Global Journal of Engineering and Technology [GJET].
ISSN: 2583-3359 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjet-home/

SENSORY PROPERTIES AND ACCEPTABILITY OF TIGER-NUT POWDER MILK AS INFLUENCED BY SOAKING TEMPERATURE, SOAKING TIME AND DRYING TEMPERATURE

By

N. I. Nwagugu[1*], W.I. Okonkwo[2]

[1]Projects Development Institute (PRODA), Enugu, Nigeria
[2]Department of Agricultural and Bioresoureses Engineering. University of Nigeria, Nsukka, Nigeria

Article History

Received: 15/03/2025
Accepted: 23/03/2025
Published: 25/03/2025

Vol – 4 Issue – 3

PP: - 30-37

Abstract

Milk derived from animal sources often contains anti-nutrient elements such as α-lactoglobulin, β-lactoglobulin, lactose, and cholesterol, which can contribute to various health challenges. Plant-based milk alternatives, such as tiger-nut milk, offer a healthier option but often have short shelf life and high storage costs as its limitations. This work aimed to investigate the effect of soaking temperature, soaking time, and drying temperature on the sensory properties (colour, mouth feels, texture) and overall acceptability of the milk powder produced. Powdered milk was produced from brown tiger nut at a combination of soaking temperatures (40, 50, 60, and 70 ^{o}C) soaking time (12, 24, 36, and 48 hrs), and drying time (50, 60, and 70 ^{o}C). The sensory properties and overall acceptability were examined for each combination. Organoleptic (colour, mouth-feel, texture) and acceptability quality of the solid milk produced was evaluated using a 48-member untrained panel to establish the sensory properties of the milk using a 9-point hedonic scale with 9-Extremely desirable and 1-Extremely undesirable. The attributes assessed are Colour, Mouth-feel, texture, and overall acceptability. Water was made available for the panellist to rinse their mouth after testing each sample and they were also allowed to retest the powdered milk. The results obtained showed that the colour of the milk produced by soaking the tiger nuts at 60 ^{0}C for 12 and 48 hours, dried at 60, 50, and respectively was the most preferred, the mouth-feel of milk powder produced by soaking the tiger nuts at 60 0C for 12 hours and drying at 60 0C is the most preferred by the panel, while the most preferred texture of the milk is of that produced by soaking the tiger-nuts at 50 ^{0}C for 48 hours and dried at 60 ^{0}C. In earnest, the overall acceptability of powder milk with the most preferred sensory properties is that produced by soaking the tiger nuts at 60 ^{0}C for 12 hours and dried at 60 ^{0}C

Keywords: *Colour, Mouth-feel, Texture, Milk, Drying Temperature, Drying Time, Soaking Time, Soaking Temperature Tiger-nut, Milk powder*

1.0 INTRODUCTION

Milk is an essential food for many people in their daily livelihood by providing most of the required nutrients for healthy growth and it is originally sourced from mammals (cattle, sheep, camel, goat, yak, buffalo, and reindeer). Cow milk is the most consumed milk worldwide [1], and is reported to provide essential nutrients such as proteins (whey and casein protein), fat (palmitic acid, conjugated linoleic acids (CLA), -linolenic acid (ALA), milk polar lipids (MPL), vitamins (vitamin A, vitamin B complex), and minerals (iron, calcium, magnesium, phosphorus) that have been described to have crucial functions in the body's growth and metabolism for good health and well-being [2][3]

Milk is used daily in multi-choice mills [4]. Unfortunately, milk from animal sources contains anti-nutrient components like -lactoglobulin and ß-lactoglobulin, which cause food allergies in infants [5], lactose, and cholesterol, which are linked to some health issues like dietary disorders, milk-protein allergy, and/or lactose intolerance, which has been reported to affect about 70 to 75% of the human population due to genetically decreased lactase Due to its high price and scarcity, it is also out of the reach of the underprivileged. Because animal milk includes saturated fatty acids and

*Corresponding Author: N. I. Nwagugu

cholesterol, it is also associated with a rise in low-density lipoprotein [6], therefore international organizations like the WHO (World Health Organization), the FAO (Food and Agriculture Organization of the United Nations), and the IPCC (Intergovernmental Panel on Climate Change) all advocate a global shift to plant-based diets, among which is plant-based milk, which is recognized with high health benefits.

Plant-based milk is those that are made from cereals (such as oats, rice, spelled, corn, etc.), legumes (such as soy, lupins, and peanuts), and pseudo-cereals (such as quinoa, amaranth, and teff). When mixed with water, nuts and/or seeds that resemble animal milk in appearance, texture, and use are reported to have different nutritional compositions and mouth feels depending on the raw material used, method of production, and fortification [4], but Brenda claimed that all the nutrients provided by cow's milk can be obtained in other ways. Other crops like lupin, cashew, quinoa, flax, hemp, walnut, hazelnut, and tiger-nut can also yield milk.

Tiger-nut (*Cyperus esculentus L*.) is a root tuber that has been discovered to be very useful in several industries, including the food and beverage, pharmaceutical, confectionery, and biofuel sectors. It can be used to make a variety of useful products, such as food additives, coffee substitutes, malt caramel, beverages, fermented foods, flour for baking, and vegetable oil and it can be chewed as a snack.[7], [8]. By soaking, milling, screening, and sweetening with flavors and sugar, tiger nuts are transformed into an extremely nutritious beverage known as "*Horchata de chufa*" in Spain, "*Atadwe*" in Ghana, and "*Kunun aya*" in Northern Nigeria. However, the liquid form of milk obtained from tiger nuts has a very short shelf life and requires energy-intensive storage because it must be kept at a temperature between 4 and 7 ^{0}C. As a result, using such milk has become more expensive due to the rise in the price of electricity, which is the primary energy source for running refrigerators [3]. Such milk has an extremely short shelf life of 24 hours even in ideal storage circumstances ([9]. To increase the shelf life of Tiger-nut milk, reduce the cost of storage, and for ease of storage and transportation, the milk needs to be converted into powdered form [10].

The process of making liquid milk extracts into powder after soaking and blending involves drying, which is accomplished by reducing the moisture content of the milk to a level that delays the growth and reproduction of spoilage-causing microorganisms and minimizes many moisture-mediated deterioration reactions [11]. Additionally, drying also reduces the bulk of the product, which minimizes the cost of packaging, storage, and transportation while allowing storage of the product under ambient conditions. However, the production process of the extract powder involves soaking in warm or hot water, soaking for a duration of time, and drying at a particular temperature, all of these affect the product's sensory qualities and overall acceptance by the consumer.

The Tiger nut powder milk production process involves soaking the nuts for some time at a particular temperature and drying them at an elevated temperature, as mentioned earlier might influence the colour, mouth-feel, texture, and overall acceptability of the end products [8]. Therefore, this work is aimed at investigating the influence of soaking time, soaking temperature, and drying temperature on some sensory properties such as colour, mouthfeel, texture, and acceptability of the tiger-nut milk powder.

2.0 METHODOLOGY

2.1 Materials

The Materials used for this work include: Brown Tiger-nut, Weighing balance (Adam model: AE7681116, 2000g ×0.01g), Blender (EuroSonic Model Number: ES-910, Capacity: 1.8 Litres), Digital thermometer (Custom model number: CT-220 measuring range: -50 to +200 ^{0}C, Resolution: 0.1 ^{0}C), Modular Cold Room (Riva Cold, Model: MCR1, Temperature Range -50C to 5 0C), Drying Pan (Aluminum tray 25 by 40 cm by 3 cm deep), Hot Air Electric Oven (Genlab, Model OV/200/F/DIG-R38, 2 kW, temperature Range: 30 to 250 ^{0}C), Atomic Absorption Spectrometer (Buck scientific, Model 210 VGP, Flame,)

2.2 Sample Preparation

Brown Tiger-nut (*Cyperus esculent*) was procured from a Tiger-nut whole seller in the central market Bauchi metropolis, Bauchi state. The Tiger nut was screened using a 12 mm sieve to remove impurities and other materials and then washed several times, sundried, and stored in air-tight polythene bags for use in producing the milk.

2.3 Milk Production

The Tiger-nut milk was produced following the procedure described by Rumulo [12] with some modifications. From the cleaned dried Tiger-nut, 450 g were soaked in twice its volume of water at 40 ^{0}C for 12 hours, drained, and washed in clean water.

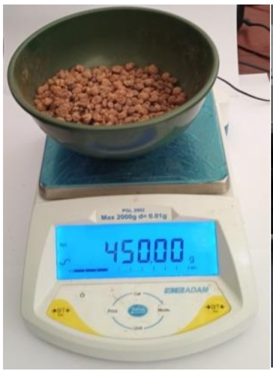

Plate 1: Weighing Sample for Soaking

Plate 2: Blending the Tiger nut

The soaked cleaned Tiger nut was then ground using a kitchen blender at high speed for 5 minutes and filtered through cheesecloth to obtain milk extracts. The quantity of water used in grinding the tiger nut and filtering the milk was twice the volume of the tiger nut after soaking, the liquid milk extracted was then pasteurized for 15 sec at 72 ^{0}C and stored in a refrigerator at 4 ^{0}C before drying. The liquid milk was then dried using a hot air oven on shallow drying trays using three different drying temperatures of 50, 60, and 70 ^{0}C until dried milk was achieved. The dried milk was then blended to

*Corresponding Author: N. I. Nwagugu

powder using a blender and stored for sensory properties and overall acceptability tests.

Plate 3: Produced Tiger nut Milk

Plate 4: Dried Powdered Milk

2.4 Experimental Procedure

The research work was carried out using four (4) soaking temperatures (40, 50, 60, and 70 ^{0}C) labeled, soaked for four (4) different soaking times (12, 24, 36, and 48 hours) all of which were blended for 5 minutes in a kitchen blender and the milk were extracted and dried at three (3) different temperatures (50, 60 and 70 ^{0}C) with three replication each fitted into complete randomized design (CRD) experiment which gives several combinations to $4 \times 4 \times 3 \times = 48$ combinations and then each combination where run was replicated 3 times and the means gotten for analysis.

2.5 Statistical Analysis

Analysis of Variance (ANOVA) was carried out on data obtained from the yield, sensory evaluation, and Tukey's test ($P < 0.05$) was used to identify the source of the differences if any using SPSS (Version 25) and Paired T-test analysis was carried out on the data from sensory evaluation as suggested [13] using the same software. Correlation analysis was done on sensory parameters using the scores obtained from the sensory panellists.

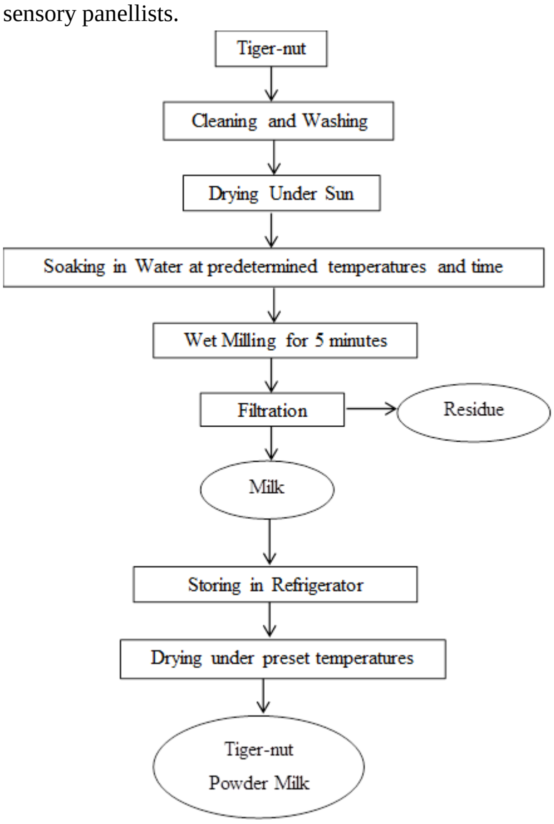

Figure 1: Flow Diagram for Tiger-nut Milk Production Process

2.6 Sensory Evaluation of Tiger Nut Milk

Organoleptic taste (colour, mouth feel, texture) and acceptability quality of tiger-nut milk produced under the different conditions were determined by carrying out a sensory evaluation using 48 member untrained panel to establish the sensory properties of the milk using a 9-point hedonic scale with a 9-Extremely desirable and 1-Extremely undesirable [14]. Data were collected using a prepared form and the attributes assessed are: Colour, Mouth-feel, texture, and overall acceptability. Water was made available for the panelist to rinse their mouth after testing each sample and they were also allowed to retest the powdered milk. The results of the sensory evaluation are presented in Tables 1 to 9.

2.7 Validation of Results

The analysis of variance for the sensory properties and acceptability was used to validate the results at a P-value of 0.05, and Poshoc analysis was carried out to identify the source of the variation using Tukey LSD.

3.0 Results and Discussion

3.1 Colour of Tiger Nut Powder Milk

3.1.1Effect of soaking temperature on the colour of tiger-nut milk powder

Tukey mean ranking for the effect of soaking temperature on the colour of tiger-nut milk presented in Table 1 shows that at P-value 0.05, the colour scores of 6.61 for the milk produced by soaking the tiger-nut at 40 ^{0}C are significantly different from those of 7.75, 7.89 and 7.33 for the milk produced by soaking the tiger-nut at 50, 60 and 70 ^{0}C respectively. The results suggest that soaking at warmer temperatures (60^{0}C) enhances color quality, potentially making the tiger-nut milk more appealing to panelists and this result agreed with the finding published by [15] and the results indicated that the colour of the milk produced by soaking the tiger-nut at 60 ^{0}C is the most preferred by the panelist.

Table 1: Effect of Soaking Temperature on Colour of Tiger-nut Milk Powder

Soaking Temperature	Colour Score
60	7.89 ^{a}
50	7.75^a
70	7.33 ^{a}
40	6.61^b

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test. With LSD = 0.691

3.1.2 Effect of drying temperature on the colour of tiger-nut milk powder

The Tukey mean ranking for the effect of drying temperature on the colour of tiger-nut milk presented in Table 2 indicated that at P- value of 0.05, the mean score of 7.75 and 7.71 obtained by the milk produced by drying tiger-nut milk at 60 and 70 ^{0}C is statistically different from that of 6.67 obtained by the milk dried at 50 ^{0}C. In a similar research carried out by [16] , it was reported that the higher drying temperatures

*Corresponding Author: N. I. Nwagugu

resulted in better retention of color but stressed that optimal temperature management must balance flavor, color, and nutrient retention. Another work published by [17], [18] have all agreed that the higher temperature influences the colour qualities of plant-based foods therefore, this work has affirmed to their finding, and from the result, it is indicated that the colour of the most preferred milk was that produced by drying it at 60 ^{0}C.

Table 2: Effect of Drying Temperature on Colour of Tiger-nut Milk Powder

Drying Temperature	Colour Score
60	7.75^a
70	7.71^a
50	6.73^b

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD = 0.600.

3.1.3 Effect of soaking temperature and soaking time on the colour of tiger-nut milk powder

Turkey LSD means separation was used to determine the effect of soaking temperature and soaking time on the colour preference of tiger-nut milk powder by the panels as presented in Table 3. The results revealed that at a P-value of 0.05, the colour score of 6.33 and 6.67 for the milk produced by soaking the tiger nut at 40 and 50 ^{0}C for 12 hours statistically differ from those of 7.56 and 8.11 obtained by the milk produced by soaking the tiger nuts at 60 and 70 ^{0}C for the same period. Similarly, the colours scores of 6.89 and 6.78 obtained by the milk produced by soaking the tiger-nut at 40 and 70 ^{0}C for 24 hours at the same P-value are statistically different from those obtained by soaking the tiger-nuts at 50 and 60 ^{0}C for the same period. The results also revealed that by soaking the tiger nut for 36 hours at 40 ^{0}C the colour score obtained of 5.44 is statistically lower than those of 7.78, 7.67, and 7.44 obtained by soaking tiger nuts at 50, 60, and 70 ^{0}C respectively for the same period. Finally, the result indicated that the colour scores of 7.78, 8.11, and 8.78 gained by milk produced by soaking tiger-nut at 40, 50 and 60 ^{0}C for 48 hours are statistically higher than that of 7.00 for the milk soaked at 70 ^{0}C for the same period of 48 hours. The results show a clear trend related to temperature. Soaking at higher temperatures (60°C and 70°C) yielded higher color scores across different soaking times. This is as a result of higher temperatures enhancing the extraction and stability of color compounds within the tiger nut and this could be due to an increase in the solubility of pigments and the enhancement of Maillard reactions, which can improve color intensity. These findings are by the report by [18]. From the result, the most preferred colour of the milk by the panelist is that produced by soaking the tiger-nut at 60 ^{0}C for 48 hours.

Table 3: Effect of Soaking Temperature and Soaking Time on Colour Preferance

	Soaking Time			
Soaking Temperature	12	24	36	48
40	6.33^a	6.89^a	5.44^a	7.78^a
50	6.67^a	8.44^b	7.78^b	8.11^a
60	7.56^{ab}	7.56^{ab}	7.67^b	8.78^{ab}
70	8.11^b	6.78^a	7.44^b	7.00^{ac}

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD = 1.382

3.2 Mouth-feel of Tiger-nut Powder Milk

3.2.1 Effect of drying temperature on mouth feel of tiger-nut milk powder

The result of Tukey's Posthoc analysis of the effect of drying temperature on mouth feels of tiger-nut milk powder milk as shown in Table 4 revealed that the mean score of the mouth feel of 6.25 obtained by the milk dried at 50 ^{0}C at a p-value of 0.05 is significantly different from those of 7.44 and 7.27 obtained by milk dried at 60 and 70 ^{0}C respectively.

Mouthfeel is greatly influenced by moisture content, fat content, and the presence of soluble solids. This means higher drying temperatures lead to reduced moisture content, resulting in a more concentrated flavor and improved mouthfeel due to the dissolution of solids during the reconstitution of the powder [19], to some extent drying temperature can affect higher drying temperatures can alter the sugar profiles of plant-based milk, and enhance flavor perception [20], based on the data obtained from the panelist's mouthfeel, the result flows with the aforementioned findings, and the best mouthfeel was achieved at a drying temperature of 60^{0}C.

Table 4: Effect of Drying Temperature on Mouth Feel of Tiger-nut Powder Milk

Drying Temperature	Mouth feel score
50	6.25^a
60	7.44^b
70	7.27^b

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD =0.666

3.2.2 Effect of soaking temperature and soaking time on mouth feel of tiger-nut powder milk

Table 5 presents the impact of various soaking temperature and time combinations on the mouthfeel of tiger-nut milk powder. At a p-value of 0.05, the mouthfeel of milk produced by soaking tiger nuts at 40, 50, 60, and 70°C for 12 and 24 hours was statistically similar. However, the milk produced by

*Corresponding Author: N. I. Nwagugu

soaking at 40°C for 36 hours (5.11) differed significantly from those soaked at 50, 60, and 70°C for the same duration.

Furthermore, milk produced by soaking tiger nuts at 40, 50, and 60°C for 48 hours exhibited similar mouthfeel with scores of 7.33, 7.78, and 6.67, respectively, and differed significantly from that produced at 70°C for the same period. Interestingly, the 48-hour soak at 70°C yielded a similar mouthfeel score to the 48-hour soak at 60°C.

The result indicates that soaking for 12 to 24 hours generally results in acceptable mouthfeel scores, with a peak at 50°C for 48 hours (7.78). However, a 36-hour soak at 40°C gives a lower score of 5.11. This suggests an optimal soaking time and temperature balance for texture improvement without compromising quality. This aligns with the findings by Jiang (2018).

The panelist's preference leaned towards shorter soaking times (12 and 24 hours) due to improved mouthfeel, likely resulting from less starch breakdown and a more desirable texture. Longer soaking times 36 and 48 hours, while beneficial for nutrient extraction, might lead to excessive starch breakdown and a less desirable mouthfeel. The lower soaking temperatures 40 and 50°C are favorable for maintaining good mouthfeel, possibly by preventing excessive starch gelatinization and protein denaturation.

From the results it has shown that the most preferred combination by the panels is that produced by soaking temperature at 60^{o}C for 12 hours or at soaking temperature of 50^{o}C for 48 hours.

Table 5: Effect of Soaking Temperature and Soaking Time on Mouth Feel of Tiger-nut Powder Milk

	Soaking time			
Soaking Temperature	**12**	**24**	**36**	**48**
40	6.67^{a}	7.22^{a}	5.11^{a}	7.33^{a}
50	7.22^{a}	6.44^{a}	7.44^{b}	7.78^{a}
60	7.78^{a}	7.67^{a}	7.22^{b}	6.67^{ab}
70	7.22^{a}	7.22^{a}	7.00^{b}	5.78^{bc}

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD = 1.538.

3.3 Texture of Tiger-nut Powder Milk

3.3.1 Texture of tiger-nut powder milk produced with the different combinations of treatments

The average scores of the tiger-nut milk powder produced by 48 combinations of soaking temperatures of 40, 50 60, and 70 ^{0}C, soaking times of 12, 24, 36, and 48 hours, and drying temperatures of 50, 60, and 70 ^{0}C on their texture were presented in Table 6 and 7.

Table 6 displays the average texture scores of tiger-nut milk powder produced at the four selected soaking temperatures. The texture scores indicate consumer preferences and sensory evaluations which are crucial for understanding the quality of the final product. The highest average texture score was observed at the moderate temperature of 50°C (7.94), This trend suggests that moderate soaking temperatures significantly enhance the texture of tiger-nut milk powder.

The decision by the panelists to prefer texture at 50°C is attributed to the optimal gelatinization of starches into a gel-like form, which can enhance creaminess and mouthfeel. Gelatinization of starch occurs at temperatures ranging from 50°C to 60°C, with the optimal range being crucial for maintaining desirable textural attributes as reported by [21]. The lower score given by the panelists at 70°C (6.94) despite the higher temperatures led to negative outcomes, the reasons being that the high temperatures leached soluble fibers and other components that contribute to texture as reported by [22].

Table 6: Effect of Soaking Temperature on Texture of Tiger-nut Milk Powder

Soaking Temperature	Texture Score
40	6.75^{a}
50	7.94^{b}
60	7.56^{b}
70	6.94^{a}

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD = 0.427

3.3.2 Effect of drying temperature on the texture of tiger-nut milk powder

Tukey's test for the effect of drying temperature on the texture of tiger-nut powder milk is presented in Table 7. It is indicated that the texture of the milk produced by drying at 50 ^{0}C is significantly different from that of the milk produced by drying milk at 60 and 70 ^{0}C which are not significantly different at a P-value of 0.05.

Textural attributes are pivotal in consumer preference for dairy alternatives. Products that are perceived as creamy and smooth tend to score higher on sensory evaluations (texture) as reported by [23]. The highest score at 60 °C (7.69) reflects better consumer acceptance due to the favorable texture that can significantly influence purchase decisions The results show that the milk that has the best texture was produced by drying the milk at 60 ^{0}C. Therefore the decision by the panelists to score high for the moderate drying temperature adhered to the report by [24],[25].

Table 7: Effect of Drying Temperature on Texture of Tiger-nut Powder Milk

Drying Temperature	Texture Score
50	6.69a
60	7.69b

*Corresponding Author: N. I. Nwagugu

70	7.52b

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD = 0.370

3.4 Overall Acceptability of Tiger-nut Powder Milk

The preference of the acceptability of the tiger-nut powder milk produced by the combinations of various soaking temperatures of 40, 50, 60, and 70 ^{0}C for the periods of 12, 24, 36, and 48 hours and dried at various temperatures of 50, 60, and 70 ^{0}C is shown in table 8. It was revealed that the milk produced by soaking the tiger nuts at 40 and 50 ^{0}C for 48 and 12 hours respectively and dried at 70 and 60 ^{0}C with mean scores of 9.00 was the most accepted by the panel followed by those with means of 8.00 to 8.67 then those with mean scores of 7.00 to 7.67. The least accepted milk was those produced by soaking the tiger nuts at the temperatures of 50 and 60 ^{0}C for 12 and 36 hours respectively and dried at 50 ^{0}C.

Out of the 48 combinations of treatments used in producing the milk, 1 was disliked by the panels and 1 was neither liked nor disliked by the panel.

3.4.1 Effect of drying temperature on the overall acceptability of tiger-nut powder milk

The Tukey's test result for the effect of drying temperature on the overall acceptability of the tiger-nut powder milk is shown in Table 8. The test revealed that the most accepted milk was that which was produced by drying it at 60 ^{0}C scores 8.23 which is similar in acceptance to the milk produced by drying the milk at 70 ^{0}C the acceptance of both is significantly different from that of the milk produced by drying the milk at 50 ^{0}C.

The optimal drying temperature for tiger-nut milk powder as scored by the panelists is determined at 60°C based on overall acceptability scores (8.23). This temperature provides a favorable balance between effective drying and preservation of sensory qualities, including, mouth feel, and texture. While the acceptability at 70°C is statistically similar, the risk of undesirable flavor development points towards 60°C as a safer choice. Lower temperatures, such as 50°C, significantly compromise acceptability due to insufficient moisture removal and potential microbial risk. This result is in line with the findings from [26].

Table 8: Effect of Drying Temperature on Overall Acceptability of Tiger-nut Milk

Drying Temperature	Overall Acceptability Score
50	7.35a
60	8.23b
70	7.98b

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD = 0.531

3.4.2 Effect of soaking temperature and soaking time on the overall acceptability of tiger-nut milk powder

The Tukey's test result for the effect of soaking temperature and soaking time on the overall acceptability of tiger-nut milk is presented in Table 9. Tukey's test showed that the overall acceptance of all the milk produced by soaking tiger nut at various temperatures of 40, 50, 60, and 70 ^{0}C for the various times of 12, 24, 36, and 48 hours are not significantly different at P=0.05 except that which was produced by soaking the tiger-nut at 40 ^{0}C for 36 hours which acceptance is significantly lower than that of the rest.

The results indicate that the overall acceptability scores for tiger-nut milk produced at different soaking temperatures and times ranged generally from 5.67 to 8.44. The highest scores were consistently obtained from soaks at 40°C and 50°C for 36 to 48 hours. This suggests that these conditions are optimal for achieving favorable sensory characteristics such as mouth-feel, texture, and overall acceptability, which are critical for consumer choice.

The result showed that Longer soaking times, particularly at moderate temperatures of 40°C and 50°C, appear to enhance the sensory profile of tiger-nut milk. However, excessive soaking durations at potentially suboptimal temperatures led to negative effects, as seen in the 36-hour soaked at 40°C which suggests that the combination of time and temperature does require careful calibration. This finding aligns with previous studies indicating that excessive soaking can result in textural changes and adverse microbial activity, leading to lower acceptability as reported by [26]

The test showed that the most accepted milk was those produced by soaking tiger nuts at 40 and 50^{o}C for the period of 36 and 48 hours.

Table 9: Effect of Soaking Temperature and Soaking Time on Overall Acceptability of Tiger-nut Milk

	Soaking time			
Soaking Temperature	**12**	**24**	**36**	**48**
40	7.78^a	8.00^a	5.67^a	8.44^a
50	8.00^a	8.00^a	8.44^b	8.33^a
60	7.78^a	8.22^a	7.78^b	7.56^a
70	8.22^a	8.00^a	7.89^b	7.56^a

Means followed by the same letter(s) in the same column are not different statistically at P=0.05 using Tukey's test with LSD = 1.226.

4.0 Conclusions

The listed conclusions were drawn from the studies conducted on the sensory evaluation of tiger-nut powder milk:

i. The most preferred colour of the powder milk is that produced by soaking the tiger nut at a temperature of 60 ^{0}C for 48 hours and dried at a temperature of 60 ^{0}C.

*Corresponding Author: N. I. Nwagugu

ii. The most preferred mouth-feel powder milk is produced by soaking the tiger nut at a temperature of 60°C for 12 hours or alternatively at a soaking temperature of 50°C for 48 hours and dried at a temperature of 60 °C.

iii. Similarly, the most preferred texture of the powder milk is that produced by soaking the tiger-nut at a temperature of 50 °C and dried at a temperature of 50°C or alternatively dried at a temperature of 60 °C.

iv. The most accepted tiger-nut powder milk is produced by soaking the tiger-nuts at 60 °C for 12 hours and dried at 60 °C.

5.0 REFERENCES

1. I. Sugrue, C. Tobin, R. Paul Ross, C. Stanton, and C. Hil, "Foodborne Pathogens and Zoonotic Diseases," in *Raw Milk*, A. F. D. C. Luís Augusto Nero, Ed., Academic Press, 2019, pp. 259–272. doi https://doi.org/10.1016/B978-0-12-810530-6.00012-2.
2. D. Bouglé and S. Bouhallab, "Dietary bioactive peptides: human studies Crit. Rev.," *Food Sci. Nutr*, vol. 57, pp. 335–43, 2017.
3. A. A. Paul, S. Kumar, V. Kumar, and R. Sharma, "Milk analog: plant-based alternatives to conventional milk, production, potential and health concerns Crit. Rev.," *Food Sci. Nutr*, vol. 60, pp. 3005–3023, 2020.
4. J. Sebastian and B. Davis, "Plant milk report," Berlin, 2019.
5. S. Ah-Leung *et al.*, "Allergy to goat and sheep milk without allergy to cow's milk," *Allergy*, vol. 61, no. 11, pp. 1358–1365, 2007.
6. R. Lordan, A. Tsoupras, B. Mitra, and I. Zabetakis, "Dairy fats and cardiovascular disease: do we really need to be concerned," *Foods*, vol. 7, no. 29, 2018.
7. A. A. Frank, "Process Development and Evaluation of Tiger Nut Based Chocolate Products," Kwame Nkrumah University of Science and Technology, Kumasi, 2015.
8. F. A. Asante, W. O. Ellis, I. Oduro, and F. K. Saalia, "Effect of soaking and cooking methods on the extraction of solids and acceptability of tiger nut (Cyperus esculentus L) milk," *J. Agric. Stud.*, vol. 2, no. 2, pp. 76–86, 2014, doi: 10.5296/jas.v2i2.5991.
9. J. Abdulfatai, A. A. Saka, A. S. Afolabi, and Kadiri Diana, "Development and Characterization of Beverages from Tigernut Milk, Pineapple and Coconut Fruit Extracts Development and Characterization of Beverages from Tigernut Milk, Pineapple and Coconut Fruit Extracts .," *Appl. Mech. Mater.*, vol. 248, pp. 304–309, 2013, doi: 10.4028/www.scientific.net/AMM.248.304.
10. M. Pal, J. Alemu, S. Mulu, O. Karanfil, B. C. Parmar, and J. B. Nayak, "Microbial and Hygienic aspects of Dry Milk Powder," *BEVERAGE FOOD WORLD*, vol. 43, no. 7, pp. 28–31, 2016.
11. A. Gambo and A. Da'u, "Tiger Nut (Cyperus Esculentus): Composition, Products, Uses, and Health Benefits – A Review," *Bayero J. Pure Appl. Sci.*, vol. 7, no. 1, pp. 56–61, 2014, doi: doi.org/10.4314/bajopas.v7i1.11.
12. A. Romulo, "Nutritional Contents and Processing of Plant-Based Milk: A Review," in *5th International Conference on Eco Engineering Development. IOP Conf. Series: Earth and Environmental Science 998*, 2022, pp. 1–9. doi: 10.1088/1755-1315/998/1/012054.
13. K. O. Alfred, "Development of Cheese Product from Coconut Milk," Kwame Nkrumah University of Science and Technology Kumasi, Ghana, 2010.
14. L. C. Ndubuisi, "Evaluation of Food Potentials of Tigernut Tubers (Cyperus Esculentus) and its Products (Milk, Coffee, and Wine)," University of Nigeria, Nsukka, 2009.
15. H. Wang and J. Chen, "Thermal Treatment Effects on Color and Compound Contents of Chinese Jujube (Ziziphus jujuba) Jujube Juice," *Food Res. Int.*, vol. 44, no. 4, pp. 974–981, 2011.
16. P. Natumanya, H. Twinomuhwezi, and V. S. Igwe, "Effects of drying techniques on nutrient retention and phytochemicals in selected vegetables," no. March, 2021, doi: 10.24018/ejfood.2021.3.2.247.
17. E. Manolopoulou and T. Varzakas, "Effect of temperature in color changes of green vegetables," *International Multidiscip. Conf. Nutraceuticals Funct. Foods*, vol. 1, no. October, pp. 10–17, 2016, doi: 10.12944/CRNFSJ.4.Special-Issue-October.02.
18. Y. Huang and C. Lee, "The Role of Drying Temperature in Food Quality Preservation," *J. Agric. Food Chem.*, vol. 66, no. 8, pp. 1885–1897, 2018.
19. G. S. V. Raghavan and M. Cereal, "Thermal Processing and its Effect on Food Quality," *Food Qual. Prefer.*, vol. 59, pp. 362–367, 2016, doi: doi:10.1016/j.foodqual.2016.03.007.
20. G. P. Kumar *et al.*, "Effect of different drying methods on the quality characteristics of pangasius hypophthalmus," *Int. J. Curr. Microbiol. Appl. Sci.*, vol. 6, no. October, pp. 184–195, 2017, doi: 10.20546/ijcmas.2017.610.024.
21. H. W. Leach, L. D. McCowen, and T. J. Schoch, "Starch: Chemistry and Technology," *Acad. Press*, vol. 1, no. 1, 1992.
22. D. C. Valencia-Flores and B. Herna´ndez-Herrero, M. Guamis, "Comparing the effects of ultra-high-pressure homogenization and conventional thermal treatments on the microbiological, physical, and chemical quality of almond beverages," *Food Sci.*, vol. 78, no. 2, pp. E199–E205., 2023.
23. S. R. Jaeger, D. A. Matos, A. F. Oduro, and J. Hort, "Sensory characteristics of plant-based milk alternatives: Product characterization by consumers and drivers of liking," *Food Res. Int.*, vol. 180, no.

*Corresponding Author: N. I. Nwagugu

February, pp. 1–14, 2024, doi: 10.1016/j.foodres.2024.114093.

24. A. K. M. Masum, J. Chandrapala, T. Huppertz, B. Adhikari, and B. Zisu, "Influence of drying temperatures and storage parameters on the physicochemical properties of spray-dried infant milk formula powders," *Int. Dairy J.*, vol. 105, pp. 1–7, 2020, doi: 10.1016/j.idairyj.2020.104696.
25. V. Priyanka, B. G. Shilpashree, H. Manjunatha, B. P. Pushpa, and C. L. Naveena, "Impact of drying techniques on the functionality of milk powder," *Int. Res. J. Mod. Eng. Technol. Sci.*, vol. 03, no. 12, pp. 2582–5208, 2021.
26. K. O. Falade and B. S. Omojola, "Effect of processing methods on physical, chemical, rheological, and sensory properties of okra (Abelmoschus esculentus)," *Food Bioprocess Technol.*, vol. 3, no. 1, pp. 387–394, 2010, doi: 10.1007/s11947-008-0126-2.

*Corresponding Author: N. I. Nwagugu