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Review Article

The Nutritional and Health Benefits of Tigernuts (Cyperus Esculentus L.): A Potential Astronaut Food

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Abstract: As space exploration progresses, the need for nutrient rich and functional foods for astronauts becomes increasingly crucial. Nigerian superfoods have gained recognition for their remarkable health and nutritional benefits. Astronauts face physiological and physical problems as a result of long exposure to radiation in the space environment that includes, oxidative damage, coronary heart disease, gastrointestinal problems, flatulence, bone resorption (osteoporosis), and muscular atrophy. To address these issues, scientists advise the use of dietary and food supplements. Tigernut is a nutritious indigenous nigerian superfood that either grows naturally or is cultivated for its edible tubers, it can be used whole as a snack, in milk, flour or oil form to produce a variety of meals, snacks and beverages. It contains antioxidants, vitamins, minerals, Essential amino acids, digestive enzymes, minerals, fiber and other important food constituents, which play an important role in combating some of the physiological changes and conditions experienced by the astronaut. This paper reviews the nutritional composition, functional benefits of tigernut (an indigenous Nigerian superfood) and its potential positive effects on astronauts' wellbeing. Evaluating its potentials through this study will provide a comprehensive understanding of the nutritional and health benefits of tigernut for Nigerian Astronauts. The result of the review carried out on the three cultivars of tigernut tubers (yellow, brown, and black) shows that they contain significant levels of macro and micronutrients, phytochemicals and antioxidants that play a significant role in preventing and maintaining some of the health and physiological changes astronauts are exposed to as a result of microgravity and space flight.

Keywords: Tigernuts, Nutritional, Health, Physiology, Astronaut, Microgravity

1. Introduction

A global perennial crop of the same species as the papyrus plant, tigernut (Cyperus esculentus L.) is a member of the division Magnoliophyta, class Liliopsida, order Cyperales, and family Cyperaceae. Many tropical and subtropical nations in the African sub region grow it and use it for food.

Tigernut is also known as edible galingale, rush nut, earth nut, yellow nutsedge, and chufa (in Spanish) [1]. Southern Europe, Africa, the Middle East, and the Indian subcontinent are just a few of the places in the Eastern Hemisphere where it is found [2]. Tigernut is known by the names "Ofio" in Yoruba, "Akiausa " in Igbo, and "Aya" in Hausa in Nigeria. It is cultivated for its edible tubers, sometimes known as tigernuts or earth almonds, which are consumed as snacks and used to prepare the drink "horchata de chufa," which is sweet and akin to milk.

Tigernuts are occasionally planted as crops or discovered growing wild. It is an invasive species outside of its natural

region and is readily mistakenly carried to become invasive. Tigernut is regarded as a weed in many nations [3]. It can be found in wet soils like those in rice paddies, peanut plantations, well-irrigated lawns, and golf courses during the summer.

The 30 mm long, sweet, and mildly milky-tasting nuts stand out for their size. Numerous growing regions have recognized the three principal cultivars (yellow, brown, and black). Most people prefer the yellow varieties over others because of their attractive color, greater size, and fleshier nuts. Additionally, when milk is extracted from it, more milk is produced. Additionally, it has reduced fat and fewer anti-nutritional elements like polyphenols [4].

Figure 1. *Yellow Tigernut.*

Figure 2. *Brown Tigernut.*

Figure 3. *Black Tigernut.*

Tigernut milk is a nutritious beverage that has been a well-liked soft drink in Spain for a number of years. It is provided as a refreshing beverage in restaurants (even competing favorably with other soft drinks). Significant amounts of both macronutrients and micronutrients are present in tigernuts. Tigernut tubers can be used to process food; the three main by products from tigernut tubers are milk, flour, and oil. Tigernut can be ground and baked, used to make the regional beverage "kunu," and added to various foods including candies, chocolate, biscuits, and pastries [5].

Tigernut is a valuable source of edible oils since it contains a lot of monounsaturated fatty acids. The oil's nutritional content is comparable to that of olive oil. It also contains a significant amount of starch, an affordable and regenerative food component. Despite having a low protein level, it has been shown to be appropriate for people with diabetes and digestive issues, and when ingested, it may assist to prevent or lessen heart disease. The dietary fiber in this tuber helps to reduce gastrointestinal issues, obesity, and colon cancer. Due to the presence of flavonoids, tigernut has excellent antioxidant properties and can be used as a natural source of antioxidants [6].

Due to the peculiar microgravity environment, astronauts are more prone to a variety of health issues, such as oxidative damage, muscle atrophy, and digestive issues. A well-planned diet should be rich in the essential macro- and micronutrients in order to maintain physiological balance and fend off chronic disorders. Hence, the goal of this review study.

2. Nutritional Value of Tigernuts

Numerous studies have been carried out on the nutritional value of various tiger nut tuber kinds grown in various regions of the world. As the use of tiger nut tubers for the production of various food commodities has increased, researchers have been carefully investigating the nutritional composition of tigernut-derived products. manufacture of a variety of food commodities has become more significant.

When comparing the proximate composition of two different types of tigernut tubers, the author [7] discovered that the brown variety has more protein, fat, ash, potassium, magnesium, manganese, and iron than the yellow kind. While the yellow form contains more copper, calcium, salt, crude fiber, and carbohydrates than the white version.

In comparison to the brown and black types, tigernut tubers of the yellow kind are more visually pleasing and appear to be larger. Tigernut tubers of the yellow variety generate more tigernut-milk than those of the black variety, and their milk's production and protein and fat content are higher. Compared to black-type tigernut tubers, yellow variation tubers of tigernuts have fewer antinutritional components, especially polyphenols [8]. Tigernut tubers of the yellow form have less antinutritional substances like polyphenols than their brown counterparts.

Table 1. *Proximate Composition of 100g of Fresh Tigernut.*

NUTRIENTS	AMOUNT (%) /100G
Moisture Content	42.40
Carbohydrate	17.82
Fat	17.00
Protein	8.51
Fibre	13.10
Ash	1.18

Table 1 shows the Proximate composition of fresh tigernuts per 100 grams.

Table 2. *Proximate Composition (%) of Yellow, Brown and Black Varieties of Tigernut.*

Composition	Tigernut	(Yellow)	Tigernut (Brown)	Tigernut (Black)
Ash	3.97	4.25	2.57	
Moisture	3.50	3.78	3.73	

Composition	Tigernut	(Yellow)	Tigernut (Brown)	Tigernut (Black)
Crude	fibre	6.26	5.62	7.02
Crude	lipid	32.13	35.43	8.94
Crude	protein	7.15	9.70	12.00
Carbohydrate	46.99	41.22	65.66	
Energy (Kj)	1343	1511	1652.53	

Source: Maduka and Ire, 2018

Table 3. *Minerals and Vitamins Content of Tigernut.*

MINERALS	AMOUNT (Mg)
Magnesium	118.14
Potassium	267.18
Phosphorus	158.86
Calcium	43.36
Manganese	33.20
Sodium	17.02
Copper	0.54
Iron	2.82
Zinc	1.39
VITAMINS	
A	0.87
C	30.70

Source: Suleiman et al, 2018

3. The Nutritional and Health Benefits of Tigernut

1. Due to the presence of flavonoids, tigernuts have good antioxidant effects. They also contain significant amounts of vitamin E and oleic acids which prevent heart disease.
2. Tigernut consumption boosts the formation of healthy and protective bacteria in the digestive tract, which is the first line of defense for the immune system and the gut.
3. Tigernuts contain resistant starch and insoluble fiber, both of which assist to enhance bowel function and lower the chance of developing colorectal disorders including diverticulitis and hemorrhoids. Additionally, it facilitates better body waste processing and aids in the treatment of constipation. It is effective in the treatment and prevention of many diseases like colon cancer, coronary heart diseases, obesity, diabetes and gastrointestinal disorders [10].
4. Digestive enzymes like Catalase, lipase and amylase are found in tiger nut tubers. These enzymes aid indigestion, flatulence, and diarrhea relief.
5. Tigernut flour is a rich source of quality oil, it contains high amounts of monounsaturated fats and moderate amounts of protein.
6. Tigernut is also an excellent source of useful minerals such as iron and calcium which are essential for body growth and development [7].
7. Tigernut tubers have a high oleic content which helps to lower cholesterol levels in the body, preventing heart attacks and thrombosis.
8. Tigernut has been demonstrated to contain higher essential amino acids than those proposed by FAO/WHO (1985) for satisfying adult needs [11].
9. Unsweetened Tigernut milk is recommended for diabetics as its carbohydrate content is a base of sucrose and starch (without glucose) It also contains Arginine which liberates the hormone that produces insulin.
10. Tigernut tubers are high in vitamin B1, which aids in the healthy functioning of the central nervous system as well as the body's ability to cope with stressful situations [12].
11. Vitamin E found in tigernut tubers, increases men’s and women's fertility. That is why the tigernut tuber is known in the Middle East as 'Hab Al-zulom,' an Arabic name. The phrase 'Hab Al-zulom' literally means ‘men’s seeds.' Residents of the Middle East refer to it as 'Hab Al-zulom,' because it can promote sexual activity in both animals and humans. [13]
12. The vitamin E found also helps to slow down the aging process in human cells, increase skin suppleness, and eliminate wrinkles, acne, and other skin problems. [14].

4. Potential Benefits of Tigernuts for Astronaut Health

1. Radiation and Oxidative Stress: Despite the spacecraft's extensive shielding, space travel is linked to an increase in oxidative stress and extremely high radiation. The splitting of water by solar radiation or low wavelength electromagnetic radiation (such gamma rays) from the earth or space environment can result in reactive free radicals in the human body. These reactivity-driven free radicals can react in the body, causing oxidative damage to DNA, proteins, and lipids. Increased lipid peroxidation in the erythrocyte membranes, a decline in certain blood antioxidants, and increased urine excretion of indicators for oxidative damage to lipids and DNA, respectively, are all observed in humans. By consuming tigernut, which contains antioxidants, and/or supplementing with certain nutrients rich in vitamins like tocopherols and tocotrienols (vitamin E), ascorbate (vitamin C), vitamin A and its precursors' beta-carotene and other carotenoids, trace elements, and minerals like copper, manganese, zinc, selenium, and iron, the antioxidant defense system can be activated to combat oxidative stress [15].
2. Bone Resorption and Formation: Increased bone resorption during space travel causes the loss of minerals like calcium and phosphorus from their storage location (bone) into the blood and urine. This raises the danger of

kidney stones on brief missions, and on longer trips, it can increase the short- and long-term risks to bone health (risk of fractures and osteoporosis-like bone degradation). Due to the high concentration of these minerals in tigernut, the danger of bone demineralization is reduced by maintaining a balance between bone growth and resorption. [16]

3. Muscle Atrophy: Microgravity exposure weakens muscular function, especially in the legs, by causing a decrease of muscle mass and volume. It is thought that the loss is due to the metabolic stress brought on by spaceflight. These results are consistent with those observed in patients suffering from severe illnesses or injuries, such as burn victims. The main defense against muscular atrophy is regular aerobic exercise and enough dietary intake of foods high in energy, protein, and amino acids [17], which tigernuts are known to contain. [18].
4. Cardiovascular Health: Tiger nuts have a fat profile that is comparable to that of heart-healthy olive oil since they are highly monounsaturated. Monounsaturated fatty acid-rich diets are associated with lower levels of LDL (bad) cholesterol and greater levels of HDL (good cholesterol). lowering the dangers of a heart attack and a stroke as a result. It enhances cardiovascular health by enhancing blood flow and lowering blood clot risks. [19, 20]
5. Immune System: Tiger nuts may help strengthen the body's defenses against infections, including those caused by bacteria resistant to antibiotics. The nut extracts were proven to be efficient against bacterial infections that are resistant to antibiotics in a cell investigation. Further study is required in this area [21], where oleic acid and vitamin E are present.
6. Gastrointestinal Health: Tigernut tubers contain digestive enzymes such amylase, lipase, and catalase. These enzymes help with indigestion, flatulence, and diarrhea alleviation as high-flatulence foods are avoided during space travel missions to prevent combustible butt gas (hydrogen and methane), which is dangerous in pressurized cabins. Tigernuts work as a probiotic, encouraging the growth of healthy, protective bacteria in the digestive tract, making them very beneficial for the gut. One preventative technique to take into account would be to restore the astronaut's intestinal microbiome by sporadically administering immune-boosting probiotic bacteria during space missions through the intake of diets consisting of tigernuts [22].
7. Vitamin Depletion: According to research, serum antioxidants and vitamins are significantly depleted during spaceflights. As some studies have connected changes in vitamin levels in astronauts to a variety of health outcomes, the implications of these changes on astronaut health could be negative. For instance, the Apollo crew experienced arrhythmias that were brought on by potassium deficiency, as well as adverse ocular alterations brought on by space exposure, which have been connected to variations in vitamin B12 levels and its related metabolic pathways [23]. However, because to the high concentration of these vitamins in tigernut meal, it can help offset negative effects in all of these situations.

5. Conclusion

The space environment exposes astronauts to high levels of radiation and weightlessness which result in negative impacts on their health. Some of the major adverse effects of long and short term exposure include oxidative stress, demineralisation of bone, muscular atrophy, slowing of cardiovascular function, vitamin depletion, changes in the immune system and gastrointestinal tract. Designing dietary and supplemental diets is a crucial action/step in addressing some of these health consequences in addition to engineering solutions. Tigernuts are rich in phytochemicals, macro- and micronutrients, and antioxidants which can help combat oxidative stress; high concentrations of calcium and phosphorus which can help maintain a balance between bone growth and resorption; presence of high levels of proteins which provide a defense against muscular atrophy; digestive enzymes and probiotics that help alleviate diarrhea, flatulence and indigestion; and are rich in vitamins which help boost immune health and reduce vitamin depletion. The inclusion of tigernut in astronauts' diets will help them overcome the many physiological difficulties they face in microgravity. Because of its health and nutritional benefits, tigernut is a promising candidate for astronaut cuisine. There should be further research into other viable native foods, as well as their formulation to make up for nutritional inadequacies in space food diets. As a result, the negative consequences of exposure to the space environment will be addressed.

Competing Interests

All the authors do not have any possible conflicts of interest.

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