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Determination of the Proximate Composition and Organoleptic Properties of Milk Produced from Tiger Nut

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Abstract: Tiger nut milk is a nutritious super food with various health benefits, including improved digestion, weight management, and better skin health. This study aimed to determine the proximate composition and organoleptic properties of tiger nut milk. The milk was prepared using conventional methods and evaluated by ten panelists over three days for aroma, color, taste, sweetness, and texture using a 9-point hedonic scale. The most acceptable sample contained 5g of ginger, while the least acceptable contained 7g of clove. Proximate analysis showed the milk had 67.38% water, 20.42% total solids, 1.07% ash, 3.25% protein, 6.06% fat, 0.48% fiber, 0.93% carbohydrate, and a pH of 5.32. The study included three treatments with varying preservatives (clove, ginger, and a combination of both) at different concentrations (3, 5, and 7g/L), with a control sample. The results showed a decrease in bacterial population as the pH became more acidic. Among the different formulations, the variant containing 5g of ginger received the highest preference, whereas the sample with 7g of clove was the least favored. Furthermore, the study examined the impact of natural preservatives (clove, ginger, and their combination) on microbial stability. The findings revealed that tiger nut milk infused with ginger exhibited enhanced sensory appeal and improved preservation, maintaining stability for over 48 hours at room temperature. These results highlight potentials of ginger in enhancing both the acceptability and shelf life of tiger nut milk.

Keywords: Acceptability, *Cyperus esculentus* L., milk, proximate, organoleptic properties

1. Introduction

Tiger nut, classified to species level as *Cyperus esculentus* L. is a tuber crop produced in some countries around the world and can be processed into different products including milk (De Castro *et al*., 2015). As a commercial crop, Sanchez-Zapata *et al.,* (2012) reported *C. esculentus* to be among the edible crops harvested in Senegal, Ghana and Nigeria. The African crop, *C. esculentus* L. for many years was not cultivated as a cash crop and has not been regarded as a potent product for economic development. It is inexpensive, can be consumed fresh or dried and has high nutritional quality (Bamishaiye and Bamishaiye, 2011). Food products from vegetables and fruits with relatively high content of fibers, minerals, phytochemicals and vitamins are considered for use as they improve human health (Slaving and Lloyd, 2012). Based on colour, tiger nut can be classified into three (3); the brown and yellow are found in Nigeria while the black is found in Ghana (Asante *et al.,* 2014). The tiger nut tuber in Nigeria is called "Aya" in Hausa land, "Aki-Hausa" in Igbo land and "Ofio" in Yoruba land (Grossman and Thomas, 2012).

C. esculentus can be prepared as snacks because of its sweet and nutty taste (Adgidzi *et al.*, 2011), and can be usefully converted into tiger nut milk locally called "Kunun Aya" in Hausa (Okorie and Nwanekezi, 2014). New processing techniques created all the time by food industries are to produce

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safe and ideally free foods from artificial ingredients. When an additive is added to food, it becomes a component of the food either directly or indirectly and have two (2) primary functions which are to; keep foods safe avoiding undesirable changes, and also make foods look appealing and palatable (Salmarsh, 2013). Carocho *et al.,* (2014) reported the existence of six (6) types of food additives which include; colouring, flavouring, nutritional, preservative, texturizing, and miscellaneous. Thus, preservative additives are the most significant as they exert antimicrobial, anti-darkening and antioxidant properties in foods.

One major source of bioactive chemicals is the fruit of the date palm (*Phoenix dactylifera*) (Tang *et al.,* 2013). Because of its many applications, including the usage of dates as a raw material for an increasing variety of food products, it is regarded as the most socioeconomically significant tree (El-Hadrami and Alkhairi, 2012). The inherent nutritional and functional qualities of dates define them. They are a great source of simple carbohydrates, primarily fructose and glucose, with cultivar-specific changes depending on the maturation stage. The fruit's total sugar content is lower in the partially ripened (Rutab) stage than in the completely ripened (Tamer) stage. Dates are high in certain nutrients like magnesium and potassium as well as dietary non-starch polysaccharides (NSPs). Nine (9) date fruits a day should be consumed in order to meet the daily recommendations for energy and carbohydrates (10% and 16%, respectively), and for NSPs and potassium (around 1/4). According to Al-Mssallem *et al.* (2020), dates are a rich source of antioxidant components that have a significant role in protecting the human body from the damaging effects of oxidative stress.

Tiger nut (*Cyperus esculentus* L.) is a lesser-known tuber crop valued for its rich nutritional profile and versatility in food applications. With the rising demand for plant-based milk substitutes, tiger nut milk stands out as a viable alternative due to its natural sweetness, high fiber content, and bioactive compounds beneficial to health (Asante *et al.*, 2020). While prior studies have examined its proximate composition and sensory attributes, there is still a need for more comprehensive research on its storage stability, microbial safety, and consumer acceptance over time (Rosello-Soto *et al.,* 2018). Furthermore, comparative analyses between tiger nut milk and other plant-based alternatives like almond and soy milk remain insufficient, warranting further investigation into its nutritional and functional advantages. This study seeks to address these gaps by analyzing the proximate composition, sensory qualities, and the effectiveness of natural preservatives in tiger nut milk.

2. Materials and Methods

2.1 Sample Collection

All the raw materials used in this study were from plant origin; tiger nut (*Cyperus esculentus* L.), from semi-dried tubers, clove (*Syzygium aromaticum*), from dried buds of flowers, ginger (*Zingiber officinale*), from dried rhizomes and dates (*Phoenix dactylifera*), from fruits of plants. These samples were purchased from Maiduguri Monday market and transported in polythene bags to Microbiology Laboratory, Faculty of life Science, University of Maiduguri, Borno State for further analysis.

2.2 Tiger Nut Milk Production

The tiger nut were manually sorted from dirt, washed using clean water, and one kilogram (1kg) of it was soaked in three liters (3L) of clean water for twelve hours (12h), three kilograms (3kg) of the deseeded dates was added, and milled into slurry. About two liters (2L) of water was added into the slurry making the ratio 1:5:3 (w/v/w) and sieved through a muslin cloth to obtain a homogenized filtrate called tiger nut milk as described by Ariyo *et al*., (2021). Temperature and pH of the sample were recorded from the production time up to spoilage time. Proximate analysis of the milk, dates, tiger nut, clove and ginger was carried out in National Agency for Food and Drugs Administration and Control (NAFDAC). About one hundred centiliter (100cl) of the milk was used as control (treatment A), one hundred centiliter (100cl) contained three grams (3g) of clove, treatment B (v/w), one hundred centiliter (100cl) contained three grams (3g) of ginger, treatment C (v/w), and another one hundred centiliter (100cl) contained three grams (3g) of both the clove and ginger, treatment D, (v/w). Two (2) other replicates were made with same quantity of the milk, a hundred centiliter (100cl) but blended with different amount of the preservatives, five and seven grams (5 and 7g) respectively. The samples were stored at ambient temperature in the laboratory; evaluate its microbial content every day while spoilage was observed every morning, day and evening, by determining a change in any of the organoleptic parameters by the respondents.

2.3 Determination of Proximate Composition of the Samples

The physicochemical composition of the tiger nut milk, tiger nut tubers, dates, clove and ginger powder were evaluated using standard laboratory methods in NAFDAC, Maiduguri, Borno State. Proximate Composition include; ash, protein, fat, fiber, carbohydrate, water content of the samples as adopted by Stanley *et al*. (2021).

2.4 Determination of pH (at ambient temperature) of Tiger nut milk

The pH meter was standardized using buffers (4) and (7) solutions at ambient temperature. The pH knob was switched off and the glass electrode was removed from the buffer solution. The electrode was rinsed with distilled water and the tip of the electrode was dried with soft tissue paper. The cleaned and dried glass electrode was inserted into the sample. The pH knob was switched on and the pH value was taken.

2.5 Determination of Fat content (%) of the Tiger nut milk

Ten grams (10g) of each sample was weighed into a separating funnel, 1ml of 0.88 ammonia was added and mixed. Exactly 10ml of alcohol (95%) was added and mixed again. Some 25ml peroxide-free diethyl ether was added stoppered and shaken vigorously for 1 minute. Another 25ml of light petroleum (b.p 40-60ºC) was added and shaken vigorously for 30s. After separation was completed (standing for at least 30 min.), the fat solution transferred into a suitable flask (previously dried at 100ºC, cooled and weighed). To the tube two successive lots of 5ml of mixed ethers were added and transferred (without shaking) to the flask. 5ml ethanol was added mixed, and then the extraction was repeated (with 15ml of ether and 15ml of light petroleum) and the subsequent operations. The extraction was repeated with the ethers once more without addition of ethanol. The solvents were distilled from the flask; the fat was dried for 1hr at 100ºC, cooled and weighed. The flask was washed with light petroleum (should there be any non-fatty matter), dried, reweighed and the result corrected accordingly.

2.6 Titratable acidity (%) of the Tiger nut milk

The acidity is usually determined by direct titration, as (10ml) of the sample was Pipetted into a conical flask, 1ml of the phenolphthalein indicator solution was added and titrated with 0.1M sodium hydroxide, with continuous stirring until the colour changes to pink tint. The acidity as citric acid (per cent m/v) was calculated using this formula;

1ml 0.1M sodium hydroxide = 0.009008g lactic acid.

2.7 Protein (%) Content

One gram (1g) of the sample was put into a Kjeldahl flask.1g of sodium sulphate and 0.1g of copper sulphate (catalyst) was added. Using a measuring cylinder 25ml concentrated sulphoric acid was added to the flask. The flask was heated gently. The flask was placed in an inclined position. It was swirled occasionally. When the initial vigorous reaction has died down, the heat was increased and digestion was continued until the liquid was clear and free from black or brown Colour. The flask was swirled from time to time to wash down charred particles from the sides of the flask.

The flask was allowed to cool and the contents was diluted with about 200ml distilled water and 85ml of 50% NaOH to make the liquid distinctly alkaline. A distillation apparatus consisting of the flask (500ml capacity), stopper carrying a dropping funnel and a splash head adaptor was connected to a vertical condenser to which is attached a straight delivery tube. Fifty milliliters (50ml) of 2% boric acid solution was weighed into a 500ml conical flask, a few drops of screened methyl red indicator was added to it and was placed on the receiver so that the end of the delivery tube dips just below the level of the boric acid.

The solution was vigorously boiled until about 250ml have distilled over. The receiver with delivery tube was later removed. The dropping funnel tap was removed and the source of heat stopped. The distillate was titrated with a standard acid to pink colour and the titer value taken.

Calculation: $\% N = T.V \times 0.0014/W \times 100$

Where W is the weight of the sample taken.

% Protein = N × F.

Where F is a factor equal to 5.70 for wheat flour, 6.38 for milk and milk products and 6.25 for other samples

2.8 Total solid (%)

An empty crucible was weighed (W1), 15ml of the sample was added and evaporated over a boiling water bath until dryness. This was further dried in an oven at 105 ºC and weighed again (W2).

% Total solid = W2 - W1 / 15 × 100

2.9 Ash (%) Content

After taking the total solid, the crucibles with the contents were placed into furnace and heated at 550 ºC for 3 h. after ashing the crucibles were removed from the furnace cooled and weighed (W3). W2 is the weight of empty crucible with sample before drying.

% Ash = W3 - W1 / W2 - W1 × 100

2.10 Carbohydrate (%) Content

100- (% water + %Ash + %protein + %fat)

Water (%)

100 – Total solid = Water content.

2.11 Evaluation of Organoleptic Property of the Sample

A structured close ended questionnaire containing (9) cardinal points (like extremely, like very much, like moderately, like slightly, neither like or dislike, dislike slightly, dislike moderately, dislike very much and dislike extremely) based on acceptance rate was used by panelists or respondents to assess the Organoleptic parameters of the milk which includes; appearance or colour, aroma or flavour, mouth feel, sweetness, taste and palatability of the samples using the method of Agbemebia *et al*. (2019).

2.12 Statistical Analysis

Descriptive Statistics (percentage and mean) of observations was used in this study.

3. Results

3.1 Proximate Composition of Date Fruit, Tiger Nut Tuber, Ginger and Clove

Moisture, ash, protein, fibre, sugar and fat were determined as the proximate composition in date fruits, tiger nut, ginger and clove powders. The dates contained 31.25% moisture, 5.36% ash, 6.37% protein, 9.05% fiber, 46.50% sugar and 1.47% fat. Contents of the tiger nut were 19.68%, 2.94%, 10.21%, 13.35%, 26.38% and 27.44% for moisture, ash, protein, fibre, sugar and fat respectively. The moisture content in ginger and clove powders were (6.40 and 14.90%), ash (9.41 and 7.40%), protein (7.68 and 1.21%), fibre (8.35 and 20.11%), sugar (62.14 and 44.25%) and fat (6.02 and 12.13%) respectively (Table 1).

Table 1: Proximate composition of date fruit, tiger nut, ginger, and clove analyzed

Parameters	Date fruit	Ginger	Clove	Tiger nut
Moisture (%)	31.25	6.40	14.90	19.68
Ash (%)	5.36	9.41	7.40	2.94
Protein (%)	6.37	7.68	1.21	10.21
Fiber (%)	9.05	8.35	20.11	13.35
Sugar (%)	46.50	62.14	44.25	26.38
Fat (%)	1.47	6.02	12.13	27.44

3.2 Proximate composition of the freshly produced tiger nut milk

Some major parameters assessed by this study in the produced milk had the following values, 0.60% (lactic acid), 20.42% (total solids), 67.38% (water), 1.07% (ash), 3.25% (protein), 6.06% (fat), 0.48% (fiber), 0.93% (carbohydrate), with 5.32% (pH) at 28ºC as presented in Table 2.

Table 2: Proximate composition of the freshly produced tiger nut milk

Parameters	**Tiger nut milk (sample)**
Acidity (lactic acid)	0.60%
Total solid	20.42%
Water	67.38%
Ash	1.07%
Protein	3.25%
Fat	6.06%
Fiber	0.48%
Carbohydrates	0.93%

3.3 Organoleptic Properties of Tiger Nut Milk

The result presented in Table 3 is a record for the palatability taste of the produced milk (control) by ten (10) panelists. The responses as shown were 20%, like extremely and 80%, like the product's colour very much. Aroma recorded 40% (like extremely), 40% (like moderately) and 20% (like slightly). About 60, 20, and 20% of the panelists like the texture of the milk extremely, moderately and slightly, while 60 and 40% do like its sweetness extremely and very much, respectively. However, the taste of the milk drink sweetened with dates was liked very much by 20%, extremely by 60% and neither like nor dislike by 20%.

Table 3: Acceptability rate of the produced tiger nut milk (control) using 9-hedonic scale by ten (10) Panelists

Organoleptic parameter	**Acceptance rate (%)**								
	4	3	2	1	0	-1	-2	-3	-4
Appearance	20	80	_	_	_	_	_	_	_
Aroma	40	_	40	20	_	_	_	_	_
Texture	60	_	20	20	_	_	_	_	_
Sweetness	60	40	_	_	_	_	_	_	_
Taste	60	20	_	_	20	_	_	_	_

Key:- 4 means like extremely, 3 means like very much, 2 means like moderately, 1 means like slightly, 0 means neither like nor dislike, -1 means dislike slightly, -2 means dislike moderately, -3 means dislike very much, -4 means dislike extremely and _ means nil or no record observed.

3.4 Organoleptic Properties of tiger nut milk blended with different conversations of clove, ginger, and both for (3) days

Figures 1 - 9 show the results of organoleptic evaluation of tiger nut milk with 3, 5 and 7g of; clove, ginger and a combination of both clove and ginger, per liter of the tiger nut milk produced, using 9-hedonic scale of rating for three (3) days. The rates (%), for each parameter were from ten (10) different responses of respondents every day and used to assess the products' acceptability and spoilage over time. The most acceptable was Fig. 6, with five grams (5g) of ginger, while the unacceptable was Fig. 9, with seven grams (7g) of clove.

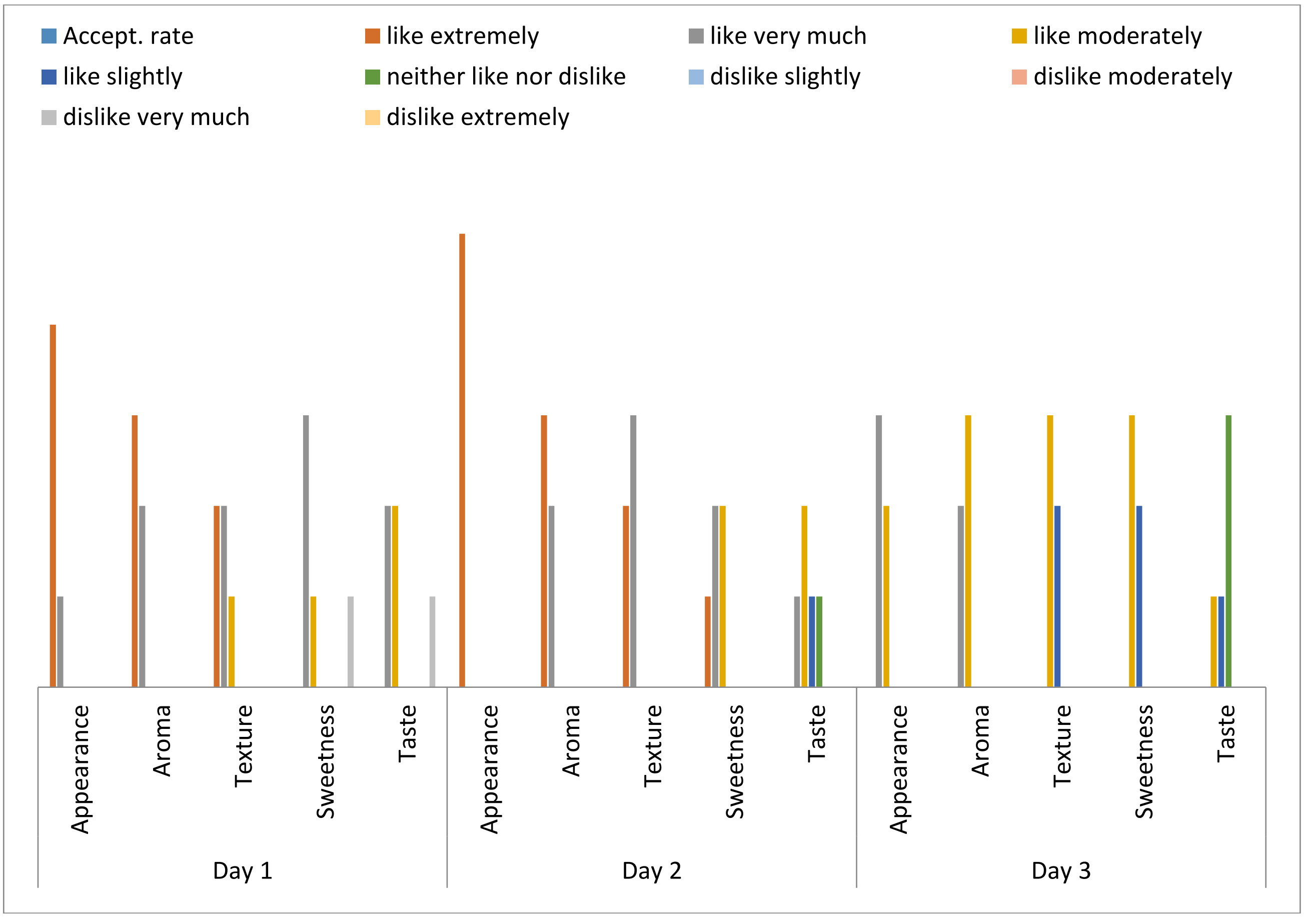

Figure 1: Organoleptic evaluation (%) of tiger nut milk blended with 3g of clove for (3) days

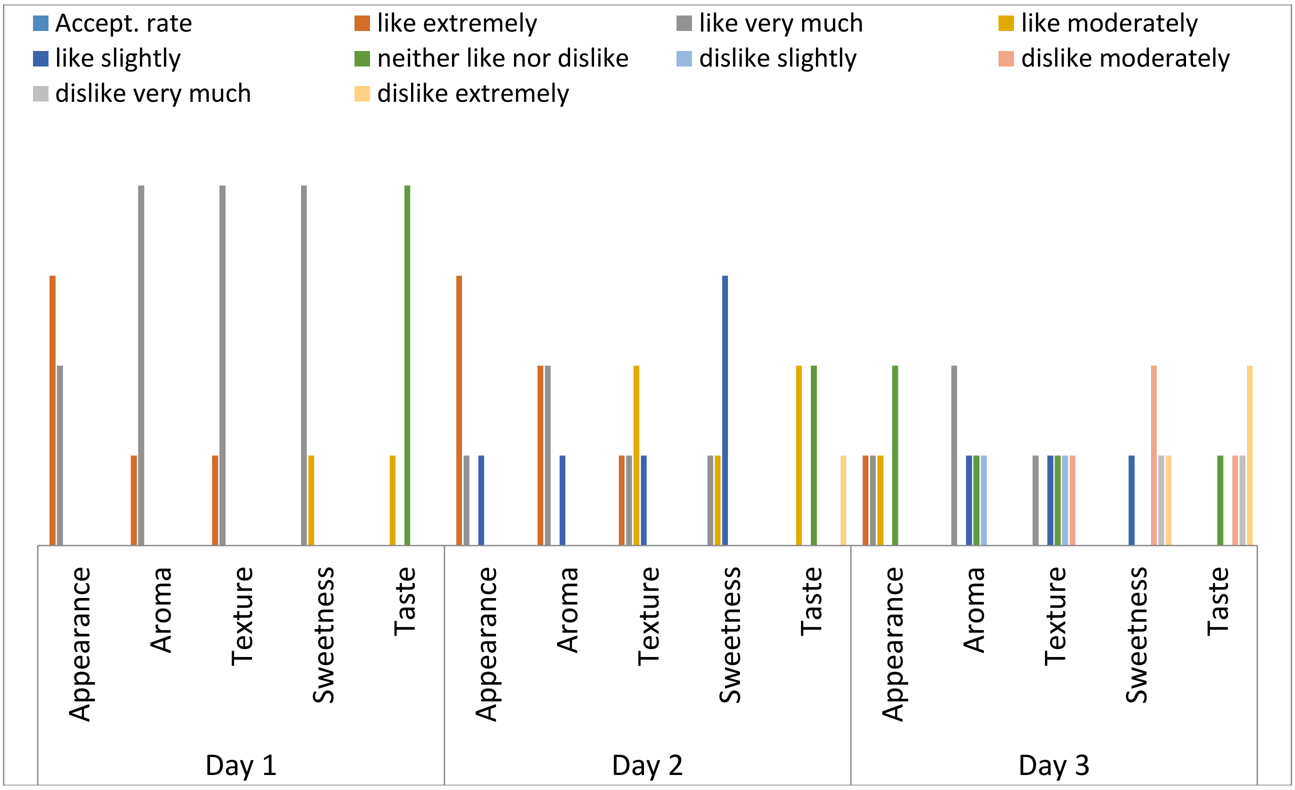

Figure 2: Organoleptic evaluation (%) of tiger nut milk blended with 5g of clove for (3) days

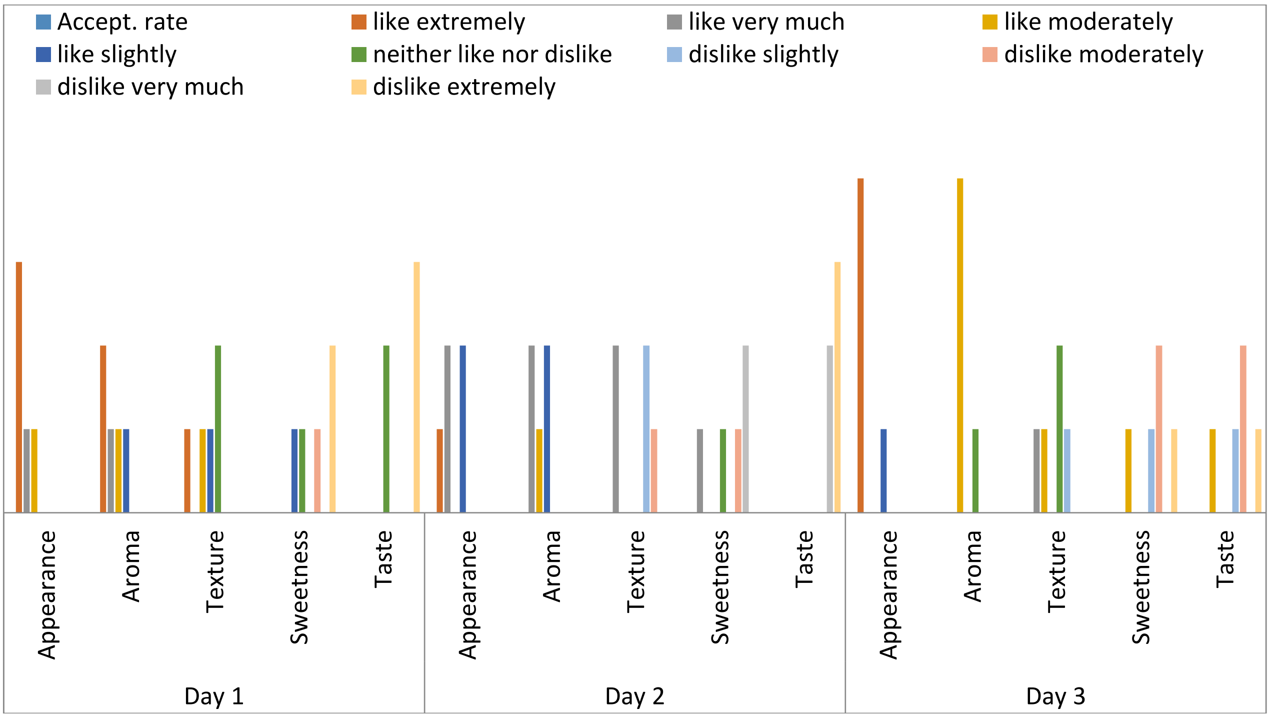

Figure 3: Organoleptic evaluation (%) of tiger nut milk blended with 7g of clove for (3) days

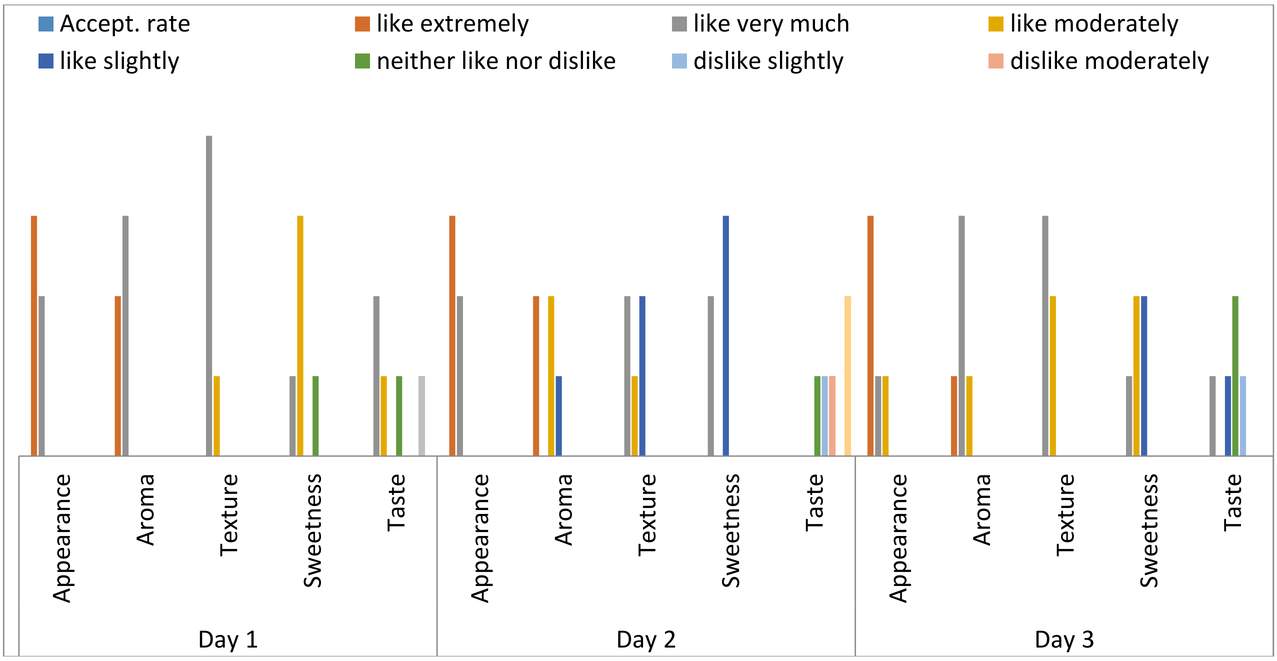

Figure 4: Organoleptic evaluation (%) of tiger nut milk blended with 3g of ginger for (3) days

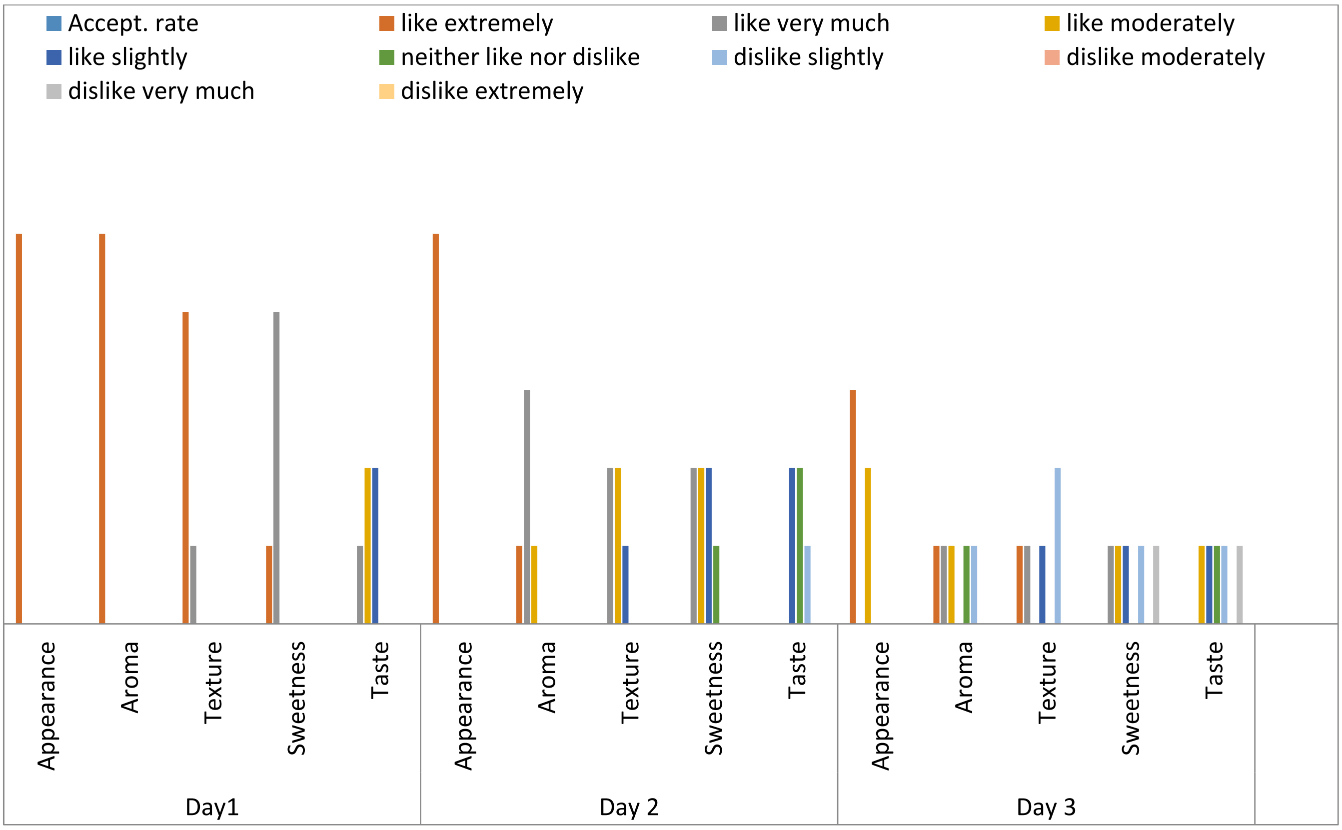

Figure 5: Organoleptic evaluation (%) of tiger nut milk blended with 5g of ginger for (3) days

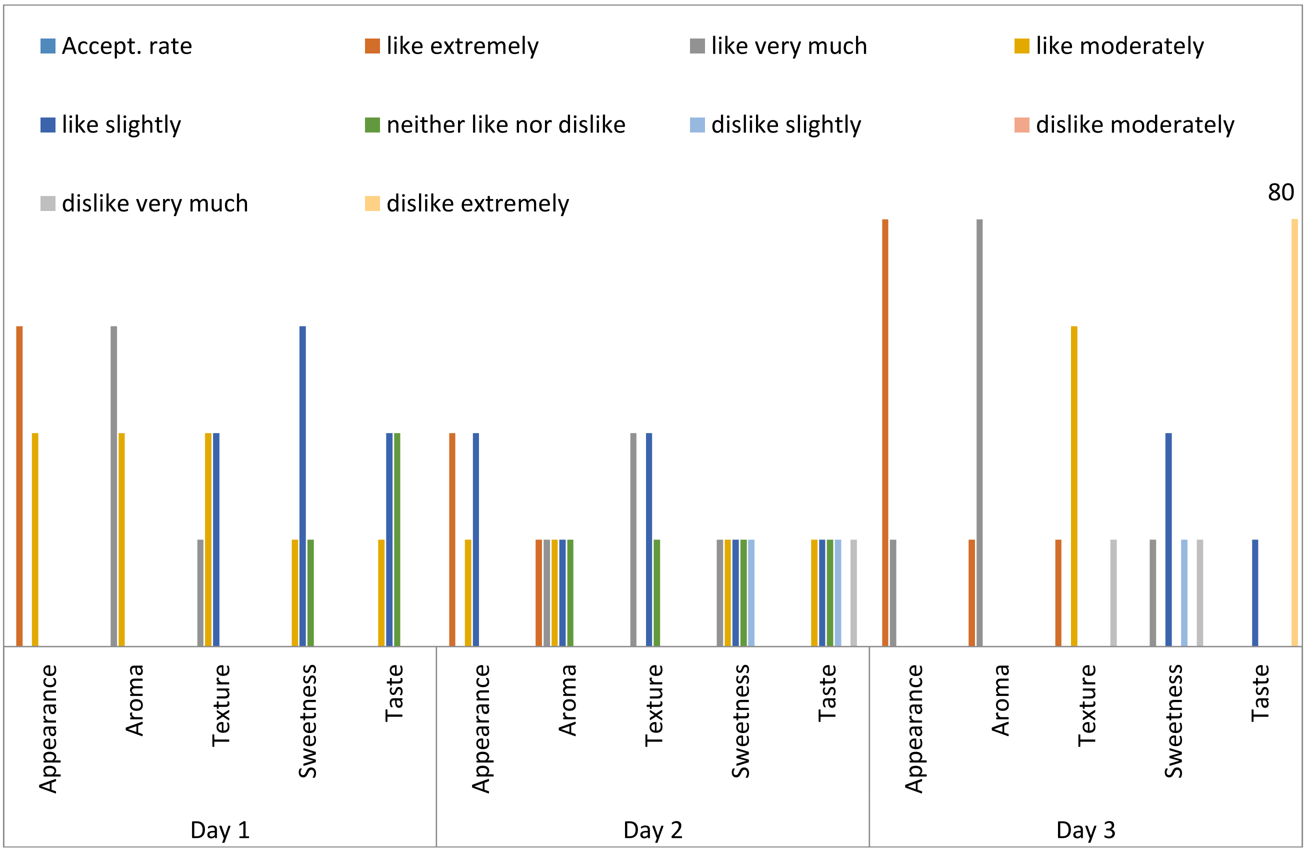

Figure 6: Organoleptic evaluation (%) of tiger nut milk blended with 7g of ginger for (3) days

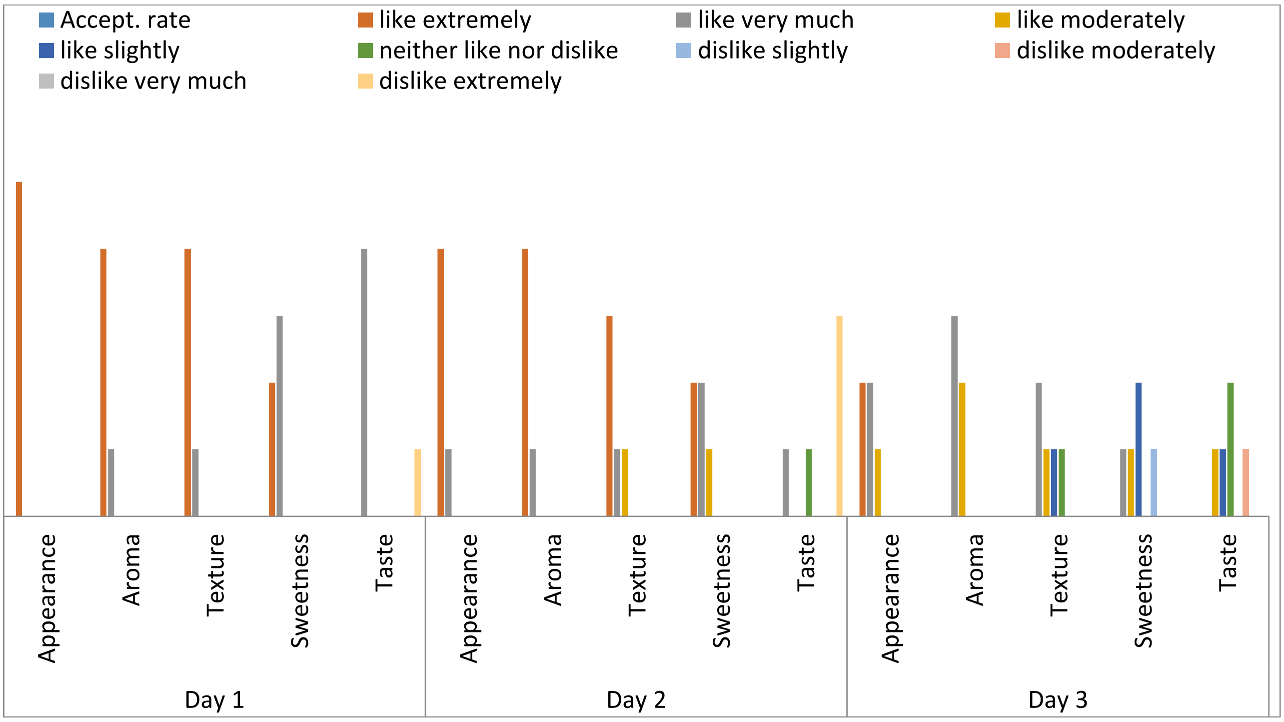

Figure 7: Organoleptic evaluation (%) of tiger nut milk blended with 3g of clove and ginger for (3) days

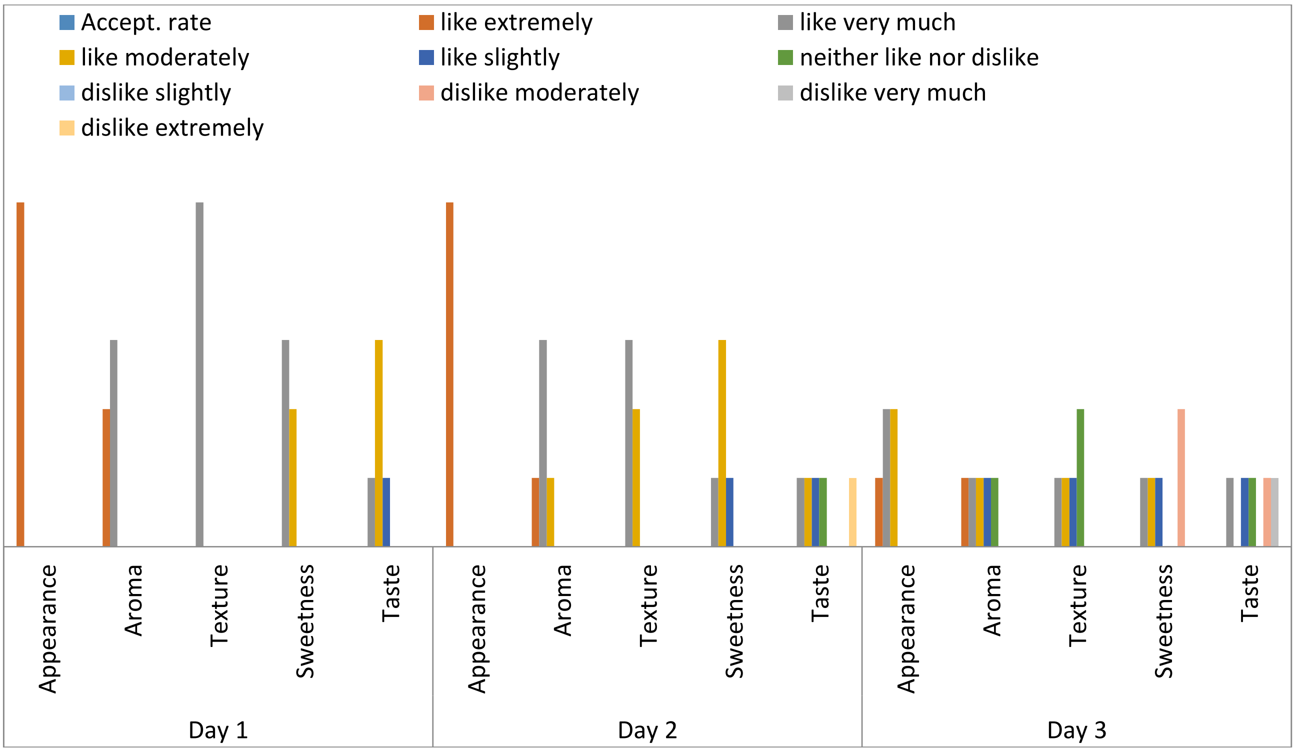

Figure 8: Organoleptic evaluation (%) of tiger nut milk blended with 5g of clove and ginger for (3) days

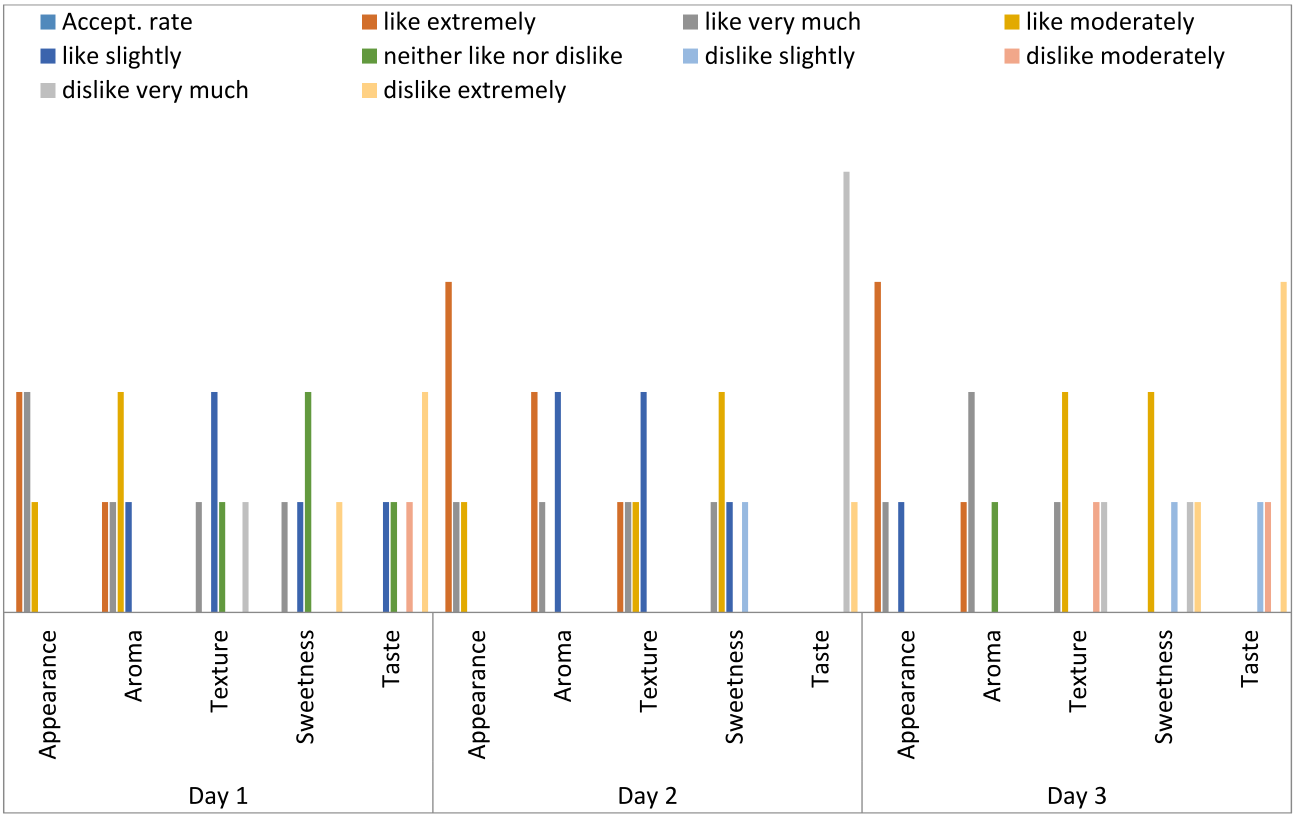

Figure 9: Organoleptic evaluation (%) of tiger nut milk blended with 7g of clove and ginger for (3) days

4. Discussion

The results of this study showed that the moisture content in the tiger nut was 19.68% which is lower than that presented by Sanchez Zapata *et al.* (2012) in Tiger nut (*Cyperus esculentus L.*) commercialization: Health aspects, composition, properties, and food applications, having 26.00% and Suleiman *et al.* (2018) in Proximate composition, mineral and some vitamin contents of tiger nut (*Cyperus esculentus L.*), having 42.40%. The work, Tiger Nut (*Cyperus esculentus* L.): Nutrition, Processing, Function and Applications by Yali *et al.* (2022) does not indicates the range of values for moisture content because it depends on whether it's fresh, semi dried or dried. This finding is not in agreement with that reported by Stanley *et al.* (2021) in comparative study of the properties of yellow and brown *Cyperus esculentus* L., thus, makes the tiger nut less susceptible to microbial attack and supplement the body with little amount of water. Ash components in the tiger nut was 2.94% analyzed by this study is out of the range (1.60 to 2.60%) as recorded by Yali *et al.,* (2022). This value is similar to that by Stanley *et al.* (2021), but different from the report by Sanchez Zapata *et al.* (2012) and Suleiman *et al.* (2018). The ash components of the tiger nut represent the amount of minerals, trace elements and vitamins in it which can boost immunity. The protein composition of the used tiger nut (10.21%) was not found within the range of 3.28-8.45% (Yali *et al.,* 2022), similar to the result of Suleiman *et al.* (2018) and not consistent with the findings of Sanchez Zapata *et al.* (2012) and Stanley *et al.* (2021). Although tiger nut is not a good source of protein, it can provide about 26% to children and 17% to adults when consumed (Yali *et al.*, 2022). Fat content (27.44%) of the tiger nut sample investigated in this study fall within the range of 22.21% - 44.92% as reported by Yali *et al.* (2022) and is yet not in consensus with the findings by Suleiman *et al.,* (2018). This value proves that oil can be extracted from it. According to this finding, the fiber content (13.35%) is found within the range (8.26-15.44%) by Yali *et al.,* (2022). This is the same with the record by Suleiman *et al.,* (2018), and deviates from 8.91% (Sanchez Zapata *et al.,* 2012) and 6.20% (Stanley *et al.,* 2021). With this value, the fiber content can control body pressure and aid digestion. The total carbohydrate contained in the tiger nut was 26.38% and falls within the range of 23.32 - 48.12% (Yali *et al.,* 2022). This record is not in agreement with that of Sanchez Zapata *et al.,* (2012) and thus, not similar to the reports of Suleiman *et al.* (2018) and Stanley *et al.* (2021). This makes tiger nut to give more energy to children, 40% and adults, 30% (Suleiman *et al.,* 2018). The nutritional value of tiger nuts are dependent on varieties, soil conditions, growth environment, cultivation techniques and storage conditions (Asare *et al.,* 2020).

Fruits are regarded as the product of matured, fertilized and developed ovules among which some have sweet taste and are even recommended as sweeteners to replace white sugar. The addition of dates in this study is to avoid any health related problems with respect to nutrients deficiency and high risk of obesity, diabetes type II, heart diseases, tooth decay, and some types of cancers in humans (Kumar *et al.,* 2020). Proximate composition of the dates used as presented were 31.25% moisture, 5.36% ash, 6.37% protein, 1.47% fat, 9.05% fiber and 46.50% sugar. According to this finding, the moisture, ash, protein, and fiber contents are all higher than 1.25, 1.60, 2.50 and 8.00% respectively as presented by Kumar *et al.* (2020). The result by Kumar *et al.,* (2020) and that of Al-Mssallem *et al.,* (2020) recorded high amount of sugar with 63.40 and 71.40% than the finding in this study. Protein content (2.14%) as observed by Al-Mssallem *et al.* (2020) was less than 6.37%, while the moisture content (18.54%) is lower than 31.25% in this result. Other results by Alasaiva and Shahidi, (2013), and Gopalan and Mohanram, (2011) were observed to record lower values in proximate composition than this work. Based on these recorded values, the moisture can affect self-life of the sample, while the Ash content can nourish human body. The amount of protein and fat in it are not enough to help in building the body nor metabolized into fatty acids and glycerol for the body to use. High sugar level in dates makes it a great source of energy to the body, while the fiber composition aid digestion. Arjmandi *et al.,* (2017) confirmed that the content of fruits may vary with respect to differences in drying process, region and variety of the fruits. According to Mooradian, (2019) the functionality and metabolism of fruit sugar (fructose) is a different pathway than glucose and as such is not associated with obesity because of the accompanying fiber content in fruits.

Clove (*S. aromaticum*) as preservative in this study has a moisture content of 14.90%, which is similar to that of Ayoola *et al.* (2022) having 16.21%, but contrary to that of Ayesha *et al.,* (2023) with 7.86%. This value is attributed to dryness and thus less prone to spoilage. Ash content of the clove (7.40%) is higher than 0.21% as presented by Ayoola *et al.* (2022) but similar to 5.68% as recorded by Ayesha *et al.* (2023). Such minerals and vitamins contents of clove (ash) can build the immune system and enhance coordination. Records by Ayoola *et al.,* (2022) and Ayesha *et al.* (2023) on the protein content of clove (i.e 18.38 and 6.96%) respectively, does not agree with 1.21% as reported in this study. This certifies that the level of amino acids available in the used sample is not enough to build the body. Fiber (food digester) content of 20.11% as presented by this study is higher than 12.24%, by Ayoola *et al.* (2022), but less than 29.97% as reported by Ayesha *et al.* (2023). There exists a slight difference in the carbohydrate content in all the three (3) studies; Ayoola *et al.* (2022), Ayesha *et al.* (2023) and this study with 49.55% then 44.50% and 44.25% respectively. This observation, shows that there is an appreciable amount of sugar level in clove, which is very significant in metabolism. It has been reported by Ayoola *et al.* (2022) and Ayesha *et al.* (2023) that the content variation in clove may be due to level of maturity of the flowers, dryness and variety of the plant.

Ginger, *Z. officinalis* has been used globally because of its several scientific properties and value to humans (Najim and Jabir, 2017). The values (6.40, 9.41, 7.68, 6.02, 8.35 and 62.14%) are the results of proximate composition of dried ginger powder with respect to moisture, ash, protein, fat, fiber and sugar respectively. In comparison of this result to that of Bijay, (2018) and Ayesha *et al.* (2023), their records show higher content in moisture (9.40 and 8.11%), may be because the ginger is too dried, protein (9.10 and 10.51%), not a good source of amino acids, and carbohydrate (70.80 and 69.61%), but enough to generate energy for biosynthesis, respectively. However, the content of ash and fiber as reported by this work are higher than that recorded by Bijay, (2018) with 4.80 and 5.90%, and Ayesha *et al.* (2023) with 5.63 and 3.01% respectively. The present value of ash in the sample of ginger can help to build strong bones and aid in healing wounds, while the fiber can help in food digestion. According to Bijay, (2018), differences in proximate composition is due to type, variety, agronomic conditions, curing methods, drying and storage conditions, while its use as preservative is due to the presence of bioactive compounds.

The ash, protein and fat content in the tiger nut milk recorded by this study were 1.07, 3.25 and 6.06% respectively. These values in the milk can nourish, build and support cellular growth of human body. In relation to the proximate composition, the results are higher than that obtained by Sanchez-Zapata *et al.* (2012) in Horchata, and Rosello-soto *et al.,* (2018) in Ghana and Nigeria. The fiber content (0.48%) is almost in agreement with the beverage in Nigeria (0.55%), lower than that of Horchata

(1.03%), but higher than that in Ghana (0.27%). This makes the milk to be less effective in controlling body pressure and digestion. However, the energy generator (carbohydrate) content in Horchata was not detected. The sugar value, 0.93% in this study is less than 2.23% in Nigeria and 2.52% in Ghana (Rosello-soto *et al.,* 2018). The tiger nut milk produced was slightly sour (5.32) than 6.64 (Chima *et al.,* 2013), creating a medium for acidophilic microbes to proliferate and possibly cause spoilage. Water availability of 67.38% in this work proves to be less than 84.60% as reported by (Chima *et al.,* 2013). Yet, fair enough to harness the tiny giants. The variability in results might be due to variety of the tiger nut and planting sites (Asante *et al.,* 2014).

Based on the sensory evaluation of tiger nut milk, with different preservatives and at different concentrations, the results prove that the milk were highly acceptable to the panelists because the scores fall within the range of likeness and very slightly dropped its potency as the storage time increased (from day 1 to day 3) and can be linked to the fact that the milk was fermented by the organisms within it. This is in consensus that tiger nut milk treated with ginger was highly preferred (Nwobosi *et al.,* 2013). There is a report by Maduka, (2017) which back up the claim that flavouring agents including clove and ginger increase the acceptability of food as shown in this study. Agbemebia *et al.* (2019) recorded a contrary acceptance rate to this work as their report started with "good", down to "neither nor bad" and then "bad". Besides the sensory attributes by the preservatives, the expected antagonism by clove or ginger, and the synergism between clove and ginger is not enough to checkmate the mechanisms of food spoilage by the bacterial and fungal contaminants in the milk.

The results of this study demonstrate that tiger nut milk has a favorable nutritional profile and high sensory acceptance, particularly when ginger is incorporated as a preservative. Microbial assessments indicate that natural preservatives like ginger and clove contribute to improved stability over short-term storage. However, this study has certain limitations. Firstly, the short duration of three days may not be adequate to fully evaluate the long-term stability and microbial safety of the product. Future research should explore changes in physicochemical properties and microbial load over extended storage periods under varying environmental conditions (Nwobosi *et al.*, 2013). Secondly, the sensory evaluation was conducted with a small group of ten participants, which may not provide a broad representation of consumer preferences. Expanding the participant pool to include a more diverse demographic would offer more reliable insights. Additionally, a comparative study with established plant-based milks, such as almond and soy milk, would help in determining tiger nut milk's positioning within the dairy alternative market (Chima *et al.*, 2013).

5. Conclusion

The proximate composition of the tigernut, clove, dates, ginger and tigernut milk produced were within the acceptable limits as compared to other studies. The proximate composition revealed that the milk produced from tiger nut have a high nutritional value. The responses of the respondents based on the colour, aroma, mouth feel, sweetness, and taste of the tigernut milk shows the magnitude of its acceptability. This study enhances the understanding of plant-based milk alternatives by investigating the nutritional and sensory characteristics of tiger nut milk. Findings highlight the effectiveness of ginger as a natural preservative, improving both acceptability and short-term stability. Given the increasing shift toward non-dairy milk products, tiger nut milk presents a viable commercial opportunity, particularly for health-conscious consumers seeking nutritious and functional alternatives to traditional dairy. However, additional studies are required to evaluate its long-term shelf life, ideal storage conditions, and broader consumer acceptance. Moreover, further research comparing the nutritional composition and sensory appeal of tiger nut milk with other plant-based alternatives would help establish its potential in the competitive dairy-free market. This study contributes valuable insights to the field of food science and nutrition, emphasizing the potential of tiger nut milk as a sustainable, plant-based beverage option.

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