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Nutritional Assessment and Sensory Attributes of Carrot-enhanced Yoghurts Produced from Àkwiyáa Goat, Rago Sheep Milks, Their Blends and Cow Milk

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Abstract One of the dairy products with high nutritional value and healthful properties is yoghurt. Considering the therapeutic value of Akwiyáa milk, nutritional content of Rago milk and health benefits of carrot, the present study was designed to produce functional yoghurt based on physico-chemical and sensory characteristics of these ingredients. Physicochemical, mineral and sensory attributes of yoghurts produced from Àkwiyáa milk(X_1), Rago milk(X_2), blends of Àkwiyáa and Rago milk samples enhanced with carrot ($X_1X_2Y_C$) and 100% cow milk(X_0) as control, were evaluated. Milk samples X_1, X_2 and X_0 were asceptically obtained manually, screened and pasteurized at 70° -75°C for 30 minutes. Twenty (20g) of carrot juice at the rate of 10% was added to 180g of each milk sample for production of yoghurts, X_1Y_C and X_2Y_C. Àkwiyáa/Rago milk blend yoghurt samples $X_1X_2Y_{C1}$ (50/50), $X_1X_2Y_{C2}$ (60/40), $X_1X_2Y_{C3}$ (70/30), $X_1X_2Y_{C4}$ (80/20) with 20g carrot; $X_1X_2Y_0$ (50/50) and X_0Y_0 (100%) without carrot were produced with 5% sugar addition. Fermentation using mixed starter culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* at the rate of 18g/L was carried out at 43°C for 6hr and terminated at pH 4.5. Minerals: calcium, potassium, magnesium, phosphorus, zinc and iron in X_1Y_C and X_2Y_C were higher than the control (X_0Y_0). Treatment samples were also nutritionally richer than the control with $X_1X_2Y_{C1}$ averagely having the highest values. In sensory evaluation, the treatment samples had similar organoleptic rating with the control. However, X_2Y_C and $X_1X_2Y_{C3}$ were rated best in general acceptability. Sample $X_1X_2Y_{C3}$ would be most acceptable to consumers as nutraceutical: based on the nutrient rich quality of ruminants' milk, carotenoids and fibre from carrot which could be harnessed for healthy living.

Keywords: *ruminants' milk, yoghurt, physicochemical, mineral and sensory attributes*

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1. Introduction

Dairy products are considered to be one of the main food groups important in a balanced diet because they provide substantial amounts of vitamins and minerals and are good sources of proteins, carbohydrates, fats and energy. These nutrients aid in proper functioning of the human system including maintenance of normal vision, red blood cells, protection of DNA, protection of proteins and lipids from oxidative changes, normal functioning of the immune system, neurological and psychological functions, reduction of oxidative stress, healthy growth and maintenance of teeth and bones [1,2]. The major source of milk for human consumption is dairy cow. However, other domesticated ruminants such as goat and sheep provide milk for the same purpose in other parts of the world [3,4]. Goat milk has special nutritional properties that make it attractive to consumers such as digestibility, longer shelf life, smaller structure of casein micelles and high concentration of medium chain fatty acids which play important role in imparting unique health benefits [5,6]. The milk allergy problems with associated symptoms as gastrointestinal disturbances, vomiting, colic, diarrhea, constipation and respiratory problems can be eliminated when cow milk is substituted with goat milk [7].

Similarly, sheep milk has very high nutritional value compared to cow milk and it also contains twice more solids than cow milk with higher levels of vitamin E, water soluble vitamins and minerals [3,7]. Sheep milk as well as yoghurt and cheese made from it may give the lactose intolerant individual the chance to enjoy milk again. Although it contains higher levels of butter fat, it is actually lower in saturated fat than other types of milk, and therefore a good source of short and medium chain triacylglycerol. Medium chain fatty acids minimize cholesterol deposition in the arteries, aid in dissolving cholesterol and gallstones and significantly contribute to normal growth of infants [8]. Sheep milk is higher in solids than milk from cow or goat. It is a rich source of important minerals such as calcium, zinc, magnesium, and phosphorous as well as vitamins A, B, D and E. It is also slightly higher in proteins than other forms of milk [3,7].

Yogurt, a fermented milk product which originated from Turkey is one of the dairy product with high nutritional value and healthful properties. Yoghurt is a food obtained by controlled fermentation of milk by a mixed culture of lactic acid bacteria selected to produce flavor and aroma [9]. It is a very popular fermented food product widely consumed all over the world. Traditionally, yoghurt is made from animal milk. However, over the years, production of yoghurt from non dairy materials as tiger nut, soy bean, coconut and yam-bean has been reported in the literature [10,11,12]. Yoghurt consumption offers health benefits which include the reduction of blood cholesterol level, anti-cancer effects and the improvement of antimicrobial activity and immunity [13,14,15]. Fermented foods containing live cultures are considered as functional foods with health benefits. As the popularity of yoghurt products grows, manufacturers are continuously investigating the use of value added materials such as functional ingredients to satisfy health-conscious consumers. Functional ingredients are non-conventional biomolecules in food which possess the capacity to modulate one or more metabolic processes or pathways in the body resulting in improved health and promotion of well-being [16]. Among these ingredients are probiotics and prebiotics. Equally, plant components known as phytonutrients have health promoting properties. Carrot is a significant source of phytonutrients [17]. Carrot is rich in β-carotene, ascorbic acid and tocopherol and is classified as vitaminized food [18]. Carrot contains variety of different desirable compounds including fibre at appreciable level; and so carrot is considered as a functional food with significant health promoting properties [19,20]. Carrot contains carotenoids, a group of natural pigments used commercially as food colorants and oxycarotenoids such as leutin which is protective against colon cancer in human [21,22]. This work was therefore designed to evaluate the effects of carrot on the quality and sensory attributes of carrot-enhanced yoghurts produced from Àkwiyáa milk, Rago milk, and their blends.

2. Materials and Methods

2.1. Sources of Materials

Samples of fresh Àkwiyáa goat milk (X_1), Rago sheep milk (X_2) and dairy cow milk (X_0) were aseptically obtained by manual milking from a local Hausa farm in Uyo, Nigeria. The samples were stored at 4°C in a refrigerator (Model: CF- KR 195N) until the time used. Sugar, gelatin and mixed starter culture (Yògourmet: J8H4G4, LYO-SAN INC. Canada) were purchased from a shop in Akpan-Andem market in Uyo metropolis. Fresh tubers of carrot and plastic containers were also bought at Akpan Andem market while the de-ionized water was obtained from the microbiology laboratory of the University of Uyo.

2.2. Sample Preparation

The milk samples were screened to remove hair strands and any undesirable material and thereafter pasteurized at 70° - 75°C for 30 minutes to destroy undesirable microorganisms. Dry mixed starter culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Yògourmet: J8H4G4, LYO-SAN INC. Canada) was propagated for 1h at room temperature using pasteurized milk sample prepared for yoghurt production. Gelatin at the rate of 2% was dissolved in milk sample and used as stabilizer. Fresh Carrot tubers were washed in flowing tap water, shredded and blended using electric powered Philip blender (Model: HR-2818) with de-ionized water added in the ratio of 1:6 (w /w). The carrot mash was thereafter filtered using cheese cloth. The Juice obtained was pasteurized at 65°C for 30 minutes, cooled rapidly to 4°C and stored at that temperature in a refrigerator until when needed.

2.3. Production Process

Method of Bano et al. [7] was used for the production of the yoghurts. A total of eight [8] yoghurt samples were produced: Àkwiyáa goat milk with carrot juice (X_1Y_C), Rago sheep milk with carrot juice (X_2Y_C), samples of Àkwiyáa / Rago milk blend with carrot juice ($X_1X_2Y_{C1}$), ($X_1X_2Y_{C2}$), ($X_1X_2Y_{C3}$), ($X_1X_2Y_{C4}$); Àkwiyáa / Rago milk blend without carrot juice ($X_1X_2Y_0$) and dairy cow milk without carrot juice (X_0Y_0) as control. The sample treatments were made up of 180g of pasteurized Àkwiyáa/Rago milk blend in different ratios of 50/50, 60/40, 70/30 and 80/20 with added 20g carrot juice at the rate of 10%. To each sample treatment, 5% (10g) sugar was added, homogenized using electric powered blender and there after cooled to 45°C. The treatment samples were inoculated at 43°C with 3.6g of the prepared mixed starter culture at the rate of 18g/L.

Fermentation was done in an incubator under anaerobic conditions for 6 hours at 43°C. When the yoghurt- mix pH decreased from initial 6.7 to 4.5, the fermentation was terminated by rapid cooling in refrigerator to 4°C. The mature yoghurt samples were then homogenized with addition of 4g gelatin (2%) as a gelling agent to obtain good texture, consistency and desirable mouth feel. The yoghurts were packaged in air-tight plastic containers, stored in refrigerator at 4°C and used for analyses within 24h.

2.4. Analysis of the Yoghurt Samples

The yoghurt samples were analysed for physico-chemical properties: moisture, protein, carbohydrate, fibre, fat, ash, pH, total titratable acidity (TTA), total solids, and carotene and also for mineral elements. Protein, fibre, fat, ash and total solids were determined by the methods of AOAC [23]. The pH was measured using pH meter (PHS-3C, B. Bran scientific instrument, England), TTA as per cent lactic acid (titration against 0.1N NaOH) and carotene and vitamin C (lesany UV-VIS spectrophotometer, AE1011041). Mineral elements: calcium, magnesium, phosphorus, iron and zinc were determined using atomic absorption spectrophotometer (UNICAM model 393) while potassium determination was by (Gallenkamp flame photometer (CL 378 ELCO). Sensory analysis method described by Iwe [24] was used to evaluate the yoghurt samples.

A 20 - member semi-trained panel with good sensory acuity, drawn from students and staff of University of Uyo carried out the sensory test. Rating was done using 9-point hedonic scale on the following attributes: colour, taste, consistency, mouth feel, flavour and general acceptability. Panelists were served potable drinking water to rinse their mouth after each sample before they proceeded to taste another.

2.5. Statistical Analysis

Data generated were subjected to statistical analysis of variance (ANOVA) using IBM statistical package for social sciences (SPSS) version 20. Significance was accepted at 5% probability level (P<0.05).

3. Result

The physicochemical properties of the yoghurts produced from Àkwiyáa goat milk with carrot juice (X_1Y_c), Rago sheep milk with carrot juice (X_2Y_c) in the ratios 180g milk : 20g carot juice; Àkwiyáa / Rago yoghurt samples $X_1X_2Y_{C1}$ from 50:50 milk, $X_1X_2Y_{C2}$ from 60:40 milk, $X_1X_2Y_{C3}$ from 70:30 milk and $X_1X_2Y_{C4}$ from 80:20 milk with added 20g carrot juice; Àkwiyáa/ Rago milk yoghurt $X_1X_2Y_0$ from 50:50 milk without carrot juice and 100% dairy cow milk yoghurt (X_oY_o**)** as control are presented in Table 1.

The results (Table 1) showed significant differences (P<0.05) among the treatments and parameters evaluated. Moisture content ranged from (82.19±0.01% in X_2Y_c to 87.03±0.04% in X_1Y_c), protein (3.53±0.01% in X_1Y_c to 5.97±0.01% in X_2Y_c), carbohydrate (2.79±0.01% in $X_1X_2Yc_3$ to 4.30±0.00% in X_2Y_c), fibre (0.13±0.01% in X_0Y_0 to 0.73±0.04% in X_1Y_c), fat (3.93±0.05% in X_0Y_0 to 6.65±0.01% X_2Y_c), ash (0.82±0.00% in X_0Y_0 to 0.87±0.01% in X_2Y_c), pH (4.49±0.06 in X_0Y_0 to 4.76±0.04 in$X_1X_2Y_{c2}$), titratable acidity (0.78±0.01% in X_2Y_c to 0.84±0.01% in X_1Y_c and $X_1X_2Y_c$), total soluble solids (12.71±0.03% in X_1Y_c to 17.85±0.01% in X_2Y_c), and carotene (2.50±0.03mg/100g in X_0Y_0 to 54.56±0.02mg/100g in X_2Y_c). Addition of the carrot juice increased the carotene and fibre contents of the yoghurt samples.

The results of the mineral composition of the yoghurt samples are presented in Table 2.

The mineral contents of dairy cow milk yoghurt (X_0Y_0) were significantly lower (P<0.05) in calcium 254.27±0.17mg, potassium 104.24±0.33mg, magnesium 14.77±0.07mg, phosphorus 275.08±0.13mg, zinc 0.44±0.01mg, and iron 0.15±0.01mg than the values of Rago milk yoghurt (X_2Y_C) and all the blends of Àkwiyáa and Rago milk yoghurt samples: $X_1X_2Y_{C1}$, $X_1X_2Y_{C2}$, $X_1X_2Y_{C3}$, $X_1X_2Y_{C4}$ and $X_1X_2Y_0$; but compared favourably with Àkwiyáa milk yoghurt X_1Y_C. The levels of all the minerals except calcium in $X_1X_2Y_{C1}$ and $X_1X_2Y_0$ yoghurt samples were slightly higher than those of individual Àkwiyáa X_1Y_C, Rago X_2Y_C and Dairy cow X_0Y_0 yoghurt samples and the blends $X_1X_2Y_{C2}$, $X_1X_2Y_{C3}$ and $X_1X_2Y_{C4}$.

Table 1. Physicochemical Properties of Carrot-enhanced Yoghurts Produced from Àkwiyáa Goat milk, Rago Sheep milk, their Blends and Cow milk (%)

	X_1Y_C	X_2Y_C	$X_1X_2YC_1$	$X_1X_2YC_2$	X_1 X_2YC_3	$X_1X_2YC_4$	$X_1X_2Y_0$	X_0Y_0
Moisture	87.03±0.04^a	82.19±0.01^f	84.21±0.01^e	86.25±0.03^c	86.86±0.10^b	86.82±0.03^b	85.47±0.00^d	86.87±0.02^b
Protein	3.53±0.01^f	5.97±0.01^a	5.80±0.01^b	4.92±0.02^c	4.70±0.05^d	4.69±0.03^d	4.88±0.02^c	3.86±0.02^e
Fat	4.31±0.01^e	6.65±0.01^a	5.70±0.02^c	4.53±0.01^d	4.13±0.04^f	4.21±0.02^g	5.91±0.02^b	3.93±0.05^h
Fibre	0.73±0.04^a	0.71±0.00^a	0.63±0.01^b	0.47±0.01^c	0.43±0.02^d	0.45±0.03^{cd}	0.17±0.01^e	0.13±0.01^f
Ash	0.85±0.02^a	0.87±0.01^a	0.85±0.01^a	0.77±0.15^a	0.82±0.02^a	0.84±0.01^a	0.85±0.01^a	0.82±0.00^a
CHO	3.48±0.02^c	4.30±0.00^a	3.01±0.01^d	2.93±0.00^e	2.79±0.04^g	2.87±0.02^f	3.01±0.01^d	3.58±0.00^b
pH	4.52±0.03^d	4.63±0.03^b	4.55±0.01^{cd}	4.76±0.02^a	4.71±0.05^a	4.74±0.03^a	4.61±0.01^{bc}	4.49±0.06^d
TTA	0.84±0.01^a	0.78±0.01^d	0.83±0.01^{ab}	0.80±0.01^c	0.84±0.01^a	0.81±0.02^{bc}	0.83±0.00^{ab}	0.82±0.02^{abc}
Total solids	12.71±0.03^h	17.85±0.01^a	15.47±0.01^b	13.73±0.02^d	12.88±0.03^f	13.14±0.04^e	14.85±0.01^c	12.78±0.01^g
Carotene (mg)	54.44±0.01^b	54.56±0.02^a	53.67±0.06^d	53.43±0.06^e	53.73±0.12^c	53.40±0.00^f	2.63±0.01^g	2.50±0.03^h

Values are means ± standard deviation of three determinations. Values with different superscript letters in the same row are significantly different (P < 0.05). X1YC = 180g Àkwiyáa milk/20g C-juice, X2YC = 180g Rago milk/20g C-juice, X1X2YC1 = 180g (50/50) Àkwiyáa and Rago milk/20g C-juice, X1X2YC2 = 180g (60/40) Àkwiyáa and Rago milk/20g C-juice, X1 X2YC3 = 180g (70/30) Àkwiyáa and Rago milk/20g C-juice, X1X2YC4 = 180g (80/20) Àkwiyáa and Rago milk/20g C-juice, X1X2Y0 =180g (50/50) Àkwiyáa and Rago milk/zero C-juice, X0Y0 = 200g cow milk/zero C-juice.

Table 2. Mineral Composition of Àkwiyáa, Rago, and Cow milk Yoghurts with and without Carrot juice (mg/100g)

Component	X_1YC	X_2YC	X_1 X_2YC_1	X_1 X_2YC_2	X_1 X_2YC_3	X_1 X_2YC_4	X_1 X_2Y_0	X_0Y_0
Calcium	254.55±0.58^e	261.42±1.00^a	257.75±0.39^c	257.76±0.64^c	256.42±0.66^d	258.90±0.73^b	258.87±0.08^b	254.27±0.17^e
Potassium	108.23±0.15^f	110.81±1.21^e	122.34±0.56^b	106.71±0.10^g	118.53±0.72^d	120.97±0.55^c	126.30±0.16^a	104.24±0.33^h
Magnesium	14.80±0.13^g	19.26±0.03^f	52.73±0.10^a	50.62±0.01^c	47.63±0.03^d	46.44±0.43^e	51.77±0.19^b	14.77±0.07^g
Phosphorus	274.75±0.21^g	284.91±1.03^f	315.50±0.08^a	300.76±0.02^b	295.46±0.57^d	293.70±0.10^e	298.28±0.10^c	275.08±0.13^g
Zinc	0.45±0.00^e	0.46±0.03^e	0.66±0.02^b	0.54±0.02^d	0.62±0.00^c	0.75±0.01^a	0.75±0.00^a	0.44±0.01^e

Values are means ± standard deviation of three determinations. Values with different superscript letters in the same row are significantly different (P<0.05). X1YC = 180g Àkwiyáa milk/20g C-juice, X2YC = 180g Rago milk/20g C-juice, X1X2YC1 = 180g (50/50) Àkwiyáa and Rago milk/20g C -juice, X1X2YC2 = 180g (60/40) Àkwiyáa and Rago milk/20g C-juice, X1 X2YC3 = 180g (70/30) Àkwiyáa and Rago milk/20g C-Juice, X1X2YC4 = 180g (80/20) Àkwiyáa and Rago milk/20g C-Juice, X1X2Y0 = 180g (50/50) Àkwiyáa and Rago milk/zero C-juice, X0Y0 = 200g cow milk/zero C- juice.

Table 3. Sensory Evaluation of Àkwiyáa, Rago and Cow milk Yoghurts with and without Carrot juice

Parameter	Samples							
	X_1Y_C	X_2Y_C	$X_1X_2YC_1$	$X_1X_2YC_2$	$X_1X_2YC_3$	$X_1X_2YC_4$	$X_1X_2Y_0$	X_0Y_0
Colour	3.53±0.08^a	2.51±0.05^e	1.83±0.01^f	2.61±0.04^d	3.21±0.04^c	3.33±0.06^b	1.82±0.02^f	2.45±0.04^e
Consistency	2.71±0.01^d	2.07±0.06^e	2.81±0.01^c	3.82±0.03^b	1.85±0.01^f	3.94±0.02^a	2.73±0.02^d	2.78±0.02^c
Mouthfeel	2.64±0.02^c	2.23±0.02^e	4.11±0.02^a	4.10±0.00^a	2.51±0.04^d	4.08±0.02^a	3.85±0.05^b	2.60±0.03^c
Flavour	2.32±0.15^d	1.88±0.02^f	2.23±0.03^d	1.90±0.01^e	3.23±0.03^a	2.52±0.03^c	2.82±0.05^b	2.60±0.03^c
Gen.Accept	2.48±0.02^d	1.90±0.01^e	3.03±0.06^c	3.11±0.02^b	1.85±0.01^e	3.16±0.06^b	3.31±0.04^a	2.51±0.02^d

Values are means ± standard deviation of three determinations. Values with different superscript letters in the same row are significantly different (P<0.05). X1YC = 180g Àkwiyàa milk/20g C-juice, X2YC = 180g Rago milk/20g C-juice, X1X2YC1 = 180g (50/50) Àkwiyàa and Rago milk/20g C-juice, X1 X2YC2 = 180g (60/40) Àkwiyàa and Rago milk/20g C-Juice, X1X2YC3 = 180g (70/30) Àkwiyàa and Rago milk/20g C-Juice, X1X2YC4 = 180g(80/20) Àkwiyàa and Rago milk/20g C-Juice, X1X2Y0 =180g (50/50) Àkwiyàa and Rago milk /zero C-juice, X0Y0 =200g cow milk/zero C-juice.

Presented in Table 3 are the results of the sensory evaluation of yoghurts from Àkwiyàa milk (X_1Y_C), Rago milk (X_2Y_C) and their blends, ($X_1X_2Y_{C1}$), ($X_1X_2Y_{C2}$), ($X_1X_2Y_{C3}$) and ($X_1X_2Y_{C4}$) enhanced with carrot juice; also ($X_1X_2Y_0$) and (X_0Y_0) yoghurt samples without carrot juice. Significance was accepted at ($P < 0.05$). The panel ratings were, $X_1X_2Y_{C1}$ (1.83±0.01) and $X_1X_2Y_0$ (1.82±0.02) best in colour, $X_1X_2Y_{C2}$ (2.31±0.02) taste, $X_1X_2Y_{C3}$ (1.85±0.01) consistency, X_2Y_C (2.23±0.02) and (1.88±0.02) mouthfeel and flavor respectively. On general acceptability, the best ratings were obtained in X_2Y_C (1.90±0.01) and $X_1X_2Y_{C3}$ (1.85±0.01).

4. Discussion

The observed differences in the moisture content of the yoghurt samples may be ascribed to the differences in casein-fat ratio values of the different milk used. Casein-fat ratio reported by Mallatou and Pappas [25] for sheep, goat and cow milk showed that the higher the moisture content, the lower the fat content, and vice versa. Of all the sample treatments, highest fat content was observed in yoghurt made from Rago milk with carrot juice (X_2Y_c), and this could be attributed to the lowest moisture content associated with sheep milk as reported by Park et al [26] and Clarence et al [27].

The highest ash content (0.87±0.01 %) also obtained in X_2Y_C was expected since sheep milk contained higher amount of ash than goat or cow milk [25].

However, the ash content of the yoghurt samples produced from Àkwiyáa, Rago and dairy cow milk with and without carrot juice which ranged from 0.77±0.15% to 0.87±0.01% were not significantly different (P<0.05) from each other; again the results agreed with the work of Ozer et al [28], who reported a value of 0.79% for Labnel, a whole cow milk concentrated yoghurt. The amount of carbohydrate (Lactose) in X_2Y_C yoghurt was significantly higher (P<0.05) than the value of X_1Y_C, blends of Àkwiyáa/Rago milks with carrot juice: $X_1X_2Y_{C1}$ to $X_1X_2Y_{C4}$, blend of Àkwiyáa/Rago milk without carrot juice $X_1X_2Y_0$ and the control X_0Y_0 (Table 1). This result was expected since the carbohydrate content of Rago was higher than that of Àkwiyáa and dairy cow milk and the result was in agreement with the work of Bano et al. [7] who also reported higher value of lactose in sheep milk than goat milk. The fibre contents of the yoghurt samples enhanced with carrot (0.45±0.03% – 0.73±0.04%) were significantly higher (P<0.05) than those without carrot (0.13±0.01% – 0.17±0.01%). Incorporation of dietary fibre into yoghurts, other dairy products and jam can modify textural properties, reduce syneresis, and give better mouth feel with increased shelf life of the products [29,30]. A high intake of soluble dietary fibre inhibits absorption of cholesterol and bile acid from the small intestine, thereby reducing blood cholesterol and possibly reducing the risk of developing gallstones [31]. Significant variations in protein content were noticed among the yoghurt samples in this study. These differences were linked to the differences in protein contents of milk from the three different animal species as shown in Table 1. Hardy [3] has also reported that sheep milk is slightly higher in protein content than other forms of milk. Rago milk yoghurt with carrot juice (X_2Y_c) had the highest total solid content among the yoghurt samples. This might be ascribed to the lower moisture but higher fat, protein and carbohydrate contents of Rago milk when compared to Àkwiyáa and cow milk. Bano et al. [7] has also reported that sheep milk contains two times more solids than other forms of milk. This attribute reflected in the firmer consistency and overall acceptability of X_2Y_c and $X_1X_2Y_c$ yoghurt samples compared to that of the control (X_0Y_0). It is also reported that curd stability in yoghurt is one of the most important quality properties and that it is influenced by total solids, protein content and the acidity of yoghurt. Equally, reported as important quality attributes of yoghurt are the rheological properties which are dependent on the content of total solids in milk [32]. The pH values of the yoghurt samples were within the acceptable limits for quality yoghurt; since higher acidity usually stimulates syneresis in yoghurt [33]. The slight differences in the pH values of the yoghurts may be attributed to the lower buffering capacities of Àkwiyáa and Cow milk due to their lower protein content. These results are similar to the works reported by Mallatou and Pappa [25]. Guler- Akin and Akin [34] have also reported that the pH value is inversely proportional to the lactic acid content in yoghurt. The total titratable acidity (TTA) of this work which ranged from 0.78±0.01% to 0.84±0.01% was within acceptable limit. International Dairy Federation has recommended the minimum value of acidity in yoghurt to be 0.70% [35].

The values of the mineral elements obtained in this study showed good levels of availability among the yoghurt samples from all the three ruminants. It was also observed that, increase in the portion of Rago (X_2) milk increased the levels of the mineral elements in the yoghurt samples. This is attributed to the higher level of ash in (X_2)

in relation to (X_1) and (X_0). It may also be accounted for by animal feed, breed, species, stage of lactation, and genetic make-up [36]. It has also been reported that calcium level of mix goat and sheep milk yoghurt increases with increase in sheep milk ratio [37].

The results of the sensory evaluation indicated that, there were significant differences (P<0.05) among parameters and treatments. This can be attributed to variation in levels of different nutrients such as protein, fat, carbohydrate and minerals in the individual samples resulting from material composition. Samples $X_1X_2Y_{C1}$ and $X_1X_2Y_0$ were rated best in colour, $X_1X_2Y_{C2}$ taste, $X_1X_2Y_{C3}$ consistency, X_2Y_C mouthfeel and flavour while sample $X_1X_2Y_{C3}$ was adjudged best in general acceptability.

5. Conclusion

Physicochemical properties of both the treatment samples and the control yoghurt showed high nutritional contents with treatment samples being hihger. Mineral elements of the yoghurt treatments were also significantly higher (P<0.05) than the control. Carrot gave added value to the yoghurt quality by providing fibre and increasing carotene content (phytonutrients) of the products. Sample $X_1X_2Y_{C3}$ (70/30 milk ratio plus 20g carrot) was rated best in general acceptability and therefore recommended for production at both domestic and commercial levels; as this would promote health of the consumers through nutritional and therapeutic properties of the combined milks and the carrot.

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