areas receiving 250-700 mm of rainfall (Tadele 2016). Pearl millet is often grown as a component in mixed crops i.e cereals-legumes cropping system with crops such as groundnut and cowpea, or with cereals such as sorghum and maize. Unfortunately, its

yield and potentials are inhibited by many factors, such as pest, diseases, soil fertility and downy mildew which have impeded progress in pearl millet production (FAO, 2014; Williams 1984).

Pearl millet can be controlled against soil borne pest such as termite and diseases by using fungicides like metalaxyl to enhance vigorous growth (Aliyu *et al*., 2011). Pearl millets are the way forward for Africa and countries such as India where food and nutritional security are major challenges (Singh *et al*., 2017). Therefore, the main objective of this article is to investigate the nutritional quality, uses, health benefits, techniques used in processing, product of pearl millet grain and storage method, so as to use it for further research in the area of post-harvest processing and value addition of pearl millet crop.

Table i. Leading Pearl Millet Producing Countries in the World

Rank	Country	Tons	(%) production
1	India	10910000	36.5
2	Nigeria	5000000	16.7
3	Niger	2955000	10
4	China	1620000	5
5	Mali	1152331	3.86
6	Other countries	8232727	27.6
7	Total	29870058	100

Source: World Atlas (2017).

Fig. 1 Map of Nigeria showing land in Borno and Adamawa state dedicated to pearl Millet farming

- Environmental Conditions Enhancing the Growth of Pearl Millet

Pearl millets are C4 plants that have very high levels of photosynthetic efficiency, a short duration, a higher capacity to produce dry matter, and a higher adaptation (compared to other tropical cereals) to drought, soil salinity, soil acidity, and high temperatures, and also its food, feed and fodder values, provide opportunities to make in-roads into new ecological niches. Despite its drought resistance, pearl millet requires evenly distributed rainfall during the growing season and it germinates well at soil temperatures of 23-30°C with emergence in 2 to 4 days under favorable conditions. Planting should be done as soon as rains are established; early planting is recommended to escape disease and insect attacks and the seeds should be planted when the soil is moist enough to enable the seed to germinate (Ajegbe *et al*., 2020). Furthermore, pearl millet thrives best in light, well-drained loamy soils but performs poorly in clay soils and predominantly grows in areas of sandy soil, rich in organic matter and inherent soil fertility (Ajayi *et al*. 1998) but cannot tolerate water-logging. However, it tolerates subsoil that are acidic even those with low pH (4-5) and high in aluminum content. Pearl millet has the capability to grow at very high temperature with low water requirement because of its deep root system and as such it extracts soil nutrient and holds higher nutritional value than the other cereal crops such as wheat, rice, maize and sorghum. Also, cropping pearl millet with legumes (cowpea, groundnut) or sesame in the preceding season is also good for its production

Fig 2. Pearl millet grains

- Pearl Millet and Nutrition

Pearl millet grain contain high amount of minerals such as iron, zinc, magnesium, copper, manganese, potassium and phosphorous. It is also a good source

of energy with 361 Kcal/100g calorific value and high in fiber content (1.2g / 100g) (Singh *et al.* 2018). Its Protein content is higher (Tylor and Emmabux, 2008) and also a good source of vitamin-B (thiamine-0.38mg, niacin-0.21mg and riboflavin-2.8mg), Vitamin-A, folic acid, calcium and magnesium (Hulse *et al.,* 1980; Pattanashett*et al.,* 2016). Also, essential amino acids such as arginine, threonine, valine, isoleucine and lysine present in pearl millet makes it to have higher digestibility than other grains (Adeola *et al.,* 2005; Kalinova & Moudry, 2006).

The lipid content in pearl millet is higher than all the other millet grain and its ranges from 1.5 to 6.8% (Taylor, 2004). Also, about 75% of the fatty acids in pearl millet are unsaturated (Hanna *et al.,* 1990) and this fatty acid is high in palmitic, stearic and linolenic acids and low in oleic acids (Adeola *et al.,* 2005). Pearl millet grain has a relatively high energy density arising from its high oil content.

Table ii. Nutritional Composition of Pearl Millet Grain (g/100g)

Parameters (g)	g/100g
Protein	11.6
Carbohydrate	76.5
Fat	5.0
crude fiber	1.2
Mineral	2.3
Calcium	42
Phosphorus	296

Source: Chapke *et al.* (*2018*).

The mineral composition in pearl millet is located in the pericarp, aleurone layer and germ layer, thus, refining i.e decortications or de-hulling remove these parts of the millet and it result in the loss of some of these important nutrients (Serna-Saldivar and Rooney, 1994; Shahidi &Naczk, 2003).

Table iii. Mineral Composition of Pearl Millet Grain (mg/100g)

Parameters	mg/100g
Phosphorus	450-990
Calcium	10.00-60.00
Iron	8.3-9.90
Zinc	5.3-7.70
Copper	1.8
Manganese	2.3
phytic acid	354-796

Source: Rathi *et al* (2004).

- Health Benefit of Pearl Millet Grain

Research studies has shown that diets rich in plant foods are protective against several degenerative diseases such as cancer, cardiovascular ailments, diabetes, metabolic syndrome, and Parkinson's disease (Manach *et al.,* 2005; Scalbert *et al.,* 2005; Chandrasekara & Shahidi, 2012). Pearl millets grains are crops that are significant for their nutritional content, producing almost all the required nutrients needed by human health such as dietary fibers, proteins, energy, minerals, vitamins, and antioxidants (Izge*et al.,* 2007). It also has medical advantages, used in animal feed, and role as lifesavers in times of food scarcity especially of the entire drier regions of Northern Nigeria. (Joshi & Agnihotri 1984;Izge 2006;Izge *et al*., 2007; Yenagi *et al.,* 2010; Singh *et al*., 2017). They produce higher protein content levels than maize and has roughly 85% of the energy content of maize (Filardi *et al*., 2005). Below are the health benefits of pearl millet grains

i. The consumption of pearl millet reduces type 2 diabetes, because it has a relatively low glycemic index that helps to digest gradually and produce glucose at a slower rate than other foods (Asp, 1996). Its nutritional and medicinal value helps in reducing other human ailments such as cancer, cardiovascular and neurodegenerative diseases.
ii. Pearl millet increases insulin sensitivity, lowers the level of triglycerides, and it is efficiently used to regulate blood sugar levels (Arora, 2017).
iii. Pearl millet is an excellent food for babies from six months of age, lactating mothers, elderly and convalescents because it has a lot of nutrients and easily digestible and as such, it has a very low probability of causing allergic reactions due to its hypo allergic property. (Arora, 2017).
iv. It is high in iron and zinc content which may help in increasing HB (hemoglobin) and also preventing anemia disease (Vanisha *et al.,* 2011).
v. The grain is gluten-free, and it is one of the alternatives for patients who have celiac diseases to consume a gluten free diet for a normal and healthy lifestyle (Jukanti*et al.* 2016).

vi. The large amount of phosphorus and calcium present in pearl millet is very essential for bone growth and development as well as for development of ATP which is the energy currency of our body (Malik, 2015).
vii. The pearl millet lignin and phyto-nutrients serve as good antioxidants and thus prevent heart related diseases and this considered the grain good for cardiac health (Dayakar Rao *et. al.*, 2017).
viii. The most common cause for stomach ulcers is excess acidity in the stomach after food intake. Pearl millet is one of the very few foods that retains its alkaline property thus prevents formation of stomach ulcers or reduces the effect of ulcers.
ix. Pearl millet have Flavonoids, phenolics Omega 3 fatty acids, which inhibits DNA scission, LDL cholesterol, liposome oxidation and proliferation of HT-29 adenocarcinoma Cells. Thus, it helps to reduce Non communicable diseases (NCD). (Chandrasekara and Shahidi, 2011).
x. Pearl millet can be beneficial in the process of weight loss because of it high fibre content (Scalbert*et al.,* 2005). This fibre content is also known to reduce the risk of gall stone occurrence. However, the insoluble fibre content in pearl millet reduces the production of excessive bile in our system (Liu, 2007).
xi. The high iron content (8mg/100g) and high zinc content (3.1mg/100g) in pearl millet may assist in increasing haemoglobin (Sehgal *et al.,* 2003)

- Utilization of Pearl Millet Grains

i. Millions of tons of pearl millet are used as staple food in many homes in Nigeria especially among the poor mostly in Northern Nigeria (FAO,2007).
ii. Pearl millet is used in making a popular fried cake known as *"masa"*. Its flour is also used in preparing *"tuwo"* a thick binding paste, also referred to as *"toh"* in northern Africa.
iii. Pearl millet can be fitted for flat bread (Roti)because it lacks gluten.
iv. Pearl millet is often ground into flour, rolled into large balls, parboiled, liquefied into a watery paste using fermented milk and then consumed as a beverage. This beverage is called *"fura"* in Hausa or *"tukura"* in Marghi language. It is a popular drink in northern Nigeria and southern Niger.
v. Pearl millet is an excellent forage crop because of its low hydrocyanic content. The green fodder is rich in protein, calcium, phosphorus and other minerals with oxalic acids in safe limits (Chopra, 2001).
vi. Pearl millet flour is traditionally used by Indian housewives to prepare variety of different products like Laddoo, chips, wadi, bread, cake etc.
vii. Pearl millet is used in making alcoholic beverage (opaque beer or Dogon millet beer, chibuku shake, mbeg, Merissa, burukutu) and non-alcoholic drink (pombe, pito, boza, kunun Zaki, bushera, mahewu, oskikundu, marewa) (Adebiyi *et. al.*,2018).
viii. The stalks of pearl millet are used in making mulches and as fuel for woods.
ix. The glumes and pericarp also known as *"dusa"* obtained from milled pearl millet are also used in preparing feeds for livestock including poultry.
x. Lastly, pearl millet seems to be an excellent feed for other birds, including dove, turkey, song-birds, ducks, and swine.

- Some Pearl Millet Food Recipes

Food from pearl millet can be grouped into two categories, traditional products and non-traditional products. The following are some traditional pearl millet food recipes:

Plate 1: Fried cake

Plate 2: Flat bread

Plate 3: Flour

Plate 4: Wadi

Plate 5: Fura

Plate 6: Puri

Plate 7: Bread

Plate 8: Chips

Fig3. Products prepared from pearl millet grains

- Pearl Millet Flour

Pearl millet flour is made from pearl millet grain and the flour are stored in air-tight polyethylene bags to avoid accumulation of moisture and kept at room temperature. Pearl millet is often not stored for long periods because it tends to turn rancid because of its high fat content.

Here is a flowchart for the production of pearl millet flour (FAO, 2020)

Sorting

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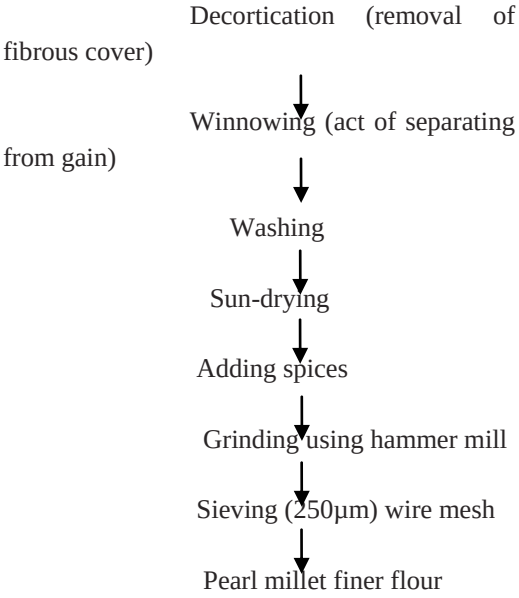

- Fura

Furaislocal food of the hausa/Fulani tribe and it is mostly common in the whole of Northern Nigeria. It is a semi-solid dumpling cereal based food used mostly together with the boiled milk sold by Fulani women in many cities of Northern Nigeria.

- Ingredient: pearl millet flour, cloves, ginger, water, mortar and pestle.
- Preparation/method: (1) Blend flour with spices; (2) mixed with water and made into stiiff dough and steam cooking for 30minutes (3); Pounded thoroughly in the mortar with the pestle (with addition of hot water); (4) Mold until a smooth, slightly elastic and cohesive lump, fura is formed (5) later re-steamed for 10 minutes. (Salihu *et al*., 2021)

- Stiff porridge (Tuwo)

Tuwo is a stiff porridge prepared from pearl millet grain. It is known in different countries by names such as *tuwo* in Niger, *to* in Burkina Faso and mali and *askfo* or *ekotutu* in Nigeria. Tuwo is usually eaten with different types of sauce or stew made with varieties of ingredients.

- Ingredients: Flour of whole or décorticated pearl millet grain
- Preparation/method: (1) Bring water to boil; (2) prepare paste of flour in cold water; (3) add the paste in small amounts to the boiling water and stir vigorously to prevent lump formation; (4) cool the thick porridge; and (5) serve with soup of your choice (FAO, 1995).

- Thin porridge (Ogi)

Ogi is a cereal based fermented thin porridge, which is mainly produced from sorghum, corn and pearl millet grain. It is a popular traditional weaning food for babies and also consumed by the old as breakfast cereal.

- Ingredients: Pearl millet grains, ginger, water, sugar or salt to taste.
- Preparation/method: (1) Soak pearl millet grains in cold water for 18 to 48 hrs to soften and ferment grains; (2) wash the grains well to remove dirt (small stones) and ground to a coarse paste; (3) screen the slurry through a muslin cloth and discard the coarse particles remaining on the muslin; (4) let the strained slurry stand for 5 to 6 hrs and pour off the excess water leaving just enough to cover the settled paste; (5) bring water to boil; (6) pour the paste in boiling water (two table spoons for every 6 cups of water) and stir vigorously until paste gelatinizes; (7) cover the bowl and cook for another 2 to 3 min; and (8) serve the thin, hot porridge as it is or add sugar or salt to taste (FAO, 1995; Akingbala*et al.,* 1981).

- Beer (Burukutu)

Burukutu is a popular indigenous alcoholic beverage of a vinegar-like flavor, consumed in the northern guinea savanna region of Nigeria, republic of Benin and in Ghana.

- Ingredients: Pearl millet grains and pure yeast culture.
- Preparation/method: (1) Soak pearl millet grain in water overnight; (2) malt for four days; (3) sun-dry the malt; (4) grind the sun-dry malt; (5) mash and sieve; (6) boil mash for 30 min; (7) add old brew or pure yeast culture; (8) ferment for 48 hrs (2 days) at room temperature; (9) boil to stop fermentation; (10) allow to mature for two days and (11) serve burukutu. (Kolawole *et al.,* 2007; Mbajiuka*et al*.,2010).

- Flat Bread (Roti)

Roti is unleavened bread typically made with pearl millet flour and it is frequently consumed in western and central India.

- Ingredients: pearl millet flour and water
- Preparation/Method: (1) mix flour with little quantity of water until preferred consistency is reached; (2) the kneaded dough is divided into small balls which are flattened with the help of a rough wooden or metal surface; (3) dust the flattened dough with pearl millet flour; (4) baked on both side on a hot plate until a brownish colour is attained; (5) serve with a preferred sauce. (Chavan *et al.,* 2019)

- Insect Pest Attack on Pearl Millet Grain

Several species of insect pest such as grasshopper (Caelifera) including the desert locust (*S. gregaria*) causes damage to grasses such as sorghum and pearl millet by feeding on leaves, flowers, and grain and the destruction is more prevalent later in the season when grain filling is at its peak (Sharma, *et al*. 1997; Azere, *et al,* 2020). Eastern leaf-footed bug (*Leptoglossusphyllopus)*is known to be a grain feeder of pearl millet in Nigeria. Obeng, *et al.,* (2015) also identified *Apis mellifera, Coleomegilla maculate, Danaus plexippus, Epicautapestifera, Euschistusservus, Harmonia axyridis, Helicoverpazea, Halictusspp, Leptoglossusphyllopus, Melanoplusdifferentialis,* and *Schistocerca Americana* asinsect pest species which are very dangerous to pearl millet production at all levels. Some insect pests causes seed erosion of pearl millet and the major ones include; Cutworm: *Agrotisipsilon Hufnagel* (Lepidoptera: Noctuidae), White grub *Holotrichiaconsanguinea Blanch* (Coleoptera: Scarabaeidae), Shoot fly: *AtherigonasoccataRondani*(Diptera: Muscidae), Stem borer: *Chilo partellusSwinhoe*(Lepidoptera: Pyralidae) (Satyagopal, *et al.,* 2014), bug: *CalocorisangustatusLethiery*(Hemiptera: Miridae), Hairy caterpillar: *Spilosomaobliqua*Walker (Lepidoptera: Arctiidae) and Blister beetle: *Mylabrispustulata*Gyllenhal (Coleoptera: Meloidae).

Striga is a parasitic weed and another most important challenge in pearl millet production. It is common especially in the drier and less fertile soils of the Sahel and northern Sudan Savannah.Farmers are known to sometimes abandon their field if *Striga* incidence is excessive. The parasitic weed is single stemmed with bright red flowers. Most of the damage is done before the parasite emerges from the soil and its symptoms include leaf wilting, leaf rolling, and leaf scorching despite the fact that the soil may have sufficient water. However, crop rotation with cotton, groundnut, cowpea and pigeon pea reduces the incidence of *Striga.*

- Seed Treatment and Insect Pest Control

Dithiocarbamate (Mancozeb) or nay and other appropriate and approved seed dressing chemical can be used to dress the seeds before planting. Dressing of seeds has shown about 25% yield advantage, pest and disease control over non-dressing seeds. Protective clothing and gloves should be worn before seed dressing. In a closed container or gourd, shake the seeds with the powder for about 3 minutes or until the seeds are completely coated with the chemical. Allow the seed dressing chemical to settle before opening the container/gourd and bury the empty seed dressing container completely. Wash hands with sand or soap and running water immediately after planting (Ajeigbe et al., 2020)

Early planting reduces disease and insect pest attack on grains. Chemicals such as Cypermethrin and Lambda-Cyhalothrin (karate) when sprayed on the farm can remedy insect pest attacks. Destroying cereal crop residues by burning or composting can reduce pest build-up. Birds can severely damage pearl millet; so, humanoid scarecrow can serve as a deterrent (Ajeigbe*et al.,* 2020)

- Post-Harvest Handling/Storage

Good post-harvest handling can result in the increase of quality and yield of pearl millet grains. If pearl millet grains are not properly dried, mould and germination of grain (sprouts) may occur so therefore, it is recommended that the grain be stored at a maximum moisture of 12-13% and be kept in a well-ventilated environment or grain shed. Since insect pest, bird, rodent and mould damage leads to the loss of viability and nutrient, pearl millet should be stored in the form of tied bundles of unthreshed heads, but threshing and storing in bags is recommended since the treatments prevent insect

infestation easier and the space required for storage is reduced. Unthreshed heads of grains can also be stored in a solid walled container called a rumbu. Some farmers spread the leaves of gwanderdaji (*Anona senegalensis*) on the bottom of the rumbu and between each layer of grain. When a rumbu is full, the mouth is sealed with clay. In some countries in West African, pearl millet grains are mixed with wood ash, and stored in clay pots while in the Sudan, pits holding 2 to 5 tonnes of grain are used as underground stores, after the pit is filled, straw is spread over the grain and then topped with a layer of soil (FAO, 2020).

Insect infestation is less in the underground storage and it is cheaper over above ground storage structures. Although, grains stored underground has poor appearance and musty smell. Pearl millet can also be stored in silos and hermetic drums and they are great for farmers who need to store a high volume and for a long-time storage without significant quality adjustment if the kernel remains intact, but the quality of the grain deteriorates rapidly once the grain is decorticated and grounded (Kaced *et. al.*, 1984).

Deterioration of pearl millet flour occurs because of its fat content with highly active lipases and this contributes to hydrolysis of fats resulting in rancidity of the pearl millet product causing unpleasant odor and bitter taste (Kaced *et.al.*, 1984). Hence, the pearl millet flour cannot be stored for a long period of time and this become a problem for individuals to grind flour on daily basis. Rancidity also limits the commercial use of pearl millet product. Therefore, research is needed to increase the shelf life of pearl millet products.

CONCLUSION AND RECOMMENDATION

Pearl millet is an underutilized grain crop with superior nutritional value and health benefits and mostly consumed by people of lower economic strata. It has so far remained a traditional food crop for subsistent farmers in Nigeria and many other dry regions of Africa and Asia. Therefore, with value-added strategies and appropriate processing technologies, the pearl millet grains can find a place in the preparation of several value-added and health food-products, which may then result in high demand from large urban populations and non-traditional millet users (Mal *et al.*, 2010). Dieticians and Nutritionist are trying their best to educating people about the potential health benefits and to promote the consumption of pearl millet.

Conclusively, more efforts should be channeled to marketing and improvement of the market potentials of pearl millet in all its forms; this will make it to survive as a commodity crop or develop into an important value-added specialty crop.

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