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Effect of Planting Period and Site on the Chemical Composition and Milk Acceptability of Tigernut (*Cyperus Esculentus* L) Tubers in Ghana

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Abstract Two varieties of tiger nuts obtained from eight different sites and two harvesting periods in Ghana were evaluated for their chemical composition. The effect of site on sensory quality of milk extracted was also evaluated. The ranges (g kg^{-1}) for fat, ash, carbohydrate and fiber of the black and brown varieties were 155.4-295.4, 128.7 - 275.3; 22.7 - 73.4, 29.8 -75.1; 12.3 - 19.4, 10.0 -16.4 ; 497.4 709.2, 506.9-717.2 and 74.2-118.4, 75.3-135.4 respectively. The mean energy and free fatty acid values for black and brown tubers for all sites and both planting periods were 4707.7 kcal kg^{-1}, 4585.4 kcal kg^{-1} and 0.59% and 0.75% respectively. The ranges for mineral compositions (mg kg^{-1}) for the black and brown varieties included sodium 521.19 -924.07, 484.51-1075.80; potassium 6750.0 - 12780, 8052.0 - 14241; magnesium 535.0 - 747.0, 551.0 - 740.0; phosphorus 279.33 - 477.41, 258.65 - 478.37 and zinc 23.08 -60.58, 33.57 -55.84. With the exception of milk from Tanoso tubers, milk from all other sites was acceptable to the sensory panel. The fat and milk obtained from tiger nuts tubers could be exploited for industrial and commercial applications.

Keywords: *tiger nut tubers, varieties, planting period, chemical composition, milk acceptability*

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1. Introduction

Tiger nut (*Cyperus esculentus* L.) is a perennial crop that is cultivated extensively in Spain, almost exclusively in the Valencia region, Turkey, Southern India, Thailand, Ghana, Nigeria, Sierra Leone and Cameroon [1,2,3,4]. Nutritionally, the tubers contain between 200-280 g kg^{-1} of yellow non-drying pleasantly flavored oil, similar to olive or sweet almond oil [4, 5]. The oil consists of 170-180 g kg^{-1} saturated fatty acids, much of which (120-140 g kg^{-1}) is palmitic acid and the rest mainly stearic acid. Of the unsaturated fatty acids present, about 75 g kg^{-1} is oleic acid and between 90-155 g kg^{-1} linoleic [4]. The oil extract has been used in cooking and for the manufacture of body and hair creams [6]. Of the tuber weight, about 500.0 g kg^{-1} is digestible carbohydrates, 40.0 g kg^{-1} protein and 90.0 g kg^{-1} crude fiber with a high fraction of it being indigestible carbohydrates mainly cellulose and lignin [7]. Tiger nuts also have a good profile of some essential minerals like zinc, 158 mg kg^{-1}; magnesium 430 mg kg^{-1} and potassium, 265 mg kg^{-1} [4].

The tubers are used as food around the Mediterranean, especially in Egypt and Spain as well as countries in West Africa, particularly in Cameroon, Nigeria and Ghana. Dried nuts are ground into flour and incorporated into various foods. It is also baked and milled into powder for use as food additives, spices or made into a refreshing beverage called "Hochata De Chufas" or tiger nut milk [8,9,10].

In Ghana two varieties, black and brown are mainly cultivated. Though it can be cropped through out the country, it has traditionally been cultivated at only a few places in the Eastern, Central and the Brong-Ahafo Regions [11]. Harvested tubers are first sorted, rubbed in baskets or washed in water and dried before distribution through intermediaries. The nuts are chewed raw, dried or roasted like sweets, or made into a highly cherished milk-like beverage referred to as "Atadwe" milk. Currently, nearly all nuts grown in Ghana are consumed locally. Due to increasing awareness of the nutritional potential, nutraceutical benefits of the tubers and the perception that it has aphrodisiac properties there is increased cultivation of tiger nuts and explorations of novel uses for its milk [12,13].

The plant variety, location and period of planting have been shown to have significant effects on physico-chemical properties of plant materials [14,15]. However though considerable studies have been done on the proximate composition and mineral content of tiger nuts tubers [4,16,17,18,19] there is very little information on the effect of site and planting period on chemical composition of tubers and acceptability of milk. The objectives of this study therefore were to determine the chemical composition and acceptability of milk of two varieties of tubers from different sites and planting periods in Ghana.

2. Materials and methods

2.1. Material Samples

Sixteen samples of tiger nut tubers (*Cyperus esculentus* L.) grown in the two planting periods (major; April to July and minor; September to November) were studied. The tubers were sorted, washed and dried in a Sanyo oven (Model MOV-212, Japan) Between 55-60°C till constant moisture content (≤10%).The oven-dried tiger nut tubers were milled in a blender (Waring) to pass through a sieve of pore size 0.5 mm and then stored in airtight containers in a freezer at -18°C until used for laboratory analysis.

2.2. Physical and Chemical Analysis

Moisture content was determined using the air oven drying method at 105°C [20]. Total ash, crude lipid, crude fibre, protein (6.25 x N) were all determined in triplicate according to AOAC, methods [20]. Crude protein (N x 6.25) was determined by the Macro-Kjeldal method using 1.0 g samples. Ash was determined by the incineration of a 1.0 g sample placed in a muffle furnace maintained at 550°C for 6 hours (until ash was obtained). Crude lipid (ether extract) was determined by exhaustively extracting 5.0 g of the sample with petroleum ether by use of a Soxhlet apparatus. The level of carbohydrate was obtained by the difference method, that is, by subtracting the sum of the protein, fat (lipid), fiber and ash from the total dry matter. The calorific value was calculated by multiplying the mean values of the crude protein, fat and carbohydrates by Atwater factors of 4, 9 and 4 respectively, [21]. Free fatty acids were determined by mixing 10.0 g of Soxhlet extracted oil with 25.0 ml diethyl ether, 25 ml ethanol and 1 ml phenolphthalein and titrating with 0.1M NaOH until a pink color persisted for 15 seconds. [22]. The FFA content was calculated as oleic acid (1.0 ml NaOH is equivalent to 0.0282 g oleic acid). Determinations were carried out in triplicate.

2.3. Mineral Analysis

The wet digestion method using nitric acid was used [20]. All elements were analyzed in triplicate using the PerkinElmer Atomic Absorption Spectrophotometer model AA 220FS.

2.4. Milk extraction methods

The procedure for extraction of milk from tubers is shown in Figure 1. One hundred grams (100g) of oven-dried nuts were soaked in covered vessels with 600 mL of water overnight. The water was discarded and the nuts milled in a Waring blender (Model 38BL41, USA) at high speed in twice its new weight of fresh water for 5 minutes. The milk was pressed through a cheese cloth, and the milk obtained was used for analysis.

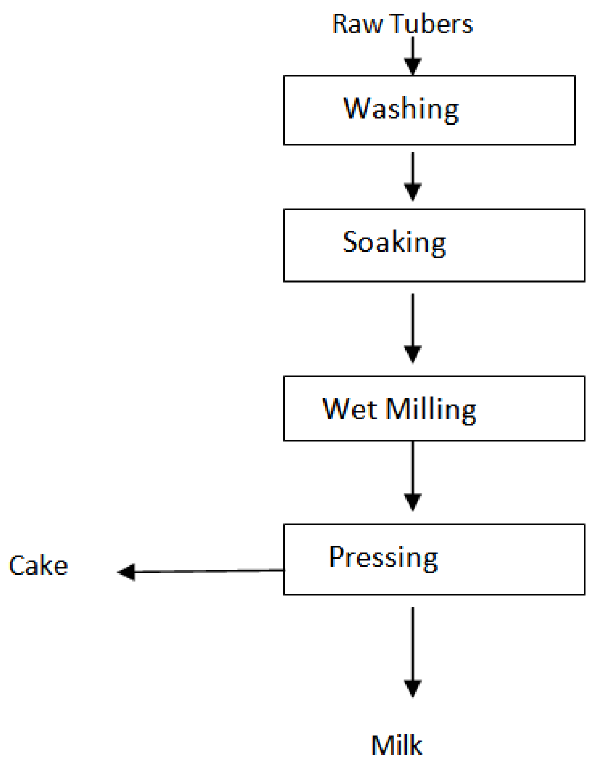

Figure 1. Flow Diagram for extracting tiger nut milk and solids

2.5. Sensory Evaluation of Milk

The preference of milk extracted from the tubers was determined using simple ranking test in a randomized complete block design [23]. 2.0% w/w of sugar was used to sweeten the tiger nut milk to facilitate ranking by the panelists. Ranking of milk was done by a panel of 10 trained persons on a scale of 1-6. The most acceptable was ranked 1 and the least acceptable was ranked 6. Water was available for panelists to rinse their mouth.

2.6. Statistical Analyses

The data obtained was subjected to ANOVA using MINITAB 14 statistical package (MINITAB Inc., U.S.A.). Tukey's test was used to identify significant differences among means ($p < 0.05$) and the Friedman's Rank Test was used to determine the rank sums of the treatments used for sensory analyses.

3. Results and Discussion

The Proximate composition, an indication of the nutritional potential of the tubers and the free fatty acid content, an indication of the effect of post harvest handling on the quality of tiger nuts obtained from different locations in Ghana are presented in Table 1. There were significant differences ($p<0.05$) in the indices measured between locations and varieties. Ampenyi black tubers planted in the major period recorded the highest energy value of 5016.2 kcal kg^{-1} while Bawjiase brown tubers from the major planting period recorded the highest carbohydrate content of 734.7 g kg^{-1}. There were also significant differences ($p<0.05$) between planting periods.

For example, Bawjiase and Danyameso which were the two sites that planted both varieties in major and minor periods recorded significant differences in their protein and fat content. The black tiger nut tubers obtained from Danyameso in the minor planting period recorded the highest fat content of 295.4 g kg^{-1}, while the major planting crop recorded 155.4 g kg^{-1}. Whereas Bawjiase brown tubers planted in the minor period recorded the highest protein content of 75.1 g kg^{-1} the major period crop recorded 39.1 g kg^{-1}. These differences in indices of tubers from different planting periods, sites and varieties are similar to observations from other studies on plant materials [24,25,26] which has been attributed to differences in rainfall, climate, soil and crop variety [27]. Comparatively, the protein content of brown tubers planted in the minor period at Bawjiase (75.1 g kg^{-1}) was lower than the 80.7 g kg^{-1} determined for raw tubers, but higher than the 68.0 g kg^{-1} recorded for roasted tubers by the same researchers and also higher than the 50.0 g kg^{-1} recorded in another study [28,29]. The mean fat content recorded for all black and brown tubers for both seasons (219.2 g kg^{-1}, 192.7 g kg^{-1}) were also relatively lower than the 296.7 g kg^{-1} recorded in an earlier study [30] and the 510.0 g kg^{-1} recorded for cocoa beans which is a major economic crop in Ghana [31]. However, considering the fatty acids composition of tiger oil [32] it will make nutritional and commercial sense to exploit it.

Free fatty acid (FFA) was determined as an index for the effect of primary processing and handling on the tubers. The Free fatty acids (FFA) values obtained ranged from 0.37-1.18% for Tanoso black tubers of the major planting period and Danyameso black tubers of the major planting period respectively. The significant differences ($p<0.05$) is an indication of the impact of different post harvest handling practices on the quality of the nuts. Currently, harvested tubers in Kwahu are normally washed to remove residual soil, while in other sites like New Ebu and Twifo Praso the soil is rubbed off the tubers. There was no obvious trend in the free fatty acid content with respect to period of harvest; however it appeared that the black variety of tiger nuts showed higher free fatty acids in the major harvesting period than in the minor period (Table 1). The reverse was observed for the brown variety. If free fatty acids content is also taken as an index of stability of fatty food, then Black tiger nuts harvested in the minor period would keep longer (i.e. be more stable) than those harvested in the major period. The average free fatty acid of 0.66% for the tubers however is less than the industry limit of 1.75% for cocoa beans [33]. There was no significant differences in mean fiber values for black and brown tubers for both major and minor periods (94.0 g kg^{-1}, 92.6 g kg^{-1}; and 107.0 g kg^{-1},111.2 g kg^{-1}) respectively. Comparatively, these figures were higher than the 8.8 g kg^{-1} recorded for sweet potatoes and 11.8 g kg^{-1} recorded for cassava [34,35]. The casual relationship between consumption of high fiber diets and reduction of coronary heart diseases, diabetes mellitus and obesity suggests that the consumption of tiger nut tubers could reduce the risk of these diseases [36]. However, considering the traditional uses of tiger nut tubers in Ghana (tubers are mainly chewed for the juice and milk extraction) it can be said that till recipes are developed to make use of the whole tuber the many benefits of high tiger nut tuber diet cannot be realized.

Table 1. Chemical composition of two varieties of tubers from different sites and periods

Variety/ Planting period/ Site	CHEMICAL COMPOSITION						
	FAT (g kg^{-1})	PROTEIN (g kg^{-1})	ASH (g kg^{-1})	CHO (g kg^{-1})	FIBER (g kg^{-1})	ENERGY (kcal kg^{-1})	FREE FATTY ACIDS (%)
Black (major)							
Ampenyi	262.8(5.6)^{a}	40.4(1.9)^{a}	12.3(1.2)^{f}	596.3	84.9(1.4)^{a}	5016.2	0.43 (0.01)^{a}
Bawjiase	174.7(2.8)^{q}	22.7(1.3)^{j}	15.4(0.1)^{a}	678.0	109.2(2.5)^{bc}	4452.9	0.81 (0.01)^{b}
Danyameso	155.4(1.0)^{b}	44.7(1.4)^{b}	19.4(0.4)^{g}	677.1	103.4(2.2)^{b}	4370.4	1.18 (0.01)^{c}
Ebu	166.0(6.6)^{q}	33.9(2.8)^{k}	16.7(0.3)^{b}	709.2	74.2(2.9)^{i}	4555.1	1.11 (0.01)^{d}
Tampiong	242.3(1.8)^{f}	38.2(1.8)^{a}	13.6(0.4)^{h}	617.1	88.8(0.6)^{a}	4879.0	0.44 (0.01)^{a}
Tanoso	203.1(5.0)^{g}	43.4(1.2)^{b}	17.7(0.6)^{b}	636.3	103.8(8.5)^{b}	4652.7	0.37 (0.01)^{e}
Black (minor)							
Bawjiase	254.0(2.4)^{s}	73.4(0.2)^{c}	15.2(0.2)^{e}	553.8	104.1(9.4)^{b}	4795.7	0.47 (0.01)^{f}
Danyameso	295.4(3.2)^{h}	72.9(1.7)^{c}	17.6(0.1)^{p}	497.4	118.4(3.8)^{c}	4939.8	0.42 (0.01)^{g}
Brown (major)							
Ampenyi	222.6(2.0)^{i}	29.8(4.3)^{e}	14.6(0.3)^{c}	643.8	85.9(3.1)^{d}	4791.5	0.58 (0.01)^{h}
Bawjiase	128.7(3.5)^{c}	39.1(3.0)^{d}	15.6(0.3)^{c}	734.7	85.3(2.7)^{d}	4315.6	0.60 (0.01)^{h}
Danyameso	165.5(2.6)^{j}	56.9(1.7)^{n}	15.6(0.5)^{cd}	672.2	89.9(1.1)^{d}	4489.0	0.52 (0.01)^{i}
Ebu	128.7(3.5)^{c}	38.7(3.1)^{d}	16.4(1.2)^{d}	717.2	102.9(2.2)^{j}	4241.9	1.12 (0.01)^{j}
Kwahu Aduamoa	191.4(4.2)^{k}	67.6(2.3)^{f}	15.5(0.4)^{cd}	646.6	75.3(2.2)^{e}	4691.1	0.33 (0.01)^{k}
Twifo Praso	176.6(1.5)^{l}	56.6(4.8)^{c}	12.3(0.7)^{i}	641.6	116.2(7.3)^{k}	4462.4	0.43 (0.01)^{l}
Brown (minor)							
Bawjiase	252.8(2.8)^{m}	75.1(0.3)^{g}	14.4(0.3)^{q}	580.0	78.6(0.4)^{de}	4895.6	0.92 (0.01)^{m}
Danyameso	275.3(3.5)^{n}	73.1(1.2)^{g}	10.0(0.2)^{j}	506.9	135.4(3.7)^{l}	4795.7	0.84 (0.01)^{n}
Major							
All Black Tubers	200.7(41.2)^{o}	37.2(7.7)^{l}	15.9(2.5)^{e}	662.2	94.0(13.20)^{h}	4654.0	0.72 (0.01)^{o}
All Brown Tubers	168.9(34.4)^{p}	48.1(13.8)^{m}	15.0(1.8)^{e}	676.0	92.6(14.1)^{h}	4499.0	0.62 (0.01)^{p}
Minor							
All Black Tubers	264.0(12.6)^{r}	74.1(1.4)^{i}	12.2(2.4)^{l}	543.5	107.0(31.3)^{g}	4845.7	0.45 (0.01)^{q}
All Brown Tubers	274.7(12.6)^{r}	73.2(1.1)^{i}	16.4(1.3)^{k}	525.6	111.2(10.1)^{g}	4868.0	0.88 (0.01)^{r}
Variety/period							
All Black Tubers	219.2(44.9)^{d}	46.2(17.2)^{h}	16.0(2.8)^{m}	620.5	98.3(14.4)^{f}	4707.7	0.59 (0.01)^{s}
All Brown Tubers	192.7(51.8)^{d}	54.6(16.5)^{h}	14.3(2.1)^{n}	642.9	98.2(20.0)^{f}	4585.4	0.75 (0.01)^{t}

Means in the same column but with different superscripts are significantly different ($P<0.05$)

The mineral content of the two tiger nut varieties obtained from different locations of the two planting period are shown in Table 2. Sodium, potassium, magnesium and phosphorus which are very useful for very important reactions in the body and the proper development of bones and teeth [37] were the major macro elements in the tubers while iron, copper manganese were the least abundant. This was similar to studies conducted by other researchers on tubers from other countries [38,39]. Sodium ranged from 484.51 mg kg^{-1} to 1075.80 mg kg^{-1} with Bawjiase brown of major planting period recording the highest. The minor period black variety in Bawjiase recorded the highest magnesium of 747.0 mg kg^{-1}, while the brown variety planted in the major period recorded the highest phosphorus of 478.37 mg kg^{-1}. Brown tubers planted in the minor period at Danyameso however recorded the highest potassium of 14241.0 mg kg^{-1} with the black tubers planted in the major period at the same site recording the highest sodium 924.07 mg kg^{-1} (Table 2). The trace amounts of calcium and iron which are essential in the development of strong bones and blood synthesis suggest that there is the need for the fortification of the vegetable milk produced from the tubers to prevent micro-nutrient deficiencies [37]. If used in cocoa products however there will be very little need for additional magnesium because of the high quantities in cocoa [40]. Zinc was the highest recorded minor element with the highest, 60.58 mg kg^{-1} recorded for Tanoso black. This was however only 26% of the required daily intake for adults and children above 4 years [41]. Over all Black tubers harvested in the major period had minerals profile that was not significantly different from those of the brown variety.

Table 2. Elemental composition of two varieties of tiger nut tubers from different sites and periods

Variety/Planting period/Site	Na (mg kg^{-1})	Ca (mg kg^{-1})	K (mg kg^{-1})	Mg (mg kg^{-1})	Ph (mg kg^{-1})	Fe (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})
Black (major)									
Ampenyi	550.30(1.47)^{e}	7.67(0.42)^{a}	6750.0(219.0)^{h}	535.0(36.0)^{a}	283.09(2.27)^{a}	3.21(0.02)^{e}	36.77(0.73)^{i}	3.32(0.28)^{k}	0.18(0.03)^{a}
Bawjiase	778.25(1.68)^{f}	11.27(0.31)^{b}	10891.0(227.0)^{i}	662.0(26.0)^{b}	375.37(2.93)^{f}	2.72(0.03)^{f}	47.52(0.65)^{j}	1.83(0.17)^{a}	1.00(0.06)^{b}
Danyameso	924.07(6.27)^{a}	15.80(0.60)^{c}	11659.0(430.0)^{i}	689.0(19.0)^{b}	279.33(1.91)^{a}	4.65(0.08)^{g}	45.10(0.39)^{a}	4.62(0.59)^{b}	1.42(0.09)^{c}
Edu	920.62(1.58)^{a}	8.27(0.50)^{a}	8877.0(321.0)^{a}	581.0(15.0)^{a}	477.41(0.89)^{g}	3.41(0.02)^{h}	32.88(0.41)^{k}	1.36(0.28)^{a}	8.14(0.07)^{c}
Tampiong	523.44(0.94)^{b}	12.27(0.30)^{b}	8879.0(187.0)^{a}	653.0(23.0)^{b}	294.29(0.60)^{h}	5.47(0.03)^{i}	23.08(0.16)^{l}	1.45(0.20)^{a}	0.12(0.02)^{a}
Tanoso	521.19(0.55)^{b}	11.13(0.50)^{b}	9023.0(360.0)^{a}	660.0(9.0)^{b}	354.20(0.60)^{b}	5.17(0.01)^{j}	60.58(0.72)^{m}	4.83(0.20)^{b}	9.22(0.48)^{h}
Black (minor)									
Bawjiase	682.15(1.36)^{g}	12.80(1.40)^{b}	10035.0(44.0)^{k}	747.0(23.0)^{b}	362.55(9.33)^{b}	4.05(0.07)^{k}	46.38(0.65)^{a}	1.99(0.02)^{a}	1.35(0.43)^{bc}
Danyameso	700.63(1.32)^{h}	15.27(1.92)^{c}	12780.0(449.0)^{l}	694.0(103.0)^{b}	283.95(9.31)^{a}	4.47(0.02)^{l}	46.35(1.42)^{a}	4.71(0.75)^{b}	1.90(0.15)^{c}
Brown (major)									
Ampenyi	763.16(1.41)^{i}	7.93(0.42)^{h}	8316.0(299.0)^{b}	551.0(30.0)^{c}	366.00(1.63)^{c}	2.93(0.01)^{m}	34.89(0.83)^{b}	1.24(0.09)^{c}	1.98(0.05)^{i}
Bawjiase	1075.80(4.70)^{j}	12.67(0.76)^{l}	12523.0(221.0)^{m}	695.0(29.0)^{ef}	478.37(1.95)^{d}	3.11(0.04)^{n}	41.05(1.02)^{c}	2.85(0.20)^{d}	7.44(0.15)^{d}
Danyameso	937.98(2.23)^{k}	15.60(0.40)^{c}	9758.0(220.0)^{cd}	678.0(45.0)^{e}	253.53(0.90)^{e}	5.37(0.08)^{o}	55.34(0.59)^{d}	4.90(0.37)^{h}	1.47(0.12)^{e}
Ebu	642.12(0.17)^{l}	10.13(0.61)^{d}	8593.0(213.0)^{b}	587.0(16.0)^{cd}	476.85(1.63)^{d}	2.77(0.08)^{p}	38.45(0.56)^{e}	1.09(0.11)^{c}	0.68(0.04)^{j}
Kwahu Aduamoa	538.56(1.05)^{m}	11.33(0.42)^{d}	9364.0(260.0)^{c}	587.0(10.0)^{cd}	371.35(0.91)^{c}	4.96(0.13)^{a}	33.57(0.76)^{b}	1.13(0.08)^{c}	0.39(0.02)^{k}
Twifo Praso	484.51(1.19)^{n}	16.80(0.35)^{c}	8052.0(264.0)^{b}	640.0(14.0)^{e}	398.31(0.61)^{i}	3.86(0.01)^{q}	38.43(0.70)^{e}	0.35(0.04)^{i}	1.01(0.06)^{l}
Brown (minor)									
Bawjiase	870.24(2.22)^{o}	16.13(0.42)^{c}	10176.0(348.0)^{d}	655.0(29.0)^{e}	258.65(2.25)^{e}	4.80(0.02)^{a}	55.84(1.66)^{d}	5.54(0.19)^{j}	1.65(0.18)^{e}
Danyameso	595.75(4.51)^{p}	14.40(0.92)^{i}	14241.0(427.0)^{n}	740.0(12.0)^{f}	469.88)(11.34)^{d}	3.64(0.08)^{r}	42.40(0.76)^{c}	3.03(0.09)^{d}	7.64(0.68)^{d}
All Black Tubers (major)	702.98(183.37)^{d}	11.07(2.79)^{g}	9330.0(1650.0)^{e}	630.0(58.4)^{g}	343.95(71.86)^{j}	4.11(1.07)^{b}	40.99(12.24)^{f}	2.90(1.51)^{e}	2.30(3.25)^{g}
All Brown Tubers (major)	740.36(217.45)^{d}	12.41(3.17)^{g}	9430.0(1560.0)^{e}	623.0(58.2)^{g}	390.74(78.56)^{j}	3.83(1.04)^{b}	40.29(7.40)^{f}	1.93(1.58)^{e}	2.16(2.49)^{g}
All Black Tubers (minor)	691.39(10.19)^{c}	14.03(2.02)^{f}	11410.0(1530.0)^{f}	720.0(72.4)^{h}	323.25(43.85)^{k}	4.26(0.24)^{c}	46.36(0.99)^{g}	3.36(1.56)^{f}	1.62(0.42)^{f}
All Brown Tubers (minor)	732.99(150.38)^{c}	15.27(1.14)^{f}	12210.0(2250.0)^{f}	699.0(50.5)^{h}	364.27(115.29)^{k}	4.22(0.64)^{c}	49.12(7.45)^{g}	4.29(1.38)^{f}	4.65(3.31)^{f}
All Black Tubers	700.08(157.80)^{q}	11.81(2.89)^{k}	9849.0(1837.0)^{g}	653.0(73.0)^{i}	338.78(65.72)^{l}	4.14(0.93)^{d}	42.33(10.80)^{h}	3.02(1.50)^{g}	2.13(2.82)^{m}
All Brown Tubers	738.51(199.69)^{q}	13.13(3.03)^{k}	10218.0(2099.0)^{g}	642.0(64.0)^{i}	384.12(87.29)^{l}	3.93(0.96)^{d}	42.50(8.24)^{h}	2.52(1.83)^{g}	2.79(2.86)^{m}

Tukey's test was used to locate the differences in means.

Means in the same column but with different superscripts are significantly different ($P<0.05$)

Table 3. Consumer preference of tiger nut milk extracted from tubers from different sites

VARIETY	SITE	ACCEPTABILITY	RANKING
BLACK	Ampenyi	4.5(1.3)^a	5TH
	Bawjiase	2.6(1.4)^a	3RD
	Danyameso	2.2(1.4)^a	2ND
	Ebu	2.2(0.9)^a	1ST
	Tampiong	3.9(1.2)^a	4TH
	Tanoso	5.7(0.7)^b	6TH
BROWN	Ampenyi	3.8(2.2)^a	6TH
	Bawjiase	3.3(2.0)^a	1ST
	Danyameso	3.5(1.8)^a	5TH
	Ebu	3.5(1.1)^a	3RD
	Kwahu Aduamoa	3.4(2.0)^a	2ND
	Twifo praso	3.5(1.4)^a	4TH

Means in the same column but with different superscripts differ significantly (p<0.05)

The consumer preference for milk extracted from the tiger nut tubers was obtained through a simple ranking test. The rank sums are indicated in Table 3. Friedman's ranking showed that there were significant differences ($p < 0.05$) in the acceptability of milk from the tubers of black variety with the milk from Tanoso falling below expectation due to unacceptable flavor. The unacceptable flavor could be due to the post harvest handling of the tubers, soil structure and the climatic conditions in the Tanoso area. These factors have been determined to affect the flavor of *horchata de chufas* [42,43].

4. Conclusion

The site and planting period of tiger nut tubers have significant effects on some of its chemical properties such as protein, fat and energy content, minerals as well acceptability of its milk. Tiger nut tubers have high fat, carbohydrate, fiber and energy value which could be exploited for industrial applications.

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