*Asian Food Science Journal*

*3(4): 1-8, 2018; Article no.AFSJ.42663*

# Development, Quality Evaluation and Acceptability of Ice Cream from Cow Milk, Tigernut and African Yam Bean Seed Milk

**Ebele C. Okoye[1*], Chinyere N. Onyekwelu[2] and Chinyere A. Nghowu[2]**

*[1]Department of Food Science and Technology, University of Nigeria, Nsukka, Nigeria.*
*[2]Department of Food Technology, Federal Polytechnic Oko, Anambra State, Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. Author ECO wrote the manuscript, edited and wrote the protocol. Author CNO designed the study and performed the statistical analysis. Author CAN managed the analyses of the study as well as the literature searches. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/AFSJ/2018/42663
Editor(s):
(1) Uttara Singh, Assistant Professor, Department of Foods and Nutrition, Govt. Home Science College, Panjab University, India.
Reviewers:
(1) Afolabi F. Eleyinmi, Canada.
(2) R. Prabha, Karnataka Veterinary, Animal and Fisheries Sciences University, Karnataka, India.
(3) S. Thenmozhi, Periyar University, India.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/25809

***Original Research Article***

***Received 5th May 2018***
***Accepted 11th July 2018***
***Published 7th August 2018***

## ABSTRACT

**Background and Aim:** Ice cream is a sweetened frozen food typically eaten as a snack or dessert. It is usually made from dairy products such as milk (usually cow milk). Recently, health-conscious individuals do not often consume ice cream because they are lactose intolerant. Hence, analogs made from goat's or sheep's milk, or milk substitutes (e.g., soy milk, tiger nut milk and so on) may serve as alternatives to cow milk (partially or fully substituted) in the production of ice cream. The aim of this study was production, quality evaluation and acceptability of ice cream from the blends of cow milk, tiger nut, and African yam bean seed milk.
**Methods:** The collected tiger nuts and African yam bean seed was processed into flours before the extraction of milk from the flours. Cow milk, tiger nut milk, and African yam bean milk were formulated in different proportions of 100:0:0, 50:25:25, 50:50:0, 50:0:50 and 0:50:50 respectively which were coded as CAT1, CAT2, CAT3, CAT4 and CAT5. The proximate composition, physiochemical properties and sensory evaluation of ice cream were investigated.

**Corresponding author: Email: ebele.okoye@unn.edu.ng;*

**Results:** Results generated showed that protein content ranged from 3.28 to 7.70%, fat from 0.90 to 3.09%. Addition of African yam bean and tiger nut milk increased the protein content and ash contents from 5.30 to 7.70% and 131 to 3.00% respectively. The pH, TTA total solid and solid non-fat (SNF) were significantly *p=.05* higher in the control sample (100% cow milk) when compared with ice cream produced from African yam bean and tiger nut milk blends. The sensory scores showed that sample CAT1 was the most preferred by the panelists in terms of the overall acceptability followed by sample CAT4.
**Conclusion:** There was an increase in the proximate composition of the ice cream produced from the blends of tiger nut milk and African yam bean seed milk. In terms of the overall acceptability, the control sample was the most preferred of all the samples by the panelists.

*Keywords: Cow milk; tiger nut milk; African yam bean seed milk; ice cream; physicochemical; acceptability; lactose intolerance.*

## 1. INTRODUCTION

By definition, "ice cream is a liquid mixture that turns into a paste after simultaneously shaking and cooling" [1], although the definition of ice cream varies from country to country due to differing regulations and traditions of composition [2,3]. Ice cream is a sweetened frozen food typically eaten as a snack or dessert. It is usually made from dairy products such as milk and cream and often combined with fruits or other ingredients and flavors. It is typically sweetened with sugar or sugar substitutes. Typically, flavorings and coloring are added in addition to stabilizers. The mixture is stirred to incorporate air spaces and cool below the freezing point of water to prevent detectable ice crystals from forming. The result is a smooth semi-solid foam that is solid at very low temperatures (<2°C or 35°F). It becomes more malleable as its temperature increases.

Ice cream is considered as a colloidal system. It is composed by ice cream crystal and aggregates, air that does not mix with the ice cream crystals and aggregates, air that does not mix with the ice cream by forming small bubbles in the bulk and partially colored fat globules. This dispersed phase made from all the small particles is surrounded by an unfrozen continuous phase composed of sugars, proteins, salts, polysaccharides, and water. Their interactions determine the properties of ice cream whether soft and whippy or hard [4].

In other countries such as Italy and Argentina, one word is used for all variants. Analogs made from dairy alternatives such as goat's or sheep's milk, or milk substitutes (e.g. soy milk or tofu, a tiger nut milk etc.) are available for those who are allergic to dairy protein, lactose intolerant.

Tiger nut (*Cyperus esculentus* L.) is commonly known as earth almond, chufa and chew-fa and lulu nuts. It is known in Nigeria as Aya in Hausa, Ofio in Yoruba and aki Hausa in Igbo where three varieties (black, brown and yellow) are cultivated. Among these varieties, yellow variety is preferred to all other varieties because of its inherent properties such as its bigger size attractive color and cashier body, the yellow variety also yields more milk upon extraction, contain lower fat and more protein and possesses less anti-nutritional factors especially polyphenols [5]. Tiger nut annual or perennial plant called chufa sedge, nut grass, a mildly poisonous crop of the sedge family. It is found wild as a weed [6] or as a crop often cultivated for its edible tubers in many countries including Nigeria. Tiger nut, a tuber with sweet and nutty taste can be consumed raw, roasted, dried or as tiger nut milk (Horchata, de chufas) or oil [7]. Tiger nut milk is very nutritious and energetic drink, both for young and old. It is tremendously high in starch, glucose, and proteins, also rich in minerals like potassium, phosphorus, vitamins E and C. Tiger nut milk contains a large amount of phytic acid and is cardio preventive. It depends on the internal mechanisms and prevents both constipation and diarrhea. Tiger nut milk has never been found to produce allergy [8]. It is also used as a flavoring agent for ice cream and biscuits [9] as well as in making oil, soap, starch, and flour.

African yam beans (*Sphenostylis stenocarpa*), a minor underexploited legume is an important crop in Western Africa consumed within a geographical region in Nigeria [10]. The seeds are delicious and have a crude protein level varying from 21 - 29% but lower than soybean [11], it, however, has lysine and methionine levels equal to or better than those of soybean [12]. Since legumes are important sources of

imitation for meat, milk products from legumes may contribute to the alleviation of protein malnutrition [13]. African yam bean is used extensively in various dietary preparations, it can supplement the protein requirement of many families throughout the year. The Igbos extensively explore the crop as a good source of dietary protein, feeding the displaced and severely malnourished refugees during the Niger civil war of 1967-1970 [14]. Some people in different places eat it in different forms; some other condiments. This is then wrapped into plantain leaves and boiled and then eaten as turban just like "Okpa" some also mix the flour with comparatively higher than what could be obtained in most tubers. The protein in the tuber of AYB is more than twice that in sweet potatoes (*Cipomas batatas*) or Irish (*Solanum tubersum*) potatoes [15] and very much higher than those in yam and cassava [16]. It was found out from this study, however, that nutritious ice cream could be produced from the blends of African yam bean seed milk and tiger nut milk, this could be beneficial especially to people that are lactose intolerant or lactase deficiency.

## 2. MATERIALS AND METHODS

### 2.1 Procurement of Materials

The African yam bean seeds were purchased from Ebonyi State. The tiger nut was purchased from Kogi State. The peak (powdered) milk was purchased from Eke Ekulobia in Aguata Local Government of Anambra State.

### 2.2 Sample Preparation

#### 2.2.1 Preparation of African yam beans milk

The African yam beans were sorted, clean and soaked overnight. The soaked bean was blanched in 0.5% $NaHCo_3$ solution for about 10 minutes. It was washed with cold water and was dehulled. It was milled into a paste and sieved with muslin. The slurry was stained and the recovered milk was cooked for 20-30 minutes at 82°C while stirring continuously with a wooden stirrer to prevent from burning. The milk was blend using a blender and was allowed to cool.

#### 2.2.2 Preparation of tiger nut milk

The method described by Mordi et al. [17] was used with slight modification in the preparation of tiger nut milk as shown in Fig. 2. One kilogram (1 kg) of the fresh tiger nuts were manually sorted and cleaned to remove foreign particles and unwanted materials. The nuts were soaked in portable water at ratio nut: water (1:3) overnight. The soaked nut was milled into a slurry using fabricated attrition several times with the addition of 3L of water. The slurry was pressed using muslin/ cheesecloth to extract the milk. The extracted milk was stored in a white sterile 4 liters container prior to further analysis.

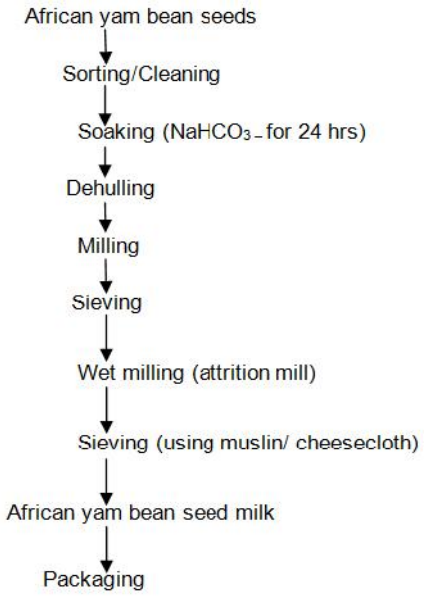


**Fig. 1. Production of African yam bean seed milk**

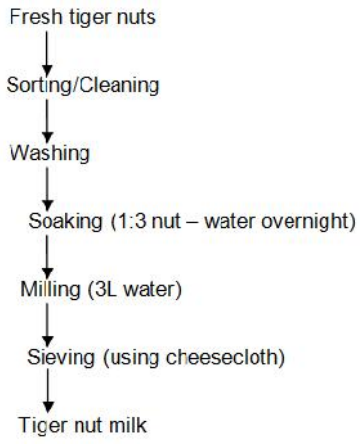


**Fig. 2. Production of Tiger nut milk**

#### 2.2.3 Preparation of cow milk

About 100 g of peak (powdered) milk was reconstituted with 1000 ml of warm water at about 40°C.

### 2.3 Formulation of Milk from the Blends of Cow Milk, Tiger Nut Milk, and African Yam Bean Milk

Cow milk, tiger nut milk, and African yam bean seed milk were blended in different ratios as shown in Table 1.

### 2.4 Recipe for the Production of Ice Cream from the Blends of Cow Milk, Tiger Nut Milk, and African Yam Bean Seed Milk

Table 2 shows the recipe used for the production of the ice cream made from the blends of cow milk, tiger nut milk, and African yam bean seed milk.

### 2.5 Preparation of Ice Cream

The Ice cream samples were prepared with the recipe described by Bear [18]. It was done by blending cow milk, tiger nut milk and African yam bean seed milk in the following ratios, sample CAT1 = (100:0:0), sample CAT2 = (100:50:50), sample CAT3 = (50:50) cow milk and tiger nut, sample CAT4 = (50:50) cow milk and African yam bean seed milk and sample CAT5 = (50:50) Tiger nut and African yam bean seed milk. Sample CAT1 (100% cow milk) served as a control. The liquid ingredients were together in a mixing vat and brought to 43°C, the dry ingredients were added to the warm mix and stirred properly after which it was pasteurized at 71°C for 30 minutes. It was later homogenized, cooled and kept in the freezer prior to further analysis.

### 2.6 Chemical Analysis

The proximate composition of the samples was determined using the method as described by AOAC [19], the carbohydrate content of the sample was obtained by difference, that is, as the difference between the summations of percentage moisture, fat, fiber, protein, ash and 100.

% Carbohydrate = 100 - (% moisture +% fat +% protein +% ash +% fiber). Determination of solid non-fat was estimated by difference as the solid non-fat (SNF), and it was calculated as % Solid non-fat = % Ts -% fat, where Ts = Total solids. Determination of total solids was done using the gravitational method as described by AOAC [19]. The titratable acidity was determined with a standardized solution of 0.1N sodium hydroxide (4.00 g of NaOH per liter) using the method described by Goff and Hartel [3] and Wehr and Frank [20], where acidity is expressed as percentage of lactic acid (1 ml of 0.1N NaOH ¼ 0.009 lactic acid). The pH was measured using a pH meter.

### 2.7 Sensory Evaluation

Sensory Evaluation of the samples was conducted using ten panelists. A 9-point Hedonic scale ranging from 9 = like extremely and 1 = dislike extremely were used to evaluate the samples for color, flavor, taste, mouthfeel and overall acceptability as described by Ihekoronye and Ngoddy [21]. Table water was used for mouth rinsing intermittently.

### 2.8 Statistical Analysis

The experiment adopted was complete randomization design (CRD). The data generated from all analyses and sensory evaluation were subjected to statistical analysis of variance (ANOVA) using the Statistical Product for Service Solutions (SPSS) version 20. Means were separated using the Duncan's Multiple Range Test and significance was accepted at $p = .05$ [22].

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate Composition of Ice Cream

Table 3 shows the result of the proximate composition of ice cream from the blend of cow milk, tiger nut milk, and African yam bean.

The percentage moisture content for the samples CAT1, CAT2, CAT3, CAT4 and CAT5 ranged from 65.00 to 85.00%. The moisture content of all the samples was significantly different at $p = .05$. Sample CAT5 had the highest value in terms of moisture which shows that fresh tiger nut is high in moisture content with the value (85%), [23]. This shows that ice cream has a high moisture content which can easily aid the growth of micro-organisms, if not well preserved, in other words, it can easily spoil if not kept at the appropriate temperature.

The ash content of the samples ranged from 1.00 to 3.00%. There was a significant ($p = .05$) difference between sample CAT1 and other enriched samples except for sample CAT4. Of all the samples, it was observed that sample CAT2

had the highest value (3.00%) of ash content indicating that it had the highest mineral contents among other samples.

The fat content of the samples ranged from 0.98 to 3.09%. There was a significant (*p =.05*) difference between sample CAT1 and other enriched samples except for sample CAT3. The relatively low-fat content of sample CAT2 (50% cow milk, 25% tiger nut milk and African yam bean seed milk) could be compared to low milk. The milk fat and milk solid non-fat constitutes about 60% of the total solids of ice cream. These components give the ice cream a rich flavor as well as improved body texture. This implies that the control sample (100% cow milk ice cream) may likely have better sensory qualities than other samples since it higher fat and milk solid non-fat contents than other enriched samples.

The percentage of the crude protein content of the samples ranged from 3.28 to 7.70%. Sample CAT1 (the control sample – 100% cow milk) was significantly (*p =.05*) different from other samples. The sample CAT5 (50% tiger nut milk and 50% AYB milk) had the highest level (7.70%) of protein content while sample CAT1 had the least mean value (3.28%). The increase in the protein content of the enriched samples may be attributed to the inclusion of African yam bean seed which is rich in protein. This may according to Adejuyitan [24] be the substantial amount of protein content of tiger nut and also the high protein content of African yam bean seed. The presence of proteins in ice cream encourage the incorporation of air into the mixture which helps to form bubbles of air, thus, they modify the texture of the mixture by allowing the formation of small bubbles of air into it. Proteins also help to emulsify the pats, keeping the fat globules suspended in the mix. The high protein content of tiger nut and African yam bean seed could solve the problem of protein-calorie malnutrition in Africa, more so, the high price of imported milk and milk products coupled with poor milk production in Nigeria [24].

The percentage of carbohydrate of the ice cream samples ranged from 2.89 to 27.72%. There was a significant (*p =.05*) difference between sample CAT1 and other enriched samples. Sample CAT1 (100% cow milk) had the highest mean score of 27.72% while the least value was obtained with ice cream product with tiger nut milk and African yam bean seed milk (sample CAT5) with a value of 2.89%.

### 3.2 Physicochemical Properties of the Ice Cream Produced from Blend of Cow Milk, Tiger Nut Milk and African Yam Bean Seed Milk

The results of the physicochemical properties of the samples are shown in Table 4.

The pH values for all the samples ranged from 6.25 – 7.18. There was a significant *p=.05* difference between the control sample and the enriched samples. The pH of all the samples was near neutral level except sample CAT1 which was at a neutral level. It implies that all the samples may have low shelf stability. Therefore, there is a need for cold storage in order to extend the shelf-life of these samples.

Total titrable acidity (TTA) of samples ranged from 0.19 to 0.36%. Sample CAT1 had the highest value (0.36%) while CAT5 had the least (0.19%) value. There was no significant *p >.0.5* difference observed in the TTA of all the samples, this implies that the all the samples will have the same shelf stability. Since the TTA values of the samples are low, the growth of microorganism will be encouraged in the samples. Ice cream with very low total acids could encourage the growth of proteolytic and lipolytic bacteria which are implicated in the deterioration of ice cream not adequately refrigerated [25].

The percentage total solids of the samples ranged from 14.10 to 34.31%. Sample CAT1 (100% Cow milk) had the highest value of 34.31% with CAT5 having the lowest level (14.10%). This implies however, that sample CAT1 had higher total solids than other samples will have good textural quality. This agrees with the findings of Umelo et al. [25], who reported that insufficient total solids in ice cream result in poor textural quality such as; coarse texture, weak body among others.

The solid non-fat of all the ice cream samples ranged from 12.10 to 31.31%. There was a significant (*p =.05*) difference between the control sample and other enriched samples. It was observed that sample CAT1 (100% Cow milk) had the highest value (31.31%) while sample CAT5 had the least value (12.10%). It could be deduced from this observation that the foams present in sample CAT1 (control sample) will collapse faster than the foams in other samples since sample CAT1 had higher mean value (31.31%) than other samples. This agrees with the report of Umelo et al. [25] who stated

that ice cream solids result in foam collapse and loss of overrun and excessive shrinkage can result from partial melting at 100 high a freeze storage temperature.

### 3.3 Sensory Scores of Ice Cream

The sensory scores of the samples are shown in Table 5. The mean scores of the taste of the ice cream samples ranged from 5.70 to 8.20, sample CAT1 (100% Cow milk) had the highest mean score (8.20) in taste while sample CAT5 (50% tiger nut and 50% AYB milk) had the lowest score (5.70). The decrease in the sensory scores of the taste of the produced samples as scored by the panelists may be as a result of the alteration in the taste of the ice cream samples caused by the inclusion of African yam bean seed milk or tiger nut or the combination. This agrees with the works of Umelo et al. [25] and Mordi et al. [17]. A similar trend of decrease in the sensory scores of the enriched samples was followed for the mean scores of color, flavor, and mouthfeel. In terms of the overall acceptability, the control sample, CAT1 (100% cow milk ice cream) had the highest mean score (8.60) while the least accepted was sample CAT5 (50% tiger nut and 50% African yam bean seed milk) with the mean score of 4.50. This implies that ice cream from 100% cow milk was more acceptable by the panelists than the ice cream from the blends of tiger nut milk and African yam bean seed milk which was the least acceptable of the enriched samples.

**Table 1. Blending ratios of cow milk, tiger nut milk, and African yam bean milk**

| Sample code | Cow milk | Tiger nut milk | African yam bean seed milk |
|---|---|---|---|
| CAT1 | 100 | - | - |
| CAT2 | 50 | 25 | 25 |
| CAT3 | 50 | 50 | - |
| CAT4 | 50 | - | 50 |
| CAT5 | | 50 | 50 |

*Note: CAT1 = 100% Cow milk, CAT2 = 50% cow milk + 25% tiger nut milk + 25% African yam bean seed milk, CAT3 = 50% cow milk + 50% tiger nut milk, CAT4 = 50% cow milk + 50% African yam bean seed milk, CAT5 = 50% tiger nut milk + 50% African yam bean seed milk*

**Table 2. Recipe for the production of Ice cream from the blends of cow milk, tiger nut milk, and African yam bean seed milk**

| Sample code | Egg | CM | Sugar | Vanilla(ml) | Gelatin(ml) | Tigernut milk | AYBSM |
|---|---|---|---|---|---|---|---|
| CAT1 | 2 | 200 | 10 | 5 | 5 | - | - |
| CAT2 | 2 | 100 | 10 | 5 | 5 | 50 | 50 |
| CAT3 | 2 | 100 | 10 | 5 | 5 | 100 | - |
| CAT4 | 2 | 100 | 10 | 5 | 5 | - | 100 |
| CAT5 | 2 | - | 10 | 5 | 5 | 100 | 100 |

*Note: CAT1 = 100% Cow milk, CAT2 = 50% cow milk + 25% tiger nut milk + 25% African yam bean seed milk, CAT3 = 50% cow milk + 50% tiger nut milk, CAT4 = 50% cow milk + 50% African yam bean seed milk, CAT5 = 50% tiger nut milk + 50% African yam bean seed milk, AYBSM = African yam bean seed milk, CM = Cow milk*

**Table 3. Proximate composition of ice cream from the blend of cow milk, tiger nut milk, and African yam bean seed milk**

| Samples/ Parameters | CAT1 | CAT2 | CAT3 | CAT4 | CAT5 |
|---|---|---|---|---|---|
| Moisture | $65.00 \pm 0.01^{e}$ | $79.00 \pm 0.95^{c}$ | $75.00 \pm 0.00^{d}$ | $80.00 \pm 0.01^{b}$ | $85.00 \pm 0.00^{a}$ |
| Ash | $1.0 \pm 0.00^{d}$ | $3.00 \pm 0.00^{a}$ | $2.00 \pm 0.11^{c}$ | $1.31 \pm 0.00^{d}$ | $2.41 \pm 0.02^{b}$ |
| Fat | $3.09 \pm 0.20^{a}$ | $0.98 \pm 0.29^{c}$ | $3.00 \pm 0.01^{a}$ | $1.90 \pm 0.10^{b}$ | $2.00 \pm 0.01^{b}$ |
| Crude protein | $3.28 \pm 0.02^{e}$ | $6.14 \pm 0.01^{b}$ | $5.60 \pm 0.20^{c}$ | $5.30 \pm 0.10^{d}$ | $7.70 \pm 0.20^{a}$ |
| CHO | $27.72 \pm 0.01^{a}$ | $10.88 \pm 0.93^{c}$ | $14.40 \pm 0.09^{b}$ | $5.30 \pm 0.10^{d}$ | $7.70 \pm 0.20^{a}$ |
| Crude Fiber | ND | ND | ND | ND | ND |

*Note: Values are the means ± SD triplicate determination. Values with different superscripts within the same row are significantly (p =.05) different. CAT1 = 100% Cow milk, CAT2 = 50% cow milk + 25% tiger nut milk + 25% African yam bean seed milk, CAT3 = 50% cow milk + 50% tiger nut milk, CAT4 = 50% cow milk + 50% African yam bean seed milk, CAT5 = 50% tiger nut milk + 50% African yam bean seed milk, CHO = Carbohydrate, ND = Not determined*

**Table 4. Physicochemical properties of ice cream**

| Samples/ Parameters | CAT1 | CAT2 | CAT3 | CAT4 | CAT5 |
|---|---|---|---|---|---|
| pH | 7.18±1.00[a] | 6.53± 0.01[c] | 6.25± 0.20[d] | 6.42± 0.10[c] | 6.77± 0.01[b] |
| TTA | 0.36 ± 0.26[a] | 0.29± 0.01[a] | 0.22± 0.01[a] | 0.25±0.01[a] | 0.19± 0.10[a] |
| Total solids (%) | 34.31± 0.01[a] | 20.70±0.00[c] | 24.00± 0.01[b] | 19.80± 0.00[d] | 14.10± 0.17[e] |
| SNF (%) | 31.31 ±0.10[a] | 19.72 ± 0.03[c] | 21.00±0.01[b] | 17.93± 0.06[d] | 12.10± 0.17[e] |

*Note: Values are the means ± SD triplicate determination. Values with different superscripts within the same row are significantly (p =.05) different. CAT1 = 100% Cow milk, CAT2 = 50% cow milk + 25% tiger nut milk + 25% African yam bean seed milk, CAT3 = 50% cow milk + 50% tiger nut milk, CAT4 = 50% cow milk + 50% African yam bean seed milk, CAT5 = 50% tiger nut milk + 50% African yam bean seed milk, CHO = Carbohydrate, ND = Not determined, SNF = Milk solid non fat, TTA = Total titrable acidity*

**Table 5. Sensory scores of ice cream from the blends of cow milk, tiger nut milk, and African yam bean seed milk**

| Samples/ Parameters | CAT1 | CAT2 | CAT3 | CAT4 | CAT5 |
|---|---|---|---|---|---|
| Color | 8.30 ± 0.95[a] | 7.20±1.03[b] | 6.10± 0.57[c] | 7.23± 1.49[b] | 2.60± 1.35[d] |
| Flavor | 8.00± 0.82[a] | 6.80± 1.03[b] | 6.60±0.84[d] | 6.70±1.16[c] | 4.70 ± 1.25[c] |
| Mouth feel | 8.30± 0.95[a] | 6.60±0.84[b] | 6.50± 1.60[b] | 6.90± 1.60[b] | 5.10± 1.10[c] |
| Taste | 8.20±1.03[a] | 6.80 ± 0.92[b] | 6.80±0.79[b] | 7.30± 1.25[b] | 5.70± 0.67[c] |
| OA | 8.60±0.70[a] | 6.80± 0.79[b] | 6.90±0.99[b] | 7.40 ±1.07[b] | 4.50± 0.85[c] |

*Note: Values are the means ± SD triplicate determination. Values with different superscripts within the same row are significantly (p =.05) different. CAT1 = 100% Cow milk, CAT2 = 50% cow milk + 25% tiger nut milk + 25% African yam bean seed milk, CAT3 = 50% cow milk + 50% tiger nut milk, CAT4 = 50% cow milk + 50% African yam bean seed milk, CAT5 = 50% tiger nut milk + 50% African yam bean seed milk, CHO = Carbohydrate, OA = General acceptability*

## 4. CONCLUSION AND RECOMMENDATION

### 4.1 Conclusion

Enrichment of ice cream with tiger nut milk and African yam bean seed milk increased the proximate composition of the enriched samples with reduced total solid and total titrable acidity than the control sample. The high total solid and total titrable acidity in the control sample will give it good texture as well as good shelf stability than all other samples. In terms of the overall acceptability, the control sample was the most preferred of all the samples by the panelists. This may be attributed to the fact that the panelists are more conversant with the organoleptic properties of the ice cream usually produced from cow milk.

### 4.2 Recommendation

It is recommended that further study should be carried out on the micronutrient composition of the samples.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Corvitto A. The secrets of ice cream - Los Secretos del helado ice cream without secrets - El helado sinsecretos 2nd ed. Sant Cugat del Valles, Vilbo. Spain; 2011.
2. Clark C. The science of ice cream. RSC Publishing, London; 2012.
3. Goff DH, Hartel R. Ice Cream 7th edn Springer Ed., USA; 2013.
4. Arana I. Physical properties of foods: Novel measurement techniques and applications. CRC Press. 2012;385. ISBN: 9781439835364.
5. Okafor JNC, Mordi JI, Ozumba AU, Solomon HM, Olatunji O. Preliminary studies on the characterization of contaminants in tiger nut (Yellow variety). Proceedings of 27th Annual Nigerian Institute of Food Science and Technology (NIFST) Conference, October 13-17, Nigeria. 2003;210-211.
6. Sánchez Z, Juana FL, José APA. Tiger Nut (*Cyperus esculentus*) Commercialization: Health aspects, composition, properties, and food applications. Article first published online: 12 Jun; 2012. DOI: 10.1111/j.1541-4337.2012.00190.x © 2012 Institute of Food Technologists®

7. Rita ES. The use of tiger-nut (*Cyperus esculentus*), cow milk and their composite as substrates for yogurt production. Pak. J. Nutr. 2009;6:755-758.
8. Belewu MA, Abodunrin OA. Preparation of kunnu from unexploited rich food source: Tiger nut (*Cyperus esculentus*). Pak. J. Nutr. 2008;7:109-111.
   CrossRef | Direct Link |
9. Cantalejo MJ. Analysis of volatile components derived from raw and roasted earth almond (*Cyperus esculentus* L.). J. Agric. Food Chem. 1997;45:1853-1860.
10. Njoku HO, Eli I, Ofuya CO. Effect of pretreatment on the cooking time of the African yam bean (*Sphenostylis sternocarpa*). Journal of Food Science. 1989;54:758–759.
11. Evans IM, Boulter D. Amino acid composition of seeds of meals of yam bean (*Sphenostylis stenocarpa*) and Lima bean (*Phaseolus lunatus*). Journal of Science, Food, and Agriculture. 1974;25: 919-922.
12. Okigbo BN. Introducing the yam bean (*Sphenostylis stenocarpa*) (Hochst ex. A. Rich.) Harms. Proceedings of the first IITA Grain Legume Improvement Workshop 29 October – 2 November, Ibadan. Nigeria. 1973;224-238.
13. Rao DR, Pulussani SR, Chawan CB. Preparation of a Yogurt –like Product from cowpea and Mung Beans. International Journal of Food Science and Technology. 1998;23:195-198.
14. Nwokolo E. The need to increase consumption of pulses in the developing world. In: Nwokolo E, Smart J (eds) Food and feed from legumes and oilseeds. Chapman and Hall, London. 1996;3-11. CrossRef Google Scholar
15. National Research Council (NRC). Tropical legumes: Resources for the future. National Academy of Sciences, Washington DC; 1979.
16. Amoatey HM, Klu GYP, Bansa D, Kumaga FK, Aboagye LM, Benett SO, Gamedoagbao DK. African yam bean (*Sphenostylis stenocarpa*) a neglected crop in Ghana. West Afr J Appl Ecol. 2006; 1:53–60.
    Google Scholar
17. Mordi J, Ozumba AU, Elemo GN. Production and Evaluation of Ice cream from Nigerian Tiger-nut milk extract Nigerian Food Journal. 2011;29(2):91–95.
18. Bear AC. Ice cream making, Wisconsin, Agric. Expt. Sta. Bulletin. 1993;4(3):38.
19. AOAC. Association of Official Analytical Chemist. Official methods of analysis 18th edn, Washington DC, USA; 2010.
20. Wehr H, Frank J. Standard methods for the examination of dairy products 17th ed American Public Health Association, Washington, DC; 2004.
21. Ihekoronye AI, Ngoddy PO. Integrated Food Science and Technology for the Tropics. Macmillan Publisher Ltd., London. 1985;272-273.
22. Steel RGD, Torrie JH. Principles and Procedures of Statistics. McGraw Hill, Intern. Singapore. 1980;107-110.
23. Elana SZ, Juana FL, Jose APA. Tigernut (*Cyperus esculentus*) Commercialisation: Health Aspects, Composition, properties and Food Applications. Pub. Online: 12th June 2012. Institute of Food Technologist.
24. Adejuyitan JA. Tigernut processing. Its food uses and health benefits. American Journal of Technology. 2011;6: 197-201.
25. Umelo MC, Uzoukwu AE, Odimegwu EN, Agunwah IM, Njoku NE, Alagbaoso SO. Proximate, physicochemical and sensory evaluation of ice cream from blends of cow milk and tiger nut (*Cyperus esculentus*) milk. International Journal of Scientific Research and Innovative Technology. 2014;1(4):63-76.




*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://prh.sdiarticle3.com/review-history/25809*