PROXIMATE, PHYSICOCHEMICAL AND SENSORY EVALUATION OF ICE CREAM FROM BLENDS OF COW MILK AND TIGERNUT (*Cyperus esculentus*) MILK

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Abstract

Ice cream was produced from blend of cow milk and tigernut milk. Cow milk and tigernut milk were used in the formulation of the ice cream at different compositions. The compositions were 100% cow milk, 50% cow milk and 50% tigernut milk, 60% cow milk and 40% tigernut milk, 40% cow milk and 60% tigernut milk and 100% tigernut milk to give samples A, B, C, D and E respectively. The ice cream made from 100% cow milk served as the control (sample A). The proximate composition showed that sample B (50% cow milk and 50% tigernut milk ice cream) had the highest percentage crude protein of 14.17±0.42 while sample A (100% cow milk ice cream) had the least protein content of 7.38±0.20. The percentage crude fat content for the control sample (100% cow milk ice cream) had the highest value of 10.33±0.08 but was not significantly different with the other samples at P<0.05. The ash content ranged between 0.60±0.03 to 1.71±0.01. The % moisture content increased as the level of substitution of cow milk with tigernut milk increased. Sample E had the highest value of 70.01% moisture content while the control sample (100% cow milk ice cream) had the least value of 51.34%. .The percentage crude fibre content ranged between 0.25±0.02 to 0.03±0.02.The carbohydrate content of all the ice cream samples were below 28.98 ±0.29. In terms of the physicochemical properties of the ice cream, the pH values ranged from 6.43 to 6.73. The value of the specific gravity (S.G) increased as the quantity of cow milk used in the production of the ice cream increased except for sample B (50% cow milk and 50% tigernut milk ice cream).The same trend was repeated for the solid non-fat (SNF) and the % total solids. The percentage total titratable acidity (TTA) had the highest value of 0.146 for sample B (50% cow milk and 50% tigernut milk ice cream) while the least value was sample A and C with both having value of 0.141. The ice cream samples were evaluated for sensory attributes of colour, taste, flavour, mouth feel (texture) and general acceptability. In terms of colour, taste, flavour and general acceptability the panelist preference decreased with increased addition of tigernut milk in the ice cream production. The texture of the control sample had the highest value of 6.08±1.16 while sample E (100% tigernut milk ice cream) had the least score for texture with a mean value of 4.08±1.31. This work showed that acceptable ice cream could be produced by substituting cow milk with tigernut milk with good sensory properties preferably at 40% - 50 % substitution of cow milk with tigernut milk. In addition there is improved nutritional content with respect to the percentage protein content which will go a long way to alleviate protein malnutrition. The pH of all the samples were near neutral pH, this could negatively affect the shelf stability of the ice cream as a result of possible microbial infestation and thus there is every need to keep the product always refrigerated before use.

Key words: cow milk, tigernut milk, blend, ice cream

INTRODUCTION

Ice cream is a frozen dessert usually made from dairy products, such as milk and often combined with other ingredients and flavours. In addition to dairy products, ice cream contains sugar, stabilizers, emulsifiers, flavouring materials, water and air. The mixture of these ingredients, before air is incorporated and the mixture frozen is known as ice cream mix. The composition of ice cream varies depending upon the ingredients used in the preparation. The percentage composition of good ice cream is: 12% milk fat, 14% milk solid non–fat, 15% sugar, 0.2% stabilizer, 6.2% emulsifier, 55-64% water which comes from the milk or other ingredients and a trace of vanilla. This composition is exclusive of air. That is they are based on the weight of ice cream mix because ice cream is a whipped product and contains a great deal of air to prevent it from being too dense, too hard, and too cold in the mouth. The total solid is about 38.4%, the remainder would be water. Addition of ingredients such as nuts, fruits, chocolate and additional flavour will result in the change of the composition.

Over the years, attempts have been made to find cheaper substitutes for cow milk, due to the rising cost of cow milk and its products irrespective of its high nutritional quality in terms of proteins. The development of tigernut (*Cyperus esculentus)* based milk is a cheap substitute for traditional cow milk. In Nigeria, cow milk is predominantly used to produce commercial ice cream, while hardly any attention has been given to the use of nuts, milk extract or in combination with milk to produce palatable ice cream (Mordi, 2003). Tigernut is included as one of the underutilized crop and commonly known as “earth almond”, “chufa” and “zula” nuts. Tigernut can be eaten raw, roasted, dried, baked or be made into refreshing beverage called “Horchata De Chufas’ or tigernut milk. Tigernut is rich in dietary fibre, minerals like potassium, phosphorus and Vitamins E and C. Thus the objective of this study was to evaluate the physicochemical, proximate and sensory properties of ice cream from blends of the cow and tigernut milk.

MATERIALS AND METHODS

Sample collection

Fresh tigernut seeds were purchased from Ekeukwu market in Owerri municipal council of Imo state, Nigeria. Commercially available ingredients such as stabilizers, vanilla, sugar, egg, and milk were obtained from one of the stores in the market.

Sample preparation

Preparation of tigernut milk

About 500g of tigernut seeds were sorted and washed in mixture of water and salt. It was then grinded with kitchen blender and the milk extracted with a muslin cloth that was placed on a plastic jar. One liter of water was used to aid the extraction of the milk leaving behind the chaff (Mordi *et al.,* 1999).

Preparation of cow milk

About 100g of powdered milk (Cowbell) was reconstituted with 1000ml of warm water at about 40^0C.

Preparation of ice cream

The ice cream samples were prepared with the recipe described by Bear (1993). It was done by blending cow milk with tigernut milk in the following ratios: Sample A= (100:0), Sample B= (50:50), Sample C= (60:40), Sample D= (40:60) and sample E is 100% tigernut milk = (0:100). Sample A which consists of 100% cow milk ice cream served as the control. The liquid ingredients were mixed together in a mixing vat and brought to about 43^0C. The dry ingredients were added to the warm mix and were stirred very well after which it was pasteurized at 71^0C for 30min. It was later homogenized, cooled and freezed prior to analysis.

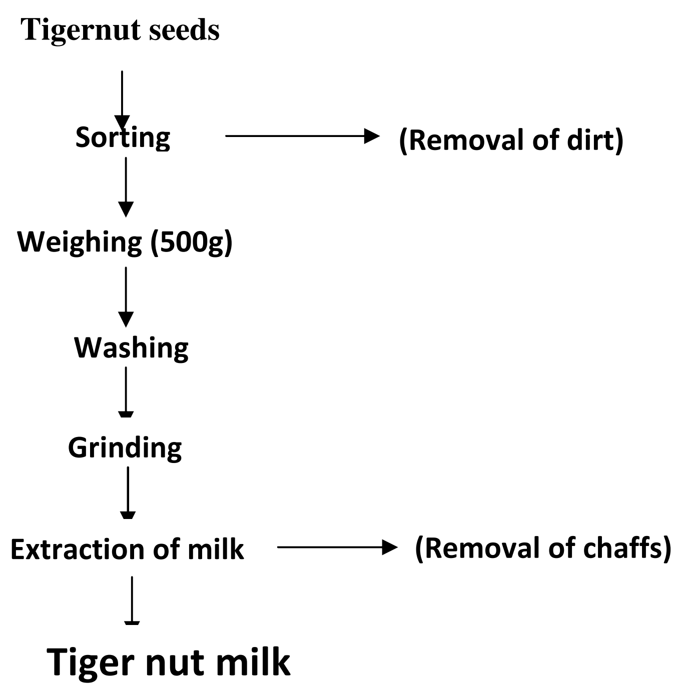

Fig. 1.0 Flow diagram for the production of tigernut milk

Source: Mordi *et al.,* (1999).

Table 1.0 The recipe for the production of ice cream from blend of cow and tigernut milk

Samples	Egg	Cow milk (ml)	Sugar (g)	Water (ml)	Vanilla (ml)	Stabilizer (g)	Tigernut milk (g)
A	2	200	10	10	5	10	-
B	2	100	10	10	5	10	100
C	2	120	10	10	5	10	80
D	2	80	10	10	5	10	120
E	2	-	10	10	5	10	200

Sample A = 100% cow milk ice cream

Sample B = 50% cow milk and 50% tigernut milk ice cream

Sample C = 60% cow milk and 40% tigernut milk ice cream

Sample D = 40% cow milk and 60% tigernut milk ice cream

Sample E = 100% tigernut milk ice cream

PROXIMATE ANALYSIS

The percentage moisture, crude protein, fat, fibre, ash and carbohydrate were determined by the standard methods of AOAC (1990).

Determination of physicochemical properties of ice cream from blend of cow milk and tigernut milk

pH Determination

The pH was measured directly using a pH meter (Jenway model-England). This was turned on and allowed to become stable; 20 ml of the buffer solution was poured into a clean 50ml polypropylene beaker. The electrode was immersed into the buffer solution. After this, the temperature was adjusted to buffer solution temperature using the temperature control knob. The buffer solution was removed and the electrode rinsed with distilled water. About 20ml of sample was put in a 50ml polypropylene beaker. The electrode of the pH meter was put inside the sample while gently agitated. Finally the pH was read directly from the screen of the meter when the point was steady.

Total Titratable Acidity: This was determined by the method described by A.O.A.C (2000).

The Specific gravity determination

This was determined by the pycnometer gravimetric method described by James (1995). A specific gravity bottle (pycnometer) was washed and allowed to dry at room temperature. It was stopped and weighed (w), it was then filled with distilled water up to the capillary of the stopper. The outside of the bottle was carefully dried with a blotting paper and it was weighed full of water, then the water was decanted and the bottle was rinsed with ethanol and allowed to dry. It was filled with the test juice sample. It was re-weighed. The weight of the sample and that of its equal volume of water were determined by difference.

Calculation

$$\text{Specific gravity} = \frac{Ws\text{-}Wa}{Ww\text{-}Wa}$$

Where;

Wa=weight of empty pycnometer

Ws=weight of pycnometer filled with sample

Ww=weight of pycnometer filled with distilled water

Determination of total solids

The gravimetric method described by AOAC (1990) was used. A measured weight of the sample was weighed into a previously weighed moisture can. It was first evaporated to dryness over a steam-bath and was dried in a Gallemkamp (made in England) moisture extractor oven at 105^{O} for 3h. It was cooled in a desiccator and weighed. The weighed sample was returned to the oven for final drying. Thereafter, it was cooled and weighed at an hourly interval until no further difference in the weight was observed (this is, constant weight is observed). The moisture content was calculated as a percentage ratio of the weight of moisture content, to that of the weight of sample analysed. The formula below was used.

$$\%\ M\ C = 100 \times \frac{W_2 - W_3}{W_2 - W_2}$$

Where

MC =Moisture content

W_1 = Weight of empty moisture can

W_2 = Weight of moisture can + sample before drying

W_3 = Weight of moisture can + sample after drying to constant weight.

% dry matter (Total solid) = 100 -% MC

Determination of solid non-fat

This was estimated by difference as the solid non-fat (SNF). It was calculated as shown below

% Solid non-fat = % Ts -% fat

Where Ts = Total solids

SENSORY EVALUATION

Sensory evaluation of the five ice cream samples produced from blend of cow milk and tigernut milk was conducted using 12 member panelists. Ice cream quality was judged in terms of appearance/colour, taste, flavour, mouth feel (texture) and overall acceptability. The 7-point hedonic scale (7 -like extremely, 4 – neither like nor dislike, 1 – dislike extremely) as described by O'Mahony (1986) was used.

STATISTICAL ANALYSIS

All data were subjected to analysis of variance (ANOVA) and means were separated by Fisher's Test at 5% level of significance to establish where there were significant differences between the means (O'Mahony, 1986).

Results and Discussion

Proximate Composition of ice cream samples from blend of cow milk and tigernut milk

The result in Table 2.0 shows the proximate composition of the ice cream samples formulated through the blend of cow milk and tigernut milk at different ratios to give five ice cream samples.

The percentage crude protein content

The crude protein content for ice cream samples A, B, C, D, and E were 7.38±0.02, 14.17±0.42, 9.05±0.21, 9.53±0.21, and 8.06±0.21 respectively (Table 2.0). The ice cream sample produced from the blend of 50% cow milk and 50% tigernut milk had the highest percentage protein content of 14.17± 0.42 (Sample B) while the least protein content was recorded for the 100% cow milk ice cream (Sample A) with a value of 7.38±0.02. The reason for sample B having the highest protein content could be that the tigernut milk contained substantial amount of protein that added up to the protein of the cow milk. According to Adejuyitan (2011) tigernut is high in protein, starch and glucose. Proteins help to incorporate air into the mixture helping to form small bubbles of air. They modify the texture of ice cream in other ways as well making it chewier and giving it body. It also help to emulsify the fats, keeping the fat globules suspended in the mix. The high protein and calorie content of the tigernut milk could solve the problem of protein-calorie malnutrition in Africa more so that the high price of imported milk and milk products coupled with poor milk production in Nigeria (Adejuyitan, 2011).

Percentage fat content

The fat content of the of the ice cream samples made from blend of cow milk and tigernut milk ranged from 8.64±0.02 to 10.33±0.08. The fat content of all the samples were not significantly different at $P<0.05$. The relatively low fat content of 100% tigernut milk ice cream (8.64±0.02) implies that tigernut milk extract contains low fat compared to cow milk (Table 2.0). Thus the fat content in the ice cream samples decreased as the quantity of tigernut milk blended with cow milk increased except for sample B

(50% cow milk and 50% tigernut milk ice cream). This is because cow milk and cream are sources of butterfat. Goff (2008) reported milk fat content of ice cream to be greater than 10% and could be as high as 16% in some premium ice creams. It is only the 100% cow milk ice cream that agreed with the report of Goff (2008) of all the samples of ice cream with a value of 10.33±0.08. Milk fat and milk solid non-fat constitutes about 60% of the total solids of ice cream. These component give ice cream a rich flavour, improve body and texture. This implies that the control sample (100% cow milk ice cream) may likely have better sensory qualities than ice creams made from blend of cow milk and tigernut milk.

Percentage ash content

The ash content of the ice cream samples ranged from 0.60±0.03 to 1.71±0.01. The ash contents were not significantly different at $P<0.05$ for all the samples. Sample A (100% cow milk ice cream) had the highest ash content of 1.71±0.01 while the least was sample E (100% tigernut milk ice cream). The value of ash content decreased as the quantity of tigernut milk blended with cow milk increased except for sample B (50% cow milk and 50% tigernut milk ice cream). This implies that cow milk had more ash content than tigernut milk. Ash content is an indication of mineral content of the ice cream samples.

Table 2.0: Mean proximate composition of ice cream from blend of cow milk and tigernut milk.

*Samples / Parameters	A 100:00	B 50:50	C 60:40	D 40:60	E 0:100	LSD
% Protein	7.38±0.20^{e}	14.17±0.42^{a}	9.05±0.21^{c}	9.53±0.21^{b}	8.60±0.21^{d}	0.44
% Fat	10.33±0.08^{a}	9.69±0.03^{a}	9.91±0.03^{a}	9.57±0.03^{a}	8.64±0.02^{a}	-
% ash	1.71±0.01^{a}	0.74±0.01^{a}	0.80±0.02^{a}	0.65±0.03^{a}	0.60.±0.03^{a}	-
% MC	51.34±0.02^{e}	65.37±0.34^{b}	62.24±0.02^{c}	67.27±0.07^{d}	70.01±0.45^{a}	0.18
% Crude fibre	0.25±0.02^{a}	0.17±0.02^{a}	0.12±0.02^{a}	0.09±0.02^{a}	0.03±0.02^{a}	-
% Carbohydrate	28.98±0.29^{a}	7.85±0.62^{e}	14.87±0.22^{c}	17.90±0.12^{b}	11.54±0.51^{d}	0.61

Means in the same row with the same superscript are not significantly different (p<0.05).

* The samples ratio represents the blend of cow milk and tigernut milk for the production of the ice cream.

Sample A = 100% cow milk ice cream, Sample B = 50% cow milk and 50% tigernut milk ice cream, Sample C = 60% cow milk and 40% tigernut milk ice cream, Sample D = 40% cow milk and 60% tigernut milk ice cream,

Sample E = 100% tigernut milk ice cream

Percentage moisture content

The percentage moisture content (%MC) for ice cream samples A, B, C, D, and E were 51.34±0.02, 65.37±0.34, 62.24±0.02, 67.27±0.07, and 70.01±0.45 respectively (Table 2.0). The moisture content of all the samples were significantly different at P<0.05. The moisture content increased as the quantity of tigernut milk blended with cow milk increased in all the samples. This implied that the tigernut milk contributed more to the moisture content of the ice cream samples than the cow milk with respect to the recipe used. This is because fresh tigernut is high in moisture content with value of 88% as reported by Elana Sanchez-zapata *et al* (2012). According to Goff (2008) the moisture content of ice cream ranged between 55% -64% which comes from the milk or other ingredients.

Percentage crude fibre

The crude fibre content of the ice samples produced from blend of cow milk and tigernut milk ranged from 0.03±0.02 to 0.25±0.02. The crude fibre contents were not significantly different at P<0.05 for all the samples. It decreased as the quantity of tigernut milk blended with cow milk increased. The crude fibre content of all the samples were relatively low compared to some other food products. The reason may be that the tigernut which is naturally rich in fibre contributed little fibre to the ice cream since only the milk extract was used and not the whole nut. According to Adejuyitan (2011) tigernut were valued for their nutritious dietary fibre, starch content and carbohydrate. This implied that tigernut milk extract (unlike the whole nut) used in the blend to produce ice cream was low in fibre and may not help solve the health challenge of those whose diet are low in fibre like constipation.

Carbohydrate content

The carbohydrate content of the ice cream samples made from blend of cow milk and tigernut milk were 28.98±0.29, 7.85±0.62, 14.87±0.22, 17.90±0.12 and 11.54±0.51 for samples A, B, C, D, and E respectively. The samples were all significantly different at P<0.05. The carbohydrate content of the ice cream was highest in the control sample (100% cow milk) with a mean score of 28.98±0.29 while the least value was obtained with ice cream produced with 100% tigernut milk-Sample E with a value of 11.54± 0.51 (Table 2.0).

Physicochemical properties of the ice cream produced from blend of cow milk and tigernut milk

pH of the samples

The physicochemical composition of ice cream produced from the blend of cow milk and tigernut milk is as shown in Table 3.0. The pH values for all the samples ranged from 6.43 to 6.73. The pH of all the samples were near neutral pH and since lower pH (acidic) in foods helps to reduce the activity of spoilage microorganism it implies that all the ice cream samples may have low shelf stability. Thus there is need for cold storage in order to extend its shelf stability.

The Specific gravity

The specific gravity of the ice cream samples were 1.249, 1.218, 1.236, 1.250, and 1.246 for samples A, B, C, D and E respectively (Table 3.0). The values of the specific gravity (S.G) increased as the quantity of cow milk used in the production of the ice cream increased except for sample B (50% cow milk and 50% tigernut milk ice cream). Sample A (100% cow milk ice cream) had the highest S.G of 1,249. The high content of the S.G of some samples of ice cream could be attributed to the high content of total solids present in the ice cream sample. This implied that samples with high total solids had less moisture content which added weight to the ice cream mix resulting in higher specific gravity.

Percentage solid non-fat

The solid non-fat for all the ice cream samples ranged from 21.35 to 38.33. The solid non-fat decreased as the amount of tigernut milk increased. It was highest for the controls sample A (100% cow milk ice cream) with a value of 38.33% while the least was ice cream made from 100% tigernut milk (sample E) with a value of 21.35%. Ice cream recipe low in solids results in foam collapse and loss of overrun and excessive shrinkage can result from partial melting at too high a freezer storage temperature.

Percentage Total Solids

The percentage total solids for the ice cream samples ranged from 29.99 to 48.66. The value of % total solids increased in all the samples as the proportion of cow milk added increased except for sample B (50% cow milk and 50% tigernut milk ice cream). Insufficient total solids in ice cream results to poor textural quality such as coarse texture, weak body etc.

Total Titratable Acidity

The percentage total titratable acidity (TTA) had the highest value of 0.146 for sample B (50% cow milk and 50% tigernut milk ice cream) while the least value was sample A and C with both having value of 0.141. The percentage TTA did not follow a reverse trend with the pH. Ice cream with very low total acids could encourage the growth of proteolytic and lipolytic bacteria which are implicated for deterioration of ice cream not adequately refrigerated.

Table 3.0: Physicochemical composition of ice cream from blend of cow milk and tigernut milk.

*Samples / Parameters	A 100:00	B 50:50	C 60:40	D 40:60	E 0:100
pH	6.43	6.48	6.44	6.73	6.64
Specific gravity	1.249	1.218	1.236	1.250	1.246
% Solid non-fat	38.33	22.95	28.16	24.84	21.35
% Total Solids	48.66	32.63	37.73	34.76	29.99
Total Acids	0.141	0.146	0.141	0.116	0.119

* The samples ratio represents the blend of cow milk and tigernut milk for the production of the ice cream.

Means in the same row with the same superscript are not significantly different ($p<0.05$).

Sample A = 100% cow milk ice cream, Sample B = 50% cow milk and 50% tigernut milk ice cream, Sample C = 60% cow milk and 40% tigernut milk ice cream, Sample D = 40% cow milk and 60% tigernut milk ice cream,

Sample E = 100% tigernut milk ice cream

Sensory evaluation of ice cream samples from blends of cow milk and tigernut milk

The sensory scores of the ice cream samples were as shown in Table 4.0. The scores of the taste of the ice cream samples ranged from 4.25±0.97 to 6.50± 0.67. The highest score for taste was recorded for the 100% cow milk ice cream (control) with a mean score of 6.50± 0.67 and the lowest was sample E (100% tigernut milk) with a mean score of 4.25±0.97. The mean score for taste in all the ice cream samples decreased as the amount of tigernut milk blended with cow milk increased. This indicates that increase in the tigernut milk content alters the normal taste of ice cream. This agrees with the work of Mordi *et al* (2005). In terms of colour and flavour a similar trend with the mean scores for the taste was repeated Table 4.0 .The panelists scored highest with respect to general acceptability for the control sample (100% cow milk ice cream) with mean score of 5.83±0.58 followed by sample B (50% cow milk and 50% tigernut milk ice cream) while the least accepted was sample E (100% tigernut ice cream). This implied that the more tigernut milk blended with cow milk in the production of the ice cream the less its acceptability by the test panel and vice versa

Table 4.0: Mean sensory scores for ice cream made from blend of cow milk and tigernut milk

*Samples / Parameters	A 100:00	B 50:50	C 60:40	D 40:60	E 0:100	LSD
Taste	6.50±0.67[a]	5.58±0.67[b]	5.83±0.58[ab]	5.08±0.90[bc]	4.25±0.97[c]	0.84
Colour	6.25±0.62[a]	5.67±0.78[ab]	5.83±0.58[a]	4.67±1.72[c]	4.08±0.67[c]	0.88
Flavour	6.08±0.29[a]	5.33±0.49[b]	5.5±0.78[ab]	5.00±1.04[bc]	4.58.±1.13[b]	0.62
Consistency (Mouth feel)	6.08±1.16[a]	4.92±1.93[ab]	4.75±0.97[b]	4.83±0.94[b]	4.08±1.31[b]	1.19
Acceptability	5.83±0.58[a]	5.25±0.45[b]	5.00±0.43b[c]	4.42±0.10[d]	3.67±0.98[e]	0.44

Means in the same row with the same superscript are not significantly different ($p<0.05$).

* The samples ratio represents the blend of cow milk and tigernut milk for the production of the ice cream.

Sample A = 100% cow milk ice cream, Sample B = 50% cow milk and 50% tigernut milk ice cream, Sample C = 60% cow milk and 40% tigernut milk ice cream, Sample D = 40% cow milk and 60% tigernut milk ice cream,

Sample E = 100% tigernut milk ice cream

Conclusion

In conclusion an ice cream with acceptable sensory attributes like taste, flavour and consistency (mouth feel) could be produced from blend of cow milk and tigernut milk at 50% level of substitution of cow milk with tigernut milk but preferably at 40% cow milk substitution with tigernut milk. In addition the high protein and calorie content of ice cream produced from blend of cow milk and tigernut milk could solve the problem of protein-calorie malnutrition in Africa more so that the high price of imported milk and milk products coupled with poor milk production in Nigeria (Adejuyitan, 2011). In addition considering the nutritive and health benefit of tiger nut which is considered to be one of the underutilized tubers, its incorporation in ice cream production has increased its utilization and health benefit derived from it.

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