

Physicochemical and sensory characteristics of yoghurt produced from ewe milk, goat milk and a mixture of ewe and goat milk

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ABSTRACT

Objective: To evaluate the physicochemical and sensory acceptability of yoghurt produced from ewe, goat and a mixture of ewe milk and goat milk in Nigeria in order for the populace to harness the nutritional and therapeutic benefits of the milks.

Methods: Samples of whole cow milk (WCM) as standard, goat milk (GM), ewe milk (EM) and mixture of goat milk and ewe milk (GM/EM) in 1:1 (v/v) ratio, obtained from a local dairy farm were used for yoghurt production. The milk samples were each pasteurized, inoculated with 5g/l of mixed cultures of *L. bulgaricus* and *S. thermophilus*, fermented for 4h at 45°C, homogenized, before sugar and gelatin were added. The yoghurt samples were packed into sterile 200ml air tight plastic container, stored at 0°C for 24h and assayed for pH, titratable acidity, proximate composition, zinc, mg, Fe, Cu and sensory characteristics.

Results: The yoghurt samples produced from GM, EM, and GM/EM had significantly ($P<0.03$) higher values for fat ash, pH, and mineral elements (Fe, Cu), total solids, than the WCM. The protein content of yoghurt from EM and GM/EM samples were significantly higher ($P<0.05$) than the WCM. The yoghurt produced from EM and GM/EM were comparable in all the parameters tested and were significantly ($P<0.05$) rated higher than those of yoghurts produced from WCM and GM, except for color in the case of GM.

Conclusion: GM, EM and GM/EM (1:1 v/v) yoghurt samples had comparable organoleptic rating to the WCM (standard) sample. However, the best rating was obtained for GM/EM and EM yoghurts in terms overall acceptability. Therefore, yoghurt produced from either equal portions of GM/EM or from EM milk would be acceptable to Nigerian consumers such that the nutritional and therapeutic benefits of the milks would be available to the populace.

Key words: Physicochemical and sensory characteristics, yoghurts ewe milk, goat milk, whole cow milk.

INTRODUCTION

Milk is a nutrient dense fluid secreted by the mammary glands, and could be processed into shelf-stable products such as yoghurt, cheese, butter etc. The main source of milk for human consumption in Nigeria is from dairy cow [1]. There is a huge demand for milk and milk products as result of the large population of over 140 million people. However, there is very limited supply of milk from the local dairy farmers in Nigeria resulting in huge expenditure of foreign exchange for milk importation to augment the limited supply. The resultant effect is an increasing cost of dairy products in Nigeria. However, a number of other domesticated ruminants such as goat and ewe (sheep) could be used to provide milk for human consumption as is the case in France and Italy [2]. These ruminants (sheep & goats) are readily available in Nigeria but their milk is not being utilized for human consumption.

Besides taking advantage of inexpensive milk from goat and sheep to meet increase milk demand, the uniqueness

of the milk from these ruminants is of importance to consumer [3]. Goat and ewe milk exceed cow milk significantly in most short, medium chain, monounsaturated, polyunsaturated and essential fatty acids, which are invaluable in maintaining physiological and metabolic activities of today's health conscious consumers [4]. Short chain fatty acids have the little cholesterol effect on human blood levels or formation of plaque in the arteries and they make digestion easier due to smaller fat globules [5].

Three different medium chain fatty acids; Caproic (C_6), Capric (C_{10}) and Caprylic acid (C_8) found in goat milk have health benefits for people with such diseases like cystic fibrosis, gallstones, heart disease and various digestive problems. Goat milk also contains less of the enzyme, xanthine oxidase than cow's milk, which can create scar tissue on the heart when it enters the blood stream, and this in turn causes the body to produce cholesterol for protection that could be precursor to arteriosclerosis [4]. In addition, sheep milk has more

conjugated linoleic acid (CLA) than milk from pigs, cattle and humans [5]. CLA is a cancer-fighting fat-reducing fat. Also goat and sheep milk contain more solids than cow's milk, such that there would be no need to add stabilizer during yoghurt production [6].

Yoghurt is a fermented milk product obtained by lactic acid fermentation through the action of friendly bacteria or true yoghurt cultures: *Lactobacillus bulgaricus* and *streptococcus thermophilus*. The friendly bacteria found in live yoghurt can be used to cure different health problems such as fungal problems of the mouth, tongue and skin due to a reduction in the number of commensal bacteria in the gut, apart from its high nutritional value. The aim of this research work therefore is to evaluate the physicochemical and sensory acceptability of yoghurt produced from ewe, goat and a mixture to ewe and goat milk in Nigeria, in order for consumers to harness the therapeutic and nutritional properties of these milks.

MATERIALS AND METHOD

Samples of Whole Cow Milk (WCM), Goat Milk (GM), Ewe Milk (EM) as well as a mixture of goat and ewe (GM/EM) in a 1:1 (v/v) ratio were obtained from a local dairy farm in Calabar, Nigeria and used for yoghurt production.

Duplicate samples were pasteurized at 65°C for 30min, cooled to 45°C at which they were then inoculated with 5g/l of mixed cultures of *L. bulgaricus* and *S. thermophilus* (Peyma-Chr. Hansen's Turkey). The samples were left to coagulate for 4h after which the yoghurt samples were homogenized using an electric blender (Philips Type, HR28151) with addition of 30g/l sugar (sucrose), and 0.5% dissolved gelatin (stabilizer). The samples were packed into 200ml sterile air tight plastic containers labeled, stored at 0°C and used for analyses within 24h.

The yoghurt samples were analysed for total solids, protein, fat, moisture, pH, ash, mineral elements and organoleptic quality.

Total solids, protein and ash were determined by the AOAC [7] methods. pH was measured using a mettler 320 pH meter (Mettler-Toledo, Halstead, UK). Titratable acidity (as percent lactic acid) and fat were determined by the method of Mistry and Hassan [8]. Trace elements content was determined according to the procedure of AOAC [9] using a Varian Spectra AA-200HT atomic absorption spectrophotometer (Varian, Victoria, Australia). All analyses were made in triplicate. The sensory analysis were carried out by the method of Larmond [9] using a completely randomized multiple comparison hedonic scale involving 9 panelists who were non-smokers that had good sensory acuity and consistency and were very familiar with yoghurt products. The panelists rated the yoghurt samples on a scale of 1-9 for colour, mouth feel, aroma, and consistency, where 1 was extremely better than WCM (standard) and 9 was extremely inferior to WCM. All

samples were served in plastic cups at a temperature of about 10°C. The panelists rinsed their mouth with water in-between samples.

Statistical analysis of the data was made using the analysis of variance (ANOVA) of SPSS program, version 11.5 at 5% confidence level. Duncan's multiple range test was used to determine the level of

Table 1: Physicochemical properties of Yoghurt produced from Goat Milk (GM), Ewe milk (EM) and Goat milk/Ewe milk (GM/EM) and Whole Cow Milk (WCM)

Properties	Yoghurt Samples(mg/100g)*			
	GM	EM	GM/EM	WCM (Reference)
Moisture (%)	87.20 ^a ±0.30	81.25 ^c ±0.05	85.50 ^b ±0.10	87.20 ^a ±0.10
Fat (%)	4.30 ^c ±0.10	6.83 ^a ±0.10	5.58 ^b ±0.02	3.71 ^d ±0.20
Ash (%)	0.82 ^b ±0.12	0.86 ^a ±0.01	0.84 ^b ±0.11	0.73 ^c ±0.03
Carbohydrate (%)	4.37 ^c ±0.02	5.36 ^b ±0.01	3.57 ^d ±0.03	4.93 ^b ±0.04
Protein (%)	3.43 ^c ±0.10	5.70 ^a ±0.20	4.54 ^b ±0.03	3.45 ^c ±0.05
pH	4.37 ^c ±0.01	4.43 ^b ±0.01	4.39 ^b ±0.01	4.25 ^d ±0.01
Titrate acidity (%)	2.21 ^c ±0.30	2.51 ^a ±0.21	2.32 ^b ±0.32	2.15 ^d ±0.20
Total solids (%)	13.56 ^c ±0.02	20.03 ^a ±0.02	16.83 ^b ±0.01	12.70 ^d ±0.10

*Mean values of triplicate determinations
a,b,c,d means in the same column with different superscripts are significantly different (P<0.05)

RESULTS

The physicochemical properties of the yoghurt samples are shown in Table 1. The moisture content of the GM samples ranged from 87.20±0.30 to 81.25±0.05 of percent. The GM yoghurt moisture content was significantly higher (P<0.05) than that from EM and GM/EM, but was similar to that of WCM.

The fat content of the samples ranged from 3.71 ± 0.02 to 6.83 ± 0.10 percent. The fat content of the EM yoghurt was significantly (P<0.05) higher than the others, with the WCM yoghurt having the least value of 3.71± 0.20 percent. The ash content of the samples ranged from 0.73±0.03 percent for WCM yoghurt to 0.86±0.01 percent for EM yoghurt. The values of the ash contents were significantly different (P<0.05).

Table 2: Mineral elements contents of yoghurt produced from Goat Milk (GM), Ewe milk (EM) and Goat milk/Ewe milk (GM/EM) and Whole Cow Milk (WCM)

Properties	Yoghurt Samples (mg/100g)*			
	GM	EM	GM/EM	WCM (Reference)
Potassium	103.92 ^a ±0.03	100.84 ^a ±0.01	105.41 ^a ±0.04	105.41 ^a ±0.04
Magnesium	14.32 ^c ±0.02	17.52 ^b ±0.02	35.22 ^a ±0.05	14.32 ^c ±0.05
Iron	0.05 ^c ±0.04	0.21 ^b ±0.01	0.26 ^b ±0.04	0.04 ^d ±0.01
Zinc	0.42 ^b ±0.04	0.61 ^a ±0.05	0.27 ^c ±0.04	0.42 ^b ±0.02
Copper	0.35 ^c ±0.01	0.55 ^b ±0.03	0.83 ^a ±0.02	0.32 ^d ±0.03

*Mean values of triplicate determinations
a,b,c,d means in the same column with different superscripts are significantly different (P<0.05)

Table 3: Sensory mean scores ratings of yoghurt produced from Goat Milk (GM), Ewe milk (EM) and Goat milk/Ewe milk (GM/EM) and Whole Cow Milk (WCM)

Properties	Yoghurt Samples (mg/100g)*			
	GM	EM	GM/EM	WCM (Reference)
Colour	2.0 ^a	1.8 ^a	1.7 ^a	2.3 ^b
Mouth feel	2.5 ^b	2.0 ^a	2.0 ^a	2.6 ^b
Consistency	2.7 ^c	2.0 ^a	1.8 ^a	2.5 ^b
Taste	2.6 ^b	2.0 ^a	2.0 ^a	2.8 ^b
Aroma	2.5 ^b	1.9 ^a	2.1 ^a	2.7 ^b
Overall acceptability	2.5 ^b	1.9 ^a	1.9 ^a	2.4 ^b

*Mean values of triplicate determinations
a, b, c, d means in the same column with different superscripts are significantly different (P<0.05)

The carbohydrate results showed that EM yoghurt had significantly (P<0.05) higher value, followed by WCM, GM and GM/EM with values of 5.36±0.01, 4.93±0.04, 4.37±0.02 and 3.57±0.03 percent respectively. The values for the protein content of the samples ranged from 3.43±0.10% for GM to 5.70±0.20% percent for EM yoghurt. The EM yoghurt had significantly (P<0.05) higher protein than the other samples; however, there was no significant difference (P<0.05) in the protein value of GM and WCM.

The total solids ranged from 12.70±0.10 to 20.03±0.02 percent. The EM yoghurt had a significantly (P<0.05) higher value of 20.03±0.02 percent, while the WCM sample had the lowest value of 12.70±0.10 percent.

The Reference Sample (WCM) developed the most acid having a significantly lower pH value of 4.25±0.01, while yoghurts made from GM, EM and GM/EM had pH values of 4.37±0.01, 4.43±0.01 and 4.39±0.01 respectively.

Titrate acidity (TA) values ranged from 2.15±0.20 for WCM to 2.51±0.21% lactic acid for EM yoghurt. These values were significantly (P<0.05) different with the Reference (WCM) having the least value of 2.15±0.20% lactic acid.

The results of the mineral composition of the samples are shown in Table 2. The mineral content of the GM/EM sample was significantly higher (P<0.05) in magnesium, iron and copper, with values of 35.22±0.02mg, 0.26±0.04mg and 0.83±0.02mg respectively. The potassium content of GM yoghurt was significantly higher (P<0.05), followed by WCM (Reference), EM and GM/EM yoghurts with values of 201.53±0.03mg, 105.41±0.04mg, 103.53±0.03mg and 100.84±0.01mg respectively. The EM yoghurt was significantly higher (P<0.05) in Zinc than in other samples.

Table 3 shows the organoleptic properties of the yoghurt samples. The colour, mouth feel, consistency, taste, aroma and overall acceptability of EM and GM/EM yoghurts were significantly (P<0.05) rated higher by panelists compared to WCM (Reference) and GM yoghurts.

DISCUSSION

The observed differences in the moisture content may be attributed to the differences in casein: fat ratio values of the different milk used [10]. The casein: fat ratios reported for the different milks were 0.75, 0.64, 0.69 and 0.73 for ewe's, goats, mixed and cow's milk respectively [11]. The result showed that the higher the moisture content, the lower the fat content, and inversely, the lower the moisture content the higher the fat content. This variation in moisture content may be attributable to the reduced hydration of casein as fat content increased. The highest fat values were found in yoghurt made from ewe milk (EM). This is probably due to the compositional variations in the different milk used. The highest ash content was observed in yoghurt made with ewe's milk. This was expected since ewe's milk contains a higher amount of ash than goat's or cow's [12, 13]. Mistry and Hassan [14] reported an ash content of between 0.89% and 1.13% for non-fat skimmed cow milk yoghurt, while Ozer *et al.* [15] reported a value of 0.79% for labneh, a whole cow milk concentrated yoghurt.

Yoghurt produced from EM showed the highest value for carbohydrate content. This was as expected since the carbohydrate content of ewe milk is greater than that of goat's or cow's milk [16]. The values for the carbohydrate content are in agreement with the report of Alichanidis and Polychroniadou [17]

The observed differences in the protein content of the yoghurts in this study may be attributed to the differences in casein: fat ratio values of different milks used [18]. EM yoghurt had the highest value for total solids, and this may have impacted on the EM and GM/EM yoghurts having better consistency and overall acceptability (Table 3). This is in agreement with results of Posati and Orr [16], who reported that sheep milk contain high total solid which resulted in superior yoghurt quality because of its higher yield and firmer processing quality without additives. The result also agrees with the result of Rasic and Kurman [19], who reported that curd stability in yoghurt is one of the most important physical properties and that it is influenced by total solid and protein contents and the acidity of yoghurt. Also Ana *et al.* (2006) reported that the rheological properties of yoghurt were highly dependent on the content of total solids in milk.

The difference in the pH values of the yoghurt might be attributed to the lower buffering capacity of goat's and cow's milk due to its lower protein content (3.43% and 3.35% respectively). These results are in agreement with those reported by Mallatou *et al.* [21] and Mallatou and Pappa [11]. However, the pH values of the samples were within favourable range as higher acidity stimulates syneresis in yoghurt [22].

The mean level of acidity of EM yoghurt was higher than the other samples. This might be due to higher percentage total solids (20.03%) and protein (5.70%) of EM yoghurt. The values of the mineral elements obtained in this study showed an important variability among the yoghurts from the four types of milk as had been reported by Coni *et al.* [23, 24]. This may be

accounted for by animal feeding, environmental condition, time of the year of sample collection and genetic makeup [25]. The results of the sensory evaluation indicated that GM/EM yoghurt had the highest consistency but the value was not significantly ($P < 0.05$) different from the score of EM yoghurt. This may be as a result of the higher total solids and protein content (Table 1) of EM and GM/EM yoghurts respectively which therefore resulted in firmer consistency. This results is in agreement with the report of Guven *et al.* [26] who reported that the high level of consistency of yoghurt type was due to its protein quality. The firmer consistency of EM and GM/EM yoghurt may have contributed to the highest overall acceptability scores of the samples. Guven *et al.* [26] reported that curd stability in yoghurt is one of its most important physical properties. However, it is significant to note that there was no significant ($P < 0.05$) differences in the ratings for yoghurts made from GM and the WCM (Reference) in the colour, mouth feel, taste, aroma and overall acceptability. These results indicate that acceptable yoghurts could be produced from GM, EM as well as from mixtures of GM/EM. The significantly ($P < 0.05$) high taste ratings of EM and GM/EM yoghurts could be attributed to the presence of essential nutrients required to generate acids [27] and therefore resulted in yoghurts with distinctive and characteristic sharp and acidic taste [28]. In addition, Taste is a combination of flavor and aroma and yoghurt flavour is formed by volatile components via the fermentation and/or thermal degradation of some milk constituents. Kirdar *et al.* [29] reported that one of the most important aroma compounds in yoghurts which influenced taste was acetaldehyde. The high taste score of the EM and GM/EM yoghurts may be due to the adequate production of acetaldehyde.

CONCLUSION

The results showed that GM, EM and GM/EM (1L1 v/v) yoghurt samples had comparable organoleptic ratings to the WCM (Reference) sample. However, the best rating was obtained for GM/EM and EM yoghurts in terms of overall acceptability. Therefore, the use of a mixture of GM/EM for yoghurt production is recommended as it would be acceptable to consumers in order to harness the therapeutic and nutritional properties of goat and ewe milk.

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