

# Processing and Preservation of Tiger Nut (*Cyperus esculentus*) Milk: An Overview

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## Abstract

*Tiger nut (Cyperus esculentus) is a root crop which is grass-like, edible and perennial plant. Tigernut has long been utilized as functional food with a lot of health benefits such as vitamins, minerals, sugar, dietary fibre and rich in protein. It is consumed raw, fried, toasted or blended with milk, dates fruits, coconut and so on. as smoothie which provides the body with essential nutrients required per daily intake. The processed tiger nut milk has a beverage like appearance to natural milk but differs in their consistency and viscosity which is obtained through blending, addition of water, filtration as well as addition of spices and sweeteners although. The tiger nut drinks are rich in sugar. This review documents microorganisms associated with tiger nut milk spoilage, different extraction methods and their effects on nutritional composition and shelf stability. Some of the preservation techniques employed especially in large scale production. Finally, this review summarize various preservation techniques that can be employed in enhancing a better shelf life of the milk derived from tiger nut.*

**Keywords:** Tiger nut, Milk, Processing, Spoilage, and shelf-life

## INTRODUCTION

Tiger nuts are sweet nut-like vegetable root tubers of the perennial grass-like cyperaceous plant called *Cyperus esculentus* L. (Coskuner *et al.*, 2002). The tiger nut roots grow well in tropics and subtropical regions of Africa such as; Nigeria, Ghana, Togo, Ivory Coast, and Egypt as well as Spain for its high utilization as one of the major sources of nutrients (Aguilar *et al.*, 2015). Tiger nut is a rich source of carbohydrate, lipids, fibre, some proteins, minerals, ascorbic acids and tocopherols (Ekeanyanwu and Ononogbu, 2010). Tiger nuts have recently been experimented for enriching the fibre content in gluten-free bread and biscuits (Aguilar *et al.*, 2015; Zahra and Ahmed, 2014). Tiger nut milk is a plant base source of milk (beverage) which is similar to milk in appearance but has different properties to milk from that of animal sources and the nutritional composition (Vesa *et al.*, 2000). Naturally sweet and nutritious, consumed especially in summer and served cold (Vesa *et al.*, 2000).

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The composition of tiger nut is extensively reviewed in many literature (Arema *et al.*, 2015; Bado *et al.*, 2015; Codina-Torrella *et al.*, 2015), but little is known about the nutrient transfer from tiger nuts to the tiger nut milk after the extraction procedure. Due to inadequate data on the standard operation procedure of tiger nut milk extraction, the processing steps and quality of the tiger nut milk which includes the percentage yield, proximate composition, physiochemical as well as shelf-stability have not fully documented in the literature.

### **Distribution of Tigernut**

The origin of tiger nut cultivation can be traced to ancient Egypt (Ahmed and Hussein, 2014). According to (Sánchez-Zapata *et al.*, (2012) 6,000 years back evidently claim that the cultivars of tiger nut was first stated in Egypt (Sánchez-Zapata *et al.*, 2012). Back then in Egypt, tigernut tubers were roasted and used as sweet meat (Sánchez-Zapata *et al.*, 2012). This author reports that Tiger nut was first discovered in Sudan which then spread to Southern Europe through the Arabs trade union in the Middle East during trade by barter eras. In 1822, Lesant, a French Chemist was the first scientist to analyze tiger nut tubers (Gambo and Dau, 2014). Dates back to 13th century, human consumption of tiger nut milk become dominant among the people as one of the cheap and readily available sources of nutrients (Gambo and Dau 2014; Sánchez-Zapata *et al.*, 2012). The plant base milk source from Tiger nut tubers advance to Europe, America and Asia which becomes an internationally utilized cash crop with high industrial and commercial significance (Gambo and Dau 2014). It naturally grows in Ghana, Nigeria and Sierra Leone (Sánchez-Zapata *et al.*, 2012).

### **Nutritional Composition of Tiger nut**

As regards nutritional profile of plant base sources of milk such as tigernut seeds, rich in protein, minerals, carbohydrate, fats as well as vitamins content (Asante *et al.*, 2014). The nutritional content of tigernut may vary depending on type, geographical location and the harvest period (Asante *et al.*, 2014; Codina-Torrella *et al.*, 2015). Tiger nut have a high energy content (approximately 370 kcal / 100 g dry matter), which mainly originates from the carbohydrates and fat (Bado *et al.*, 2015; Ekeanyanwu and Ononogbu, 2010). Recent reports indicate that tiger nut oil shows comparable nutritional quality to olive oil, and might be economically competitive as an alternative source of food nutrients (Ezeh *et al.*, 2014).

Phytochemical analysis of tiger nut showed trace amounts of alkaloids, resin, tannins, sterols, saponins and cyanogenic glycosides (Chukwu *et al.*, 2013). Currently, no hypersensitivity or allergy associated with raw or processed tigernut consumption is known (Galindo Bonilla *et al.*, 2002). Consumption of tiger nut is alleged to contribute to a lowering of blood cholesterol, prevention of coronary heart disease, controlled blood pressure, weight control, glycemic control and improved gastrointestinal function, probably because of its high fibre content (Anderson *et al.*, 1994). A recent report by Allouh *et al.* (2015) based on mouse models suggested that tiger nut consumption might be relevant for improving fertility in mammals.

### **Tiger nut Milk Processing**

Tiger nut milk is in the form of aqueous liquid containing the properties of animal based milk with significant different in composition, milking and preparation. Traditional method of processing has a limitation of shelf life in which the tigernut milk majorly last for a day after which spoilage set in even after refrigerating (Asante *et al.*, 2014). From a colloidal point of view, tiger nut milk is a system formed by a complex phase, composed of oil droplets, starch granules, and small solid particles, which are dispersed in an aqueous phase formed by water, sugars, and minerals (Codina-Torrella *et al.*, 2015). The milk extracted from tiger nut seeds contain the macro and micro nutrients required by the body in adequate amount of daily

intake for minerals and vitamins and also plays an important role in colloidal stability and functionality (Asante *et al.*, 2014).

Insoluble solids in the mush that is obtained after the wet-milling process is filtered using either a muslin cloth, cheese cloth, tissue bags, cotton bags or sediments under centrifugal force (Ukwuru and Ogbodo, 2011; Adgidzi *et al.*, 2011; Sanful, 2009). The stages involved in milk separation determined the final product as the Tiger nut milk is in aqueous soluble solid phase. However, most filtering systems show undefined pore size so that it is difficult to compare the properties of Tiger nut milk in different literatures (Okyere and Odamtten, 2014).

### **Processing of tiger nut Milk**

The unit operations in tiger nut milk processes consist of sorting-grading, grinding, filtering with an addition of water which is further pressed using muslin clothes to obtain the milk and then mixed with sugar. Depending on the end product required, producers may either modify the process with addition of other fruits for composite tigernut milk beverage or plain tiger nut milk depending on consumers preference and desired end product. Despite improvement by industries on the production process, the main steps are still similar to those followed traditionally which includes; Soaking, toasting, fermentation and addition of spices are some important unit operation carried out during either traditional or industrial production of tigernut milk (Ukwuru and Ogbodo, 2011). Djomdi *et al.* (2007) studied the soaking behavior and milky extraction performance of tiger nut at different soaking temperature. The effects of toasting tigernut on the quality of tigernut milk were reported by (Gambo *et al.*, 2018).

### **Soaking**

Soaking is a unit operation in milk extraction from a plant based source where the tigernut seeds are soaked for a given period of time in clean water after cleaning, sorting / grading, to soften the tiger and serves as a medium for the removal or reduction of possible antioxidants compound present, e.g. tannins and oxalates, phytic acids, polyphenols which could be released in to the water and discharged during draining process. This process involves submerging the samples in water for a wet milling techniques. Tiger nut are soaked in water at a specified temperature of 60 °C for 12 hours for completed adsorbed the water and releases the complex compounds (Ukwuru and Ogbodo, 2011). Djomdi *et al.* (2007) reported that 60°C for 6 hours are used as the best soaking temperature and time for high yield and high quality of tiger nut milk. Soaking increased the protein and fat, but sometimes reduced the moisture and carbohydrate content and soluble nutrients (e.g. tannins and polyphenols) which can be eliminated with the discarded soaking water (Sa'id *et al.*, 2017). The extraction yield of the tiger nut milk from soaked tubers increases with soaking temperature and reaches a maximum of 30 g milk/100 g tuber (dry weight basis), whatever the size of the tubers as reported by Djomdi *et al.* (2007).

### **Toasting**

Toasting process involves the act of shallow frying of the tiger nut seeds to control antinutritional compounds as well as to improve taste and flavour of the milk. Toasting is an important unit operation because it aids in flavor development improve minerals and protein content and remove heat labile anti-nutrients (Gambo *et al.* 2018). Sa'id *et al.* (2017) reported that toasting improves flavour intensity, removes heat labile anti-nutrients and releases the nutritional constituents of the seeds such as protein and fat contents, minerals and vitamins. Gambo *et al.* (2018) reported that tiger nut milk prepared from toasted tiger nut has longer shelf life than that prepared from untoasted tuber, and it is more acceptable to consumers in terms of taste and aroma.

### **Fermentation process in tiger nut milk**

Fermentation process involved in tiger nut milking is an anaerobic process in which lactic acid bacterial, yeast some catalytic activities are set in to produce a desirable taste, aroma, texture and appearance as well as undesirable changes may occur. Tiger nut milk is not a fermented product but microorganisms are easily set in during processing and handling which are widely distributed in nature (Gambo *et al.* 2018). Lactic acid fermentation of tiger nut (*Cyperus esculentus* L) aqueous extracts, is known to give lactose-free, sweet-sour products that might serve as important source of food nutrients (Wakil *et al.*, 2014; Akoma *et al.*, 2000). However, lactic acid fermentation of plain tiger nut milk leads to products with low viscosity and high susceptibility to phase separation (Wakil *et al.*, 2014), which adversely affects consumer acceptance of the product (Akoma *et al.*, 2000).

Wakil *et al.*, (2014); Belewu (2010) showed that fermented tigernut milk might have relevance due to its chemical, nutritional, sensory and microbiological properties. Fermentation of tiger nut milk is important because it might lead to microbiologically stable products with improved shelf life, considering that tigernut milk shows high susceptibility to microbial spoilage (Sebastià *et al.*, 2012).

### **Tigernut Milk Spoilage and Stability**

Study conducted by (Sagoo *et al.*, 2001) revealed that the lack of effective antimicrobial treatments at any steps from planting to consumption suggested that pathogens introduced at any point may be present in the final food product. Nyarko *et al.* (2011) reported that tiger nut milk is prone to microbial deterioration due to the unhygienic method of preparation or by use of contaminated raw materials and utensils. The deteriorating effect of microorganisms and other factors on the drink has hampered the production of the milk especially at local level. Djomdi *et al.* (2006) reported that despite its high nutritive value, its production has been hampered due to the deteriorating effects of some microorganisms on the milk (Codina-Torrella *et al.*, 2016).

### **Characteristics of Tiger nut Drinks**

A colloidal substance is made up of two miscible phases consisting of a homogeneous and a dispersed phase distributed in submicroscopic form from 1.0 nm to 1.0 µm having a continuous phase (Sagoo *et al.*, 2001). A suspension contains larger insoluble particles than colloids and therefore, particles may float or sediment in a continuous medium over a specific period of time (Tadros, 2009). The emulsification process refers to an immiscible phase liquid where each droplet is dispersed continuously in a liquid medium. Emulsification may be categorized as water in oil droplets, or oil in water droplets (Nyarko *et al.*, 2011).

### **Microorganisms Associated with Tiger nut Milk Quality**

Tiger nut milk is gradually gaining recognition in recent times as it is consumed by people who know little or nothing about its nutritional value. Despite its high nutritive value, its production has been hampered due to the deteriorating effects of some microorganisms on the milk (Djomdi *et al.*, 2006). A mixture of microorganisms that have been isolated from exposed tiger nut include *Bacillus subtilis*, *Staphylococcus aureus*, *Aspergillus flavus*, *A. niger*, *Fusarium solani*, *Saccharomyces cerevisiae*, *S. fibuligera* and *Candida pseudotropicalis*, with varied percentage frequencies of occurrence, which have rendered it unwholesome (Onovo *et al.*, 2007). The presence of pathogenic *E. coli*, *S. faecalis* and *S. aureus* usually constitute a direct proof of faecal contamination of irrigation water (Cheesbrough, 2006).

Badau *et al.* (2018) identified *STAPHYLOCOCCUS aureus*, *E. coli*, *Salmonella*, *Shigella*, and *Pseudomonas* in, *Candida albicans*, *Saccharomyces cerevisiae* and *Rhizopus oryzae* in tiger nut milk.

Nura *et al.* (2016) reported that *Aspergillus flavus*, *Aspergillus niger*, *Saccharomyces cerevisiae*, and *Penicillium* spp are fungal species associated with spoilage of tiger nut milk. These authors also revealed that spoiled tiger nut milk contained higher percentage of fungi than fresh ones as a result of changes in fungal species during storage.

### **Tiger nut Milk Preservation**

Tiger nut milk is highly perishable due to its nutritional composition (Nutso, 2014). It has very short shelf-life of often less than 24 hours depending on the condition of storage (Akoma *et al.*, 2006). High temperature and humidity significantly reduced the shelf-life of the product (Nutso, 2014). The short shelf-life of raw tiger nut milk hinders widespread consumption of the beverage due to the deteriorating effects of some microorganisms on the milk (Ejoh *et al.*, 2006).

### **Natural Tiger nut Milk Preservation**

Preservatives can be used to improve stability and shelf life of tiger nut milk (Akoma *et al.*, 2016), sodium benzoate, sodium meta-bisulphite only or combined (Kolapo and Oladimeji, 2008) were exploits. Other studies reported potassium meta-bisulphite (KMS), sodium-benzoate and potassium sorbate (Kohli *et al.*, 2017). Preservatives are recommended in minute's quantity for shelf stability which also enhance the taste and flavor (Nutso, 2014). However, they are reported to inhibit microbial growth (Nutso, 2014). These natural preservatives include ginger (*Zingiber officinale*) and garlic (Maduka, 2017), citric acid, and clove but with little success (Nwobosi *et al.*, 2013). However, the use of natural and or chemical preservatives would not be enough to preserve tiger nut milk, other preservation treatment has to be incorporated (Said *et al.* 2017).

### **Cold Temperature Preservation**

Low temperature storage is an alternative method employed in tiger nut milk preservation to lower or inhibits the growth and activities of microorganisms, enzymatic, and chemical reaction lower the spoilage rate (Nutso, 2014). Refrigeration between 0 and 2 °C allows the preservation of tiger nut milk for a maximum of 2–3 days, depending on the initial microbial load, or for a few weeks if the product is previously pasteurized (Codina *et al.*, 2016). When freezing process is applied to un-concentrated milk, it caused phase separation and coagulation phenomena negatively affecting the colloidal characteristics and, hence, the general aspect of sensorial and nutritional quality (Codina *et al.*, 2016).

### **Thermal Preservation**

Thermal preservation of foods gives the possibility of destroying heat liable microorganisms and enzymes. Heat processing of tiger nut milk includes pasteurization and sterilization (Nutso, 2014). However, tiger nut milk may contain high concentration of microbial spores, the amount of heat required could be drastic and can cause changes in the milk compositions, especially the starch content, which gives the sensory attributes of the product (Codina *et al.*, 2016).

### **Preservation by Non-thermal Processes**

The non-thermal preservation technologies are those in which temperature is not the main factor of inactivation of microorganisms and enzymes, although a slight increase in temperature may occur during the treatment (Bamishaiye and Bamishaiye *et al.*, 2011).

## **CONCLUSION**

Tiger nut (*Cyperus esculentus* L) are spread widely across all the tropical and subtropical regions. The technical application of unit operation in tigernut milk processing consists of

soaking, blending, filtering to obtain the milk, which is further mixed with sugar and flavour of interest which is mostly option based on the individuals preference. The tuber can be soaked or toasted to obtained a desired characteristic product. Spices can be used to enhance flavor and prevent microbial growth. Tiger nut milk is rich in sugars, fat and other essential nutritional components and has neutral pH. These make ideal site for microorganisms to grow and proliferate. Literature revealed that bacteria and fermentative fungi are involved in tiger nut milk spoilage. Creaming and sedimentation occurs through a time-dependent build-up and result in phase separation which contribute to the milk spoilage. Applying certain preservation techniques is crucial especially for commercial production to avoid microbial contamination and extend its shelf life.

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