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# ASSESSMENT OF THE QUALITY OF YOGHURT PRODUCED FROM GOAT MILK USING NATURAL AND ARTIFICIAL STARTER CULTURE AS A FUNCTION OF STORAGE TIME

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## ABSTRACT

This study assessed the quality of yoghurt produced from goat milk using natural and artificial starter cultures. It determined its physicochemical [total solids, ash, protein, fat, pH, and Lactic Acid Bacteria], antioxidant [total phenolic content, tannin, phosphomolybdate assay, and vitamin C of milk], and mineral composition [calcium, zinc, phosphorus, potassium, and sodium] within 28-day duration of storage. The study revealed that those yoghurts produced from goat milk using natural starter cultures exhibited the highest Total solids TS [13.95 %], Total Ash TAC [0.69 %], Oil [5.3 %], Protein [3.31 %], pH [4.96 %], and Lactic Acid [1.07 %] at day 1. Also, yoghurts produced from natural culture starter exhibited higher phenol [0.125 g/L], phosphomolybdate [0.082 g/L], and Tannin [0.082 g/L]; while the one with artificial starter culture had higher Vitamin C [7.56 g/L] content. The yoghurts produced using natural starters were observed to have the best mineral contents [Phosphorus: 0.234 g/L, Potassium: 1.050 g/L, Sodium: 1.450 g/L, Zinc: 0.101 g/L and Calcium 0.697 g/L]. Yoghurts produced using artificial starter culture showed higher nutritional contents at a storage duration of 28 days. Natural starter culture yoghurt exhibited the best physicochemical properties and mineral composition. While yoghurts from artificial starter culture performed exhibited better storage capability and stability of shelf life. Certain fruits and mostly citrus can be employed to improve the shelf-life of yoghurt samples as well as their nutritional composition.

**Keywords***:* Goat milk, artificial and natural starter cultured yoghurt, physicochemical analysis, antioxidant capacity, essential minerals and shelf life.

## INTRODUCTION

Dairy products provide the most important amino acid required for the body. Presently there is a perception that food production may not be enough to feed the teaming population and ensure maximum food security for all [4]. Despite Nigeria's agricultural potential to ensure food security for all, there is still insufficient food production. Over time there has been the inability to feed on the right portion of calories by most households. Animal protein consumption is not commensurate with the recommended intake by nutritionists [10].

Yoghurt is globally regarded as a dairy product, which combines unique nutritional values with



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**the** promotion of good health, heart functions, and natural immune defense in humans [10]. It is produced from milk fermented by *Lactobacillus Bulgaricus* and *Streptococcus thermophilus* working together symbiotically [30]. During fermentation of milk, lactic acid bacteria [LAB] utilize lactose and nitrogenous compounds leading to the production of extracellular lactic acid and various other primary metabolites that provoke acidification of the medium. [2]. In the acidic medium, the net negative charge on casein micelles decreases, thereby reducing electrostatic repulsion between charged groups causing coagulation and destabilization of the casein micelles and the conversion of the fluid milk into a viscoelastic gel [15]. These changes greatly influence the physicochemical characteristics and consumers' acceptability of yoghurt. While the texture components of yoghurt can be maintained and improved by optimizing the production process, the flavour, shelf-life, and health benefits can be modified or enhanced by the utilization of additives [15].

The fact that the Northern part of Nigeria is the major producer of livestock makes the assessment of antioxidants, physico-chemicals, and mineral contents on the quality of yoghurt produced from goats present in Northern Nigeria using different starter cultural methods of great nutritional and economic relevance.

In this study, yoghurts from goat milk were prepared with natural and artificial starter cultures and assessed for their physicochemical characteristics, as well as antioxidants and mineral composition.

## MATERIALS AND METHODS

### *Materials and Solvents*

All solvents used in this study were of analytical grade. They include concentrated $H_2SO_4$, 40% NaOH, 2 % $H_3BO_3$, HCl [0.02M] solution, $Na_2SO_4$, $CuSO_4$, methyl red, n – Amyl alcohol, Folincalteous reagent, 17% $Na_2CO_3$, Fresh goat milk samples, Starter cultures [artificial and/or natural], Gallic acid solutions of known concentrations, Standard solutions of ascorbic acid and Standard solutions of tannic acid. The apparatus used includes a weighing balance, furnace, oven, porcelain, the sintered crucible, desiccators, macro Kjeldahl digestion apparatus, micro steam distillation apparatus, uv /visible spectrophotometer visible, hot plate, thermometer, and Soxhlet extraction apparatus.

### *Methods*

### *Milk Collection and Preservation*

Fresh goat milk sample was collected from goat farms in the National Animal Production Research Institute [NAPRI], Ahmadu Bello University, Zaria-Kaduna State. The milk sample was kept in an ice box to protect it from fermentation.

### *Preparation of the natural starter culture*



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A 1000 $cm^3$ amount of the collected milk was boiled and cooled and then poured into a small bowl. A teaspoon of the lemon juice was added to the milk and the mixture was kept for [15-20 hours] in a warm place until it thickened [13].

***Sample Preparation***

Artificial starter and natural starter cultures [containing lime and milk from the goat culture] were used for the production of yoghurt based on the procedure provided by the literature [5]. The milk was heated at a temperature of 63°C for about 30 minutes to destroy pathogens and organisms in the milk, provide a cleaner medium in which the desired organism can be established, remove air from milk, and denature the whey proteins which increase the viscosity of the product.

The heated milk was then immediately immersed in a basin of cold water to bring the milk temperature to 42 $^oC$. The pasteurized milk samples were then mixed with 2.5 % of starter culture 2.5 % in a ratio of 2:1 [*Lactobacillus bulgaricus* and *Streptococcus thermophilus*] and stirred properly until the pH reached 4.7. The milk was then left to coagulate for 3 hours at 42 $^oC$

Each production was stored in a well-labeled sampling bottle for 28 days at 4°C. The yoghurt samples were labeled COYA [yoghurt from goat milk using artificial starter culture] and COYN [yoghurt of goat milk using natural starter culture].

***Physicochemical Analysis***

***Determination of Total Solid Content of Yoghurt:***

Total solid in yoghurt from goat milk samples of natural and artificial starter culture was determined gravimetrically [19] as seen in equation 1.

$$\% \text{ Total Solid} = \frac{W2 - W1}{W} \quad \text{--------------} \quad [1]$$

$W_1$ = the weight in gram of empty crucible

$W_2$ = the weight in gram of crucible + residue

W = the weight in gram of the sample used

***Determination of Total Ash Content of Yoghurt***

The amount of ash on the yoghurt samples from goat milk samples of natural and artificial starter culture was determined using gravimetrically according to the nutritionist [3] as seen in equation 2.

$$\% \text{ Ash} = \frac{W2-W1}{W} \times 100 \quad \text{------------} \quad [2]$$

$W_1$ = the weight in grams of empty crucible

$W_2$ = the weight in grams of crucible + ash

W = the weight in grams of the sample

***Determination of Protein Content of Yoghurt***

The protein content of the yoghurt was determined according to Nutritionists [18]. The amount of nitrogen in the yoghurt from goat milk samples of natural and artificial starter culture was determined by the Kjeldahl method and the



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values obtained were multiplied by the factor of 6.38 to determine the composition of protein.

The total percentage of nitrogen by weight [on a moisture–free basis] was calculated according to equation 3 and the percentage of crude protein according to equation 3.

$$\% \text{ Nitrogen} = \frac{(T-B)\times N\times 14.007}{Volume\ of\ sample\ [ml]} \quad \text{---------} [3]$$

Where;

T – Titration volume of sample [ml]

B - Titration volume of blank

N – Normality of acid to 4 place decimals

14.007 = Relative molecular weight.

% Crude Protein = % Nitrogen × 6.38 ------------- [4]

Where;

6.38 = Nitrogen conversion factor.

***Determination of Fat Content of Yoghurt***

The fat contents of the yoghurt from goat milk samples of natural and artificial starter cultures were determined by using the Rose Gottlieb method described by the Nutritionists [20]. The percentage of Fat content was calculated according to Equation 4.

$$\% \text{ Fat} = \frac{Weight\ of\ extracted\ fat\ [g]}{Original\ weight\ of\ sample\ used\ [g]} \quad \text{------} [5]$$

***Determination of pH of Yoghurt Sample***

The pH meter [Mettler Toledo seven2go, Germany] was used to measure the pH of Yoghurt from goat milk samples of natural and artificial starter culture samples [1].

***Determination of Lactic Acid of Yoghurt Sample***

The lactic acid of the samples was determined by the method [28]. The percentage of titratable acid as lactic acid was calculated using Equation 6;

$$\% \text{ Lactic acid} = \frac{9\times A\times N}{\text{Sample weight}} \times 100 \quad \text{-----} [6]$$

***Antioxidants Analysis***

***Determination of Total Phenolic Content***

The total phenolic content of yoghurt produced from goat, goat, and sheep milk using natural and artificial starter culture was determined by the spectrophotometric method [13]

10 $cm^3$ of the milk sample was placed in a beaker; 10 $cm^3$ of distilled water was added. The mixture was heated up on a hot plate for 5 mins. The mixture was filtered into a 50 $cm^3$ volumetric flask with the help of filter paper; the filtrate was made up to the mark with distilled water. This was then reserved for phenol analysis.

***Determination of Ascorbic Acid Analysis [Vitamin C] by Iodine Titration***

The titrimetric 2,6-dichlorophenolindophenol technique was used to determine the vitamin C concentration. The method's fundamental principle was to use a 2 % oxalic acid solution to extract the ascorbic acid from the test sample,



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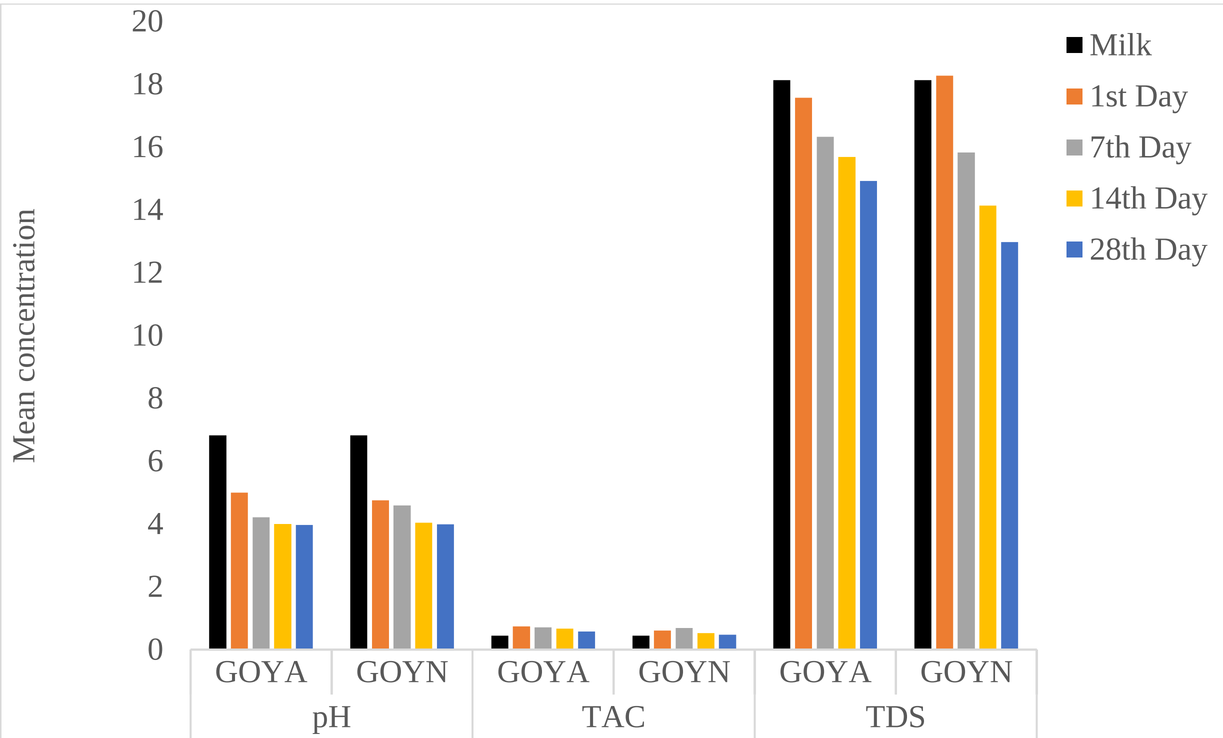
then titrate with 2,6-dichlorophenolindophenol until a pale pink colour appeared [21].

***Mineral Composition Analysis***

The Phosphorus composition of the milk and yoghurt samples was determined by colorimetry [18]. Potassium and Sodium composition were determined using atomic emission spectroscopy [5], while the Calcium and Zinc composition of the milk and yoghurt samples were determined using atomic adsorption spectrophotometry.

## RESULTS AND DISCUSSION




| | pH GOYA | pH GOYN | TAC GOYA | TAC GOYN | TDS GOYA | TDS GOYN |
|---|---|---|---|---|---|---|
| Milk | 6.82 | 6.82 | 0.44 | 0.44 | 18.13 | 18.13 |
| 1st Day | 5 | 4.75 | 0.74 | 0.61 | 17.57 | 18.27 |
| 7th Day | 4.21 | 4.59 | 0.71 | 0.69 | 16.33 | 15.83 |
| 14th Day | 4 | 4.04 | 0.67 | 0.52 | 15.68 | 14.14 |
| 28th Day | 3.97 | 3.99 | 0.58 | 0.47 | 14.92 | 12.97 |

**Figure 1. Physicochemical properties of the goat milk and prepared yoghurt samples [Total Ash content – TAC, TDS - Total Dissolved Solids]**

Total Solid content shows the total amount of dissolved solids that may have resulted from producing metabolites in the form of lactic acid during the fermentation process. It also considers the amount of sugar and organic matter present in the yoghurt sample. Generally, the higher the total solid content the better the sensory attributes and acceptability of the yogurt produced. The



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total dissolved solid of the yoghurt samples prepared by artificial starter culture was observed to decrease after fermentation had taken place as opposed to the yoghurt samples prepared by natural starter culture as presented in Figure 1. The total ash content of both cultures was however observed to increase after fermentation as shown in Figure 1. [12], the fermentation process produces metabolites in the form of lactic acid. The amounts of total sugar, lactic acid, and organic acids are calculated as total dissolved solids since these metabolites would be released from the cell and build up in the fermentation fluid. The decrease in GOYA could be due to the influence of other components already present in the artificial starter culture.

During storage, the total solids and ash content of the yoghurt samples were also observed to decrease except for the ash content in GOYA, which had a slight increase after 7 days before slightly decreasing. A significant increase in total solids during storage was also observed which aligns with the literature [7] before declining after 21 days [11.29 – 11.58 %]. This increase could be due to the loss of $CO_2$ and water during the charring of yoghurt samples. In comparison, GOYN had a higher percentage of total solids, while GOYA had a higher percentage of total ash. GOYA also retained a higher percentage of solids and ash during storage compared to GOYN. The total ash content obtained was lower than those obtained in [19]., while the total content obtained was observed to be higher than those obtained in [7] [11.29 %]. The ash content is essential for the yoghurts longevity and nutrition through storage. pH is an essential analysis in yoghurt assessment. It shows the effect of the fermentation process with the increased acid content of the yoghurt sample in the form of lactic acid and formic acid. pH of the goat milk sample declined sharply after fermentation as shown in Figure 2. GOYN was the least acidic on the 1$^{st}$ day [pH = 4.75] but the most acidic after 28 days. This could be due to the conversion of lactose to lactic acid. During fermentation, *S. thermophilus* produces lactic acid and formic acid which activates the growth of *L.bulgaricus* that produces diacetyl and acetaldehyde. These compounds were reported to give the typical yoghurt flavor [Liu *et al*., 2022]. The pH values obtained were higher than those reported in *[*7] [4.35] and lower than those reported in [29] but were closely similar to those obtained in [14].



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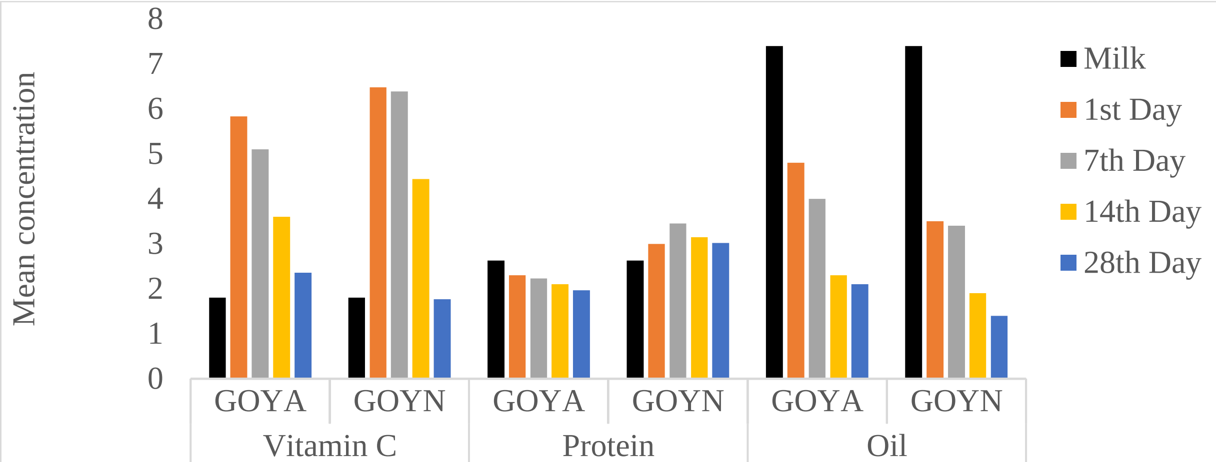


| | GOYA | GOYN | GOYA | GOYN | GOYA | GOYN |
|---|---|---|---|---|---|---|
| | Vitamin C | | Protein | | Oil | |
| Milk | 1.806 | 1.806 | 2.63 | 2.63 | 7.4 | 7.4 |
| 1st Day | 5.83 | 6.48 | 2.3 | 3 | 4.8 | 3.5 |
| 7th Day | 5.1 | 6.39 | 2.23 | 3.45 | 4 | 3.4 |
| 14th Day | 3.6 | 4.44 | 2.1 | 3.15 | 2.3 | 1.9 |
| 28th Day | 2.36 | 1.77 | 1.97 | 3.02 | 2.1 | 1.4 |

**Figure 2. Physicochemical properties and Vitamin C content of the goat milk and prepared yoghurt samples**

Oil or fat content explains the viscosity and relative particle size of the yoghurt. It is also an essential analysis to determine the acceptability of yoghurt. Fatty acids also have good nutritional values. The oil content of the yoghurt samples decreased drastically after fermentation, while protein content was observed to slightly increase when compared to the milk sample as shown in Figure 2. The decrease in fat content in yoghurt produced by starter culture [*Lactobacillus bulgaricus* and Streptococcus] as starter culture was due to the hydrolysis of lipids during fermentation [9].

During storage, a steady decline in the oil content of both yoghurt samples continued for 28 days. also observed a steady decrease in fat content from day 1 to day 28 [3.70 – 3.61%] [7]. However, an exception was observed in the percentage protein of GOYN, which showed a slight increase from day 1 to day 7 before gradually decreasing till the 28$^{th}$ day as shown in Figure 1. Mituniewicz-Małek *et al*. [2022] reported a higher fat content but a lower protein content than those obtained in these studies.

Vitamin C was observed to be higher in milk samples than yoghurt samples [Figure 2]. This was accompanied by a steady decrease during storage. GOYN showed higher values of Vitamin C than GOYA. The concentration of vitamin C in milk obtained in this study was within the range of those reported in [23]. [6] reported higher concentrations of vitamin C in yoghurts produced from goat milk with fruit additives [3.68 – 25.77 mg/100g], however, the yoghurt with Aronia additive was observed to exhibit lower Vitamin C



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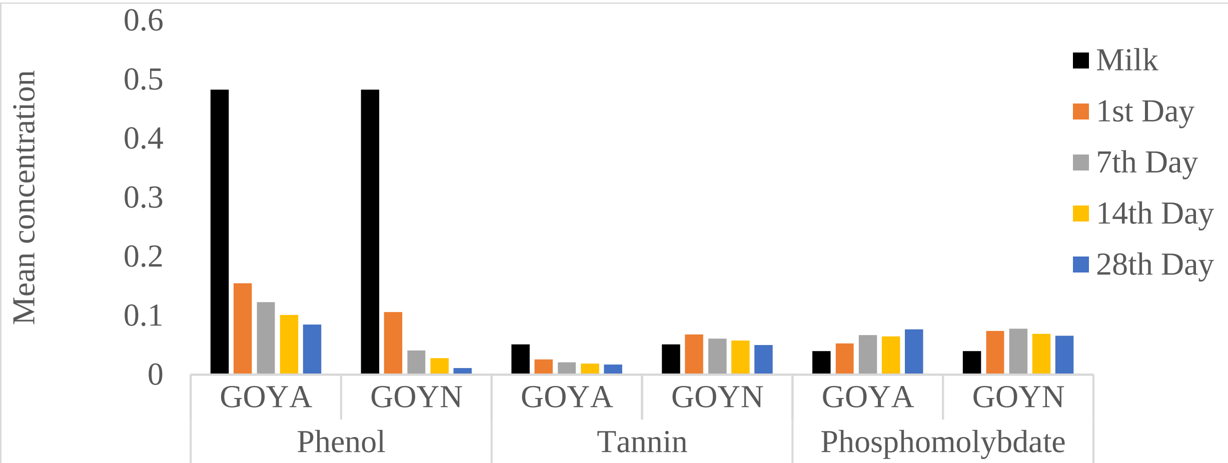
content [0.86 mg/100g] when compared with those reported in this study [5.86 – 6.48 mg/100g]. Vitamin C aids in the body's absorption of iron and calcium and stimulates the oxidation process, collagen production, and adrenal function. In addition, it aids in vitamin E regeneration [20].




| | Phenol GOYA | Phenol GOYN | Tannin GOYA | Tannin GOYN | Phosphomolybdate GOYA | Phosphomolybdate GOYN |
|---|---|---|---|---|---|---|
| Milk | 0.483 | 0.483 | 0.051 | 0.051 | 0.04 | 0.04 |
| 1st Day | 0.155 | 0.106 | 0.026 | 0.068 | 0.053 | 0.074 |
| 7th Day | 0.123 | 0.041 | 0.021 | 0.061 | 0.067 | 0.078 |
| 14th Day | 0.101 | 0.028 | 0.019 | 0.058 | 0.065 | 0.069 |
| 28th Day | 0.085 | 0.011 | 0.017 | 0.05 | 0.077 | 0.066 |

**Figure 3. Antioxidant concentration of the milk and prepared yoghurt samples**

The Total Phenolic Content of the yoghurt samples exhibited a sharp decrease after fermentation and a constant decline through 28 days. All yogurts' capacity to maintain phenolic compounds is significantly impacted by storage time [27]. They investigated four grape varieties in yogurt as additives, and [24], where they examined yoghurts made from goat and cow milk, yielded similar findings. The degradation of milk proteins during the yogurt bacteria's proteolytic activity, which releases some phenolic compounds like phenolic acids, flavonoids, and bioflavonoids in components of the natural and artificial milk protein, could account for the differences in phenolic content between the yogurt samples [22].

Tannins represent the presence of anti-nutritional factors, even though they do not cause significant harm, they can be problematic to people with iron deficiency as they easily bind with iron present in foods rendering them unavailable for adsorption. Consequently, they affect the overall acceptability of yoghurts produced. GOYA exhibited extremely lower values of tannin after fermentation while GOYN showed a slight increase as shown in Figure 3. Both samples showed a steady decrease in tannin during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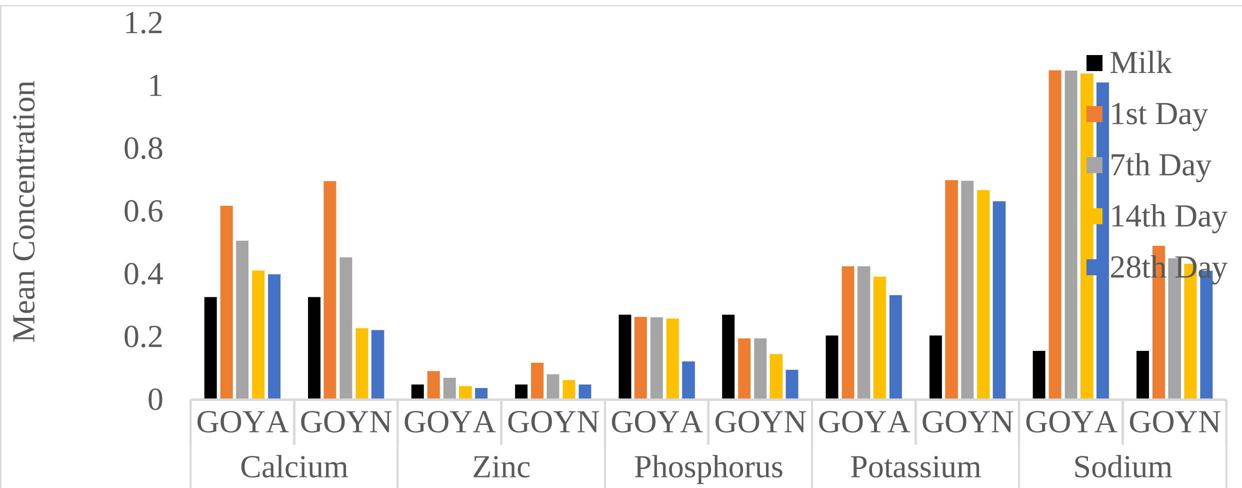
storage. Phosphomolybdate assay was also observed to slightly increase after fermentation. However, while the phosphomolybdate assay for GOYA increased slightly during storage GOYN decreased gradually during storage and increased slightly for 28 days. This implies that GOYA performed better than GOYN during storage as phosphomolybdates help to prevent oxidation of fats and oils and extend the dairy products' shelf life. The variation in phosphomolybdate concentration may result from the fact that several conditions, including temperature, pH, and enzymes, can influence antioxidants [10].




| | Calcium GOYA | Calcium GOYN | Zinc GOYA | Zinc GOYN | Phosphorus GOYA | Phosphorus GOYN | Potassium GOYA | Potassium GOYN | Sodium GOYA | Sodium GOYN |
|---|---|---|---|---|---|---|---|---|---|---|
| Milk | 0.327 | 0.327 | 0.048 | 0.048 | 0.271 | 0.271 | 0.204 | 0.204 | 0.155 | 0.155 |
| 1st Day | 0.618 | 0.697 | 0.091 | 0.118 | 0.264 | 0.195 | 0.425 | 0.7 | 1.05 | 0.49 |
| 7th Day | 0.507 | 0.454 | 0.07 | 0.081 | 0.263 | 0.195 | 0.425 | 0.698 | 1.049 | 0.45 |
| 14th Day | 0.412 | 0.228 | 0.043 | 0.063 | 0.259 | 0.145 | 0.392 | 0.668 | 1.039 | 0.433 |
| 28th Day | 0.399 | 0.222 | 0.037 | 0.048 | 0.122 | 0.095 | 0.333 | 0.632 | 1.011 | 0.411 |

**Figure 4. Mineral content of goat milk and prepared yoghurt samples**

Minerals are basically concerned with the nutritional value of the yoghurt produced. These minerals such as [Calcium, Potassium, Phosphorus, Zinc and Sodium] are essential in maintaining bone density as well as healthy living. Yoghurt products with high mineral composition are advised to help prevent osteoporosis [weak bones].

Potassium, Zinc, Calcium, and Sodium were observed to be higher in yoghurt samples than in milk samples except for phosphorus. The mineral composition was also observed to decrease gradually during storage. GOYN contained higher mineral concentrations than the GOYA in day one except for Phosphorus and Sodium. [26] reported a higher average value for Calcium [1.455 g/L], and Phosphorus [1.05 g/L], but lower values for Potassium [0.511 g/L], Sodium [0.515 g/L], and Zinc [0.37 mg/100g] for yoghurt from natural starter culture.



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***Analysis of Variance [ANOVA] of Assessed Properties***

Table 1. Analysis of Variance of the assessed properties of goat milk and yoghurt samples

| ANOVA | | | | | |
|---|---|---|---|---|---|
| | Sum of Squares | df | Mean Square | F | Sig. |
| Total Solids | 52.43 | 8 | 6.553 | 318811.06 | 0.000 |
| Total Ash | 0.19 | 8 | 0.023 | 1195.47 | 0.000 |
| Oil | 54.99 | 8 | 6.874 | 26578.94 | 0.000 |
| Protein | 4.41 | 8 | 0.551 | 36616.84 | 0.000 |
| pH | 13.53 | 8 | 1.691 | 3823.54 | 0.000 |
| Lactic Acid | 3.19 | 8 | 0.399 | 34046.99 | 0.000 |
| Phenol | 0.32 | 8 | 0.040 | 139437418.07 | 0.000 |
| Vitamin C | 57.82 | 8 | 7.228 | 199237.35 | 0.000 |
| Tannin | 0.01 | 8 | 0.001 | 448.48 | 0.000 |
| Phosphomolybdate | 0.00 | 8 | 0.000 | 675.13 | 0.000 |
| Phosphorus | 11.10 | 8 | 1.387 | 499346407.40 | 0.000 |
| Potassium | 0.53 | 8 | 0.066 | 139352.69 | 0.000 |
| Sodium | 2.02 | 8 | 0.252 | 623026.83 | 0.000 |
| Calcium | 0.42 | 8 | 0.052 | 191851.43 | 0.000 |
| Zinc | 0.01 | 8 | 0.001 | 85166.01 | 0.000 |

The ANOVA results presented in Table 1. indicated no significant differences between the goat milk and the yoghurt produced with artificial and natural starter cultures throughout the time of storage for all the assessed properties. This shows that there was a significant change in the properties of milk after fermentation and storage significantly impacted the properties of the yoghurts.

## CONCLUSION

In this study to assess the physicochemical and antioxidant properties and mineral composition of goat milk yoghurt from natural and artificial starters, it was observed that yoghurts produced from a natural starter culture exhibited the best physicochemical properties and mineral composition. While yoghurts from artificial starter culture performed exhibited better storage capability and stability of shelf life. The acceptability of yoghurt products and their storage potential are very important factors to consider in the production of yoghurts. Certain additives can be employed to improve the shelf-life of yoghurt samples as well as their nutritional composition.



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**Data availability**

All data analysed during this research are included in this article.

**DECLARATION**

J. O. Ayodele on behalf of the authors states that there is no conflict of interest

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