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Comparative Analysis of Nutritional, Physicochemical, Antioxidant, and Microbial Properties of Cattle, Sheep and Goat Milk

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ABSTRACT

This study examined the nutritional, physicochemical, antioxidant, and microbiological characteristics of milk from cattle, sheep, and goats at the Federal University Wukari Teaching and Research Farm in Taraba State, Nigeria. Milk samples of each species of animal were obtained once from five healthy lactating animals of each species. The lactating animals were randomly selected from each species. Significant variations in nutritional composition were found in the study; the highest total protein level (6.02%) was found in sheep milk, which was followed by goat milk (4.38%) and cattle milk (3.54%). Goat milk had the greatest levels of both fat (4.78%) and lactose (4.88%). Cattle milk had the highest solid non-fat (SNF) percentage (8.354%) and total solid content (17.194%). Cattle and goat milk had significantly ($p<0.05$) higher pH values (6.79 and 6.50, respectively) than sheep milk (5.52). According to antioxidant characteristics, goat milk had the highest superoxide dismutase activity (4.158 IU/L), while cattle milk had significantly ($p<0.05$) higher amounts of glutathione peroxidase (270.84 IU/L) and catalase (0.846 IU/L). Goat milk exhibits a distinct advantage in superoxide dismutase activity. Furthermore, total coliforms also differ significantly ($p<0.05$) in cattle milk (37.93×10^2 CFU/100 ml), while E. coli levels were significantly higher ($p<0.05$) in sheep milk (1.40 CFU/100 ml). Based on the result of this study consumer and commercial dairy processors can decide on the type of milk to patronize based on safety, health, and nutritional factors. Further research needs to be conducted with a larger sample size to reduce random error.

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INTRODUCTION

As a staple diet all over the world, milk is a nutrient-dense food item that offers vital proteins, lipids, vitamins, and minerals (Muehlhoff, et al., 2013). Depending on the species of the animal, breed, genetic composition and other environmental factors, milk's nutritional makeup and health advantages differ greatly (Kebede, 2018). The most widely consumed milks are those from cattle, sheep, and goats (Roy et al., 2020). Their distinct nutritional, physicochemical, antioxidant, and microbiological qualities add to their significance in human diets. Optimizing the usage of milk for various nutritional demands, processing techniques, and shelf-life requirements requires an understanding of these characteristics (Haenlein and Wendorff, 2006). The nutrients found in milk, such as proteins and lipids. which give off energy and support a number of body processes, are frequently used to assess the quality of milk. For instance, cattle milk is a staple in many areas, mainly due to its moderate protein level and relatively high lactose concentration (Kumar et al., 2012). In contrast, goat milk has a lower lactose content, which makes it a desirable choice for people who are lactose intolerant (Gül et al, 2018; ALKaisy et al., 2023). It is also well-known for having a unique fatty acid composition that may be good for the heart (Park et al., 2007). Because of its high protein and fat content, sheep milk is frequently chosen for manufacturing cheese and is especially important in Middle Eastern and Mediterranean diets (Kevin, 2006). Different species have different nutritional profiles because of things like genetic composition, food, and environmental influences. According to recent studies by Stobiecka et al. (2022), sheep milk has a higher total protein and fat content than goat and cattle milk, which improves its suitability for dairy products that need to have a thicker consistency, such as yoghurt and cheese. Despite having less protein content, goat milk has medium-chain fatty acids that are easier to digest and may have metabolic advantages (Morand-Fehr and Sauvant 1978). The physicochemical characteristics of milk, including its density, pH, and refractive index, are also crucial quality indicators, especially when it comes to processing and storage (Aguirre et al., 2009). Compared to cow and goat milk, sheep milk often has a lower pH, which adds to its inherent acidity and makes it useful for some fermentation processes (Park et al., 2007). Similarly, cattle milk has a higher solid non-fat (SNF) content, which comprises protein, lactose, and minerals (Roy et al., 2020). This gives the milk a firm consistency that facilitates pasteurization and other thermal operations (Kumar et al., 2012). These characteristics are essential for preserving the flavour and stability of milk, especially in raw and minimally processed milk products. Milk's antioxidants, which include enzymes like glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD), help to neutralize free radicals and lessen oxidative stress. Chronic diseases are known to be caused by oxidative stress, and diets high in antioxidants have been associated with lower risks of cancer, heart disease, and problems connected to inflammation (Muscolo et al., 2024). Goat milk is a good choice for those with inflammatory diseases because of its high SOD activity, which may offer further anti-inflammatory advantages (Haenlein and Wendorff, 2006). However, sheep milk's antioxidant profile improves its shelf-life stability by reducing lipid peroxidation, while cattle milk's high catalase levels help neutralize hydrogen peroxide and shield cells from oxidative damage (Kevin, 2006). Each species has a different amount of antioxidants in their milk, and factors like nutrition and lactation time affect this. According to research, grazing animals' milk frequently contains higher levels of antioxidants because the plant chemicals in their food are transferred to the milk (Kumar et al., 2012). Understanding these differences is essential for providing milk products that satisfy the demands of the health-conscious market, especially in light of the increased consumer interest in foods high in antioxidants. Another important element influencing milk's safety and shelf life is its microbial makeup. The incidence of contaminants including coliform bacteria and Escherichia coli, which are significant concerns in raw milk, might vary based on species and milking procedures (Stobiecka et al., 2022). Possibly because of their varied farming conditions and methods of milking, goat and sheep milk frequently exhibit higher microbial loads than cattle milk. Goat and sheep milk with higher microbial loads may require more pasteurization to guarantee safety, particularly for vulnerable groups like small children and the elderly (Morand-Fehr and Sauvant 1978). Another important factor to take into account is fungus contamination, especially for milk that is kept in warm, humid environments. Milk can become spoiled by fungi, which lowers its market value and shelf life. In areas with limited access to refrigeration, goat milk may be preferred due to its generally lower fungus counts (Zahra and Yodallahi, 2008). To guarantee the safety and quality of milk across species, effective microbial control techniques are crucial, including pasteurization, refrigeration, and good milking hygiene practices. A thorough grasp of the health advantages, processing requirements, and safety concerns of milk from cattle, sheep, and goats can be obtained by assessing its nutritional, physicochemical, antioxidant, and microbiological qualities. Understanding species-specific characteristics can help improve dairy processing methods and encourage consumer choice as consumer preferences continue to change, especially with a focus on minimally processed and health-conscious goods. These findings can be used in future milk product research and development to produce species-specific, customized dairy products that satisfy a range of dietary and health needs (Park et al., 2007). Therefore, this study investigated the comparative analysis of nutritional, physicochemical, antioxidant, and microbial properties of cattle, sheep and goat Milk. And to test the hypothesis that species has an effect on the nutritional, physicochemical, antioxidant, and microbial properties of their milk.

MATERIALS AND METHODS

Ethical consideration statement and approval for this study

This research was conducted with approval from the ethical committee of the Department of Animal Production and Health, Faculty of Agriculture, Federal University Wukari, and the research was conducted with strict adherence to ethical guidelines and best practices.

Location of the Study

The study was carried out at the Teaching and Research Farm of Federal University Wukari, Taraba State (Lat. 7^o 50′N and Long. 9^o 46′ E). The farm is at an elevation of between 159 to 166 meters above sea level. Wukari is situated within the Southern Guinea Savanna zone of Nigeria. It is characterized by distinct rainy (March – October) and dry (November February) seasons. The annual rainfall averages around 1,205 mm (World Atlas and Climate Data Organisation, 2015).

Sample Collection

Milk samples were collected from 5 healthy cows, 5 healthy sheep, and 5 healthy goats. All experimental animals were housed under similar environmental conditions at the Federal University Wukari Teaching and Research Farm. Approximately 50 ml of fresh milk was collected from each animal in sterile containers and transported to the laboratory under refrigeration conditions (4°C) and analyzed within 24 hours.

Nutritional Properties

Nutritional parameters such as casein content, total fat content, and ash content were determined using the Kjeldahl method, following the AOAC official methods (AOAC, 2000). The pH of the milk samples was measured using a calibrated digital pH meter (Vivosun PH007, China). Lactose content was determined using the enzymatic hydrolysis method, where lactose is converted to glucose and galactose, and glucose concentration is measured using a glucose oxidase-peroxidase kit Sigma-Aldrich, St. Louis, MO, USA) as described by (Lynch et al., 2007).

Physicochemical Properties

The physicochemical parameters, such as the refractive index, of the milk samples were measured using an Abbe refractometer at 20 °C as described by Jensen (2015). Total titratable acidity was measured by titrating the milk samples with 0.1 N NaOH to a phenolphthalein endpoint (pH 8.3) and expressed as a percentage of lactic acid (AOAC, 2000). The density of the milk samples was determined using a lactometer at

20 °C. The specific gravity was calculated from the lactometer reading, considering temperature correction factors (Varnam and Sutherland, 2001).

Solid-Non-Fats (SNF) and Total Solids

Solid-non-fats (SNF) content was calculated using the formula:

$$SNF = \frac{100 \times Density - (0.2 \times fat)}{0.25}$$

Total solids were measured by evaporating the milk samples to dryness in an oven at 100°C and weighing the residue (AOAC, 2000).

Antioxidant Properties

Antioxidant properties of fresh milk from cattle, sheep, and goats, such as glutathione peroxidase (GPx) activity, were measured using a spectrophotometric assay (Janway® 640, UV/vis, USA), where the oxidation of NADPH to NADP+ was monitored at 340 nm in the presence of glutathione, glutathione reductase, and hydrogen peroxide (Flohé and Günzler, 1984). Superoxide Dismutase (SOD) activity was determined using the nitroblue tetrazolium (NBT) reduction method. The inhibition of NBT reduction by SOD was measured at 560 nm (Marklund and Marklund, 1974). Glutamine Transferase Activity was measured using a colorimetric assay (Parr 6100 colorimeter, USA), where the conversion of glutamine to glutamate was monitored by the increase in absorbance at 340 nm (Jensen, 1995). Catalase activity was measured by the decomposition of hydrogen peroxide, monitored by the decrease in absorbance at 240 nm (Aebi, 1984). Thiobarbituric Acid Reactive Substances (TBARS) levels were determined using a colorimetric assay. Milk samples were mixed with thiobarbituric acid reagent and heated in a boiling water bath. The absorbance of the pink-colored complex was measured at 532 nm to quantify malondialdehyde, a marker of lipid peroxidation (Ohkawa et al., 1979).

Microbial Assessment

Microbial assessment of fresh milk from cattle, sheep, and goats, such as Total Bacterial Count (TBC), was determined by plating serial dilutions of milk samples on Plate Count Agar (PCA) and incubating at 30°C for 48 hours as described by Marri et al., (2020). Colonies were counted and expressed as CFU/mL (Griffiths, 2010). Escherichia coli (E. coli) counts were determined by plating serial dilutions on Eosin Methylene Blue (EMB) agar and incubating at 37°C for 24 hours in line with the study conducted by ISO (2013). Characteristic colonies were confirmed by biochemical tests and expressed as CFU/mL (Oliver et al., 2009). Total coliform counts were determined by plating serial dilutions on Violet Red Bile Agar (VRBA) and incubating at 37°C for 24 hours. Typical coliform colonies were counted and expressed as CFU/mL (Griffiths, 2010). Total fungal counts were determined by plating serial dilutions on Potato Dextrose Agar (PDA) and incubating at 25°C for 5 days. Fungal colonies were counted and expressed as CFU/mL (Jandal, 2016).

Statistical Analysis

All data obtained from laboratory analysis was statistically analyzed using SPSS version 22.0 software 2013. The results were expressed as mean ± standard error of the mean (SEM). One-way analyses of variance (ANOVA) was used to compare differences on nutritional, microbial load, anti-oxidant factors, and physiochemical parameters among the milk samples from cattle, goats, and sheep. $P < 0.05$ were considered statistically significant.

RESULTS and DISCUSSION

Table 1 is the comparative study of the nutritional characteristics of goat, sheep, and cattle milk reveals significant variations across different milk varieties. These differences are highlighted by recent research on milk composition, which further supports the impact of species on nutritional characteristics, particularly levels of protein, fat, and lactose. The highest protein concentration is found in sheep milk (6.02%), which is much higher than that of goat milk (4.38%) and cattle milk (3.54%). The amount of protein in milk is important because it helps to supply amino acids, which are necessary for body growth and repair, and it also makes the milk more satisfying (Morand-Fehr and Sauvant 1978). Recent research has revealed that sheep milk has a high protein content, making it suitable for people who require a greater protein diet (Park et al., 2007). Cattle milk has the lowest protein content, while goat milk has a decent amount, providing a midway ground. With levels ranging from 4.43% to 4.93% for all milk types, casein levels are comparatively close, indicating that casein concentration may not be as species-dependent (Bhat et al., 2006). Because casein promotes the production of curds during the cheese-making process and offers a prolonged energy release, its stable presence is essential. Recent research indicates that while the slightly greater casein concentration of sheep milk may not have a major effect on digestion, it may have an impact on certain dairy applications, such cheese output (Bhat et al., 2006). With a fat concentration of 4.78%, goat milk is significantly greater than cattle and sheep milk, which have fat contents of 3.29% and 3.17%, respectively. Goat milk's higher fat content adds to its distinct flavor and possibly higher calorie content, making it a desirable choice for consumers looking for dairy products that are high in energy (Haenlein and Wendorff, 2006). This is consistent with research by Kumar et al. (2012), which highlights the value of goat milk in high-energy compositions and its allure for the manufacturing of gourmet cheese. The mineral percentage, or ash concentration, is highest in cattle milk (0.59%), followed by goat milk (0.57%), and sheep milk (0.30%). Greater contributions to daily mineral intake, especially calcium and phosphorus, which are critical for bone health, are implied by the high mineral content of cattle and goat milk (Kumar et al., 2012). Kevin, 2006 study, which emphasizes the mineral richness of cattle milk and its significance for nutritional planning, is supported by this finding. The proportion of lactose in milk varies greatly; goat milk has the greatest concentration (4.88%), followed by cattle milk (3.70%) and sheep milk (3.32%). According to current research that emphasize lactose as the main issue with dairy consumption, goat milk's higher lactose content may make it less appropriate for people with lactose intolerance (Stobiecka et al., 2022). However, people with minor lactose sensitivity may find sheep milk easier to digest due to its low lactose content.

Table 1. Nutritional properties of cattle, sheep, and goat milk

	Samples				
Parameters	**Cattle**	**Sheep**	**Goat**	**SEM**	**P-Value**
Total protein (%)	3.54^{c}	6.02^{a}	4.38^{b}	0.28	0.034
Casein (%)	4.49	4.93	4.43	0.19	0.062
Total fats (%)	3.29^{b}	3.17^{b}	4.78^{a}	0.20	0.049
Ash (%)	0.59	0.30	0.57	0.04	0.052
Lactose (%)	3.70^{b}	3.32^{c}	4.88^{a}	0.18	0.043

^{abc} means in the same row with different superscripts are significantly different (P<0.05) %=percent SEM=Standard Error of Mean, ^{O}C=degree celsius

Table 2 shows the physicochemical makeup of milk from cattle, sheep, and goats, which offers important information about their appropriateness for a range of industrial and dietary applications. The measurements of refractive index, titratable acidity (TTA), density, solid non-fats (SNF), pH, and total solids illustrate the distinctive characteristics of each milk type and reveal notable significant differences (P<0.05) in some important characteristics. Sheep milk has the greatest refractive index (1.355), which is a measurement of the density and concentration of milk, followed by goat milk (1.337) and cattle milk (13.445). This might be as a result of the total protein recorded for each species which followed similar trend. According to Park et al. (2007) sheep milk has a higher protein and mineral content, which is consistent with a larger concentration of dissolved solids, as shown by this high refractive index (Kumar et al., 2012). Milk used in specialist goods, such as cheese, where concentrated solids are beneficial, is linked to high refractive index values (Bhat et al., 2006). The acidity of milk, which influences its flavor, shelf life, and appropriateness for processing, is measured by titratable acidity. The highest TTA (0.346%) is found in sheep milk, which is followed by goat milk (0.216%) and cattle milk (0.250%). Sheep milk's high acidity indicates a tangier flavor profile and a shorter natural shelf life, both of which are frequently preferred in fermented dairy products like cheeses and yogurt (Haenlein and Wendorff, 2006), the TTA might be influenced by the total protein of the milk. Higher acidity levels have been shown in recent research to increase microbial activity during fermentation, which is advantageous for the creation of artisan cheese (Morand-Fehr and Sauvant, 1978). With goat milk at 1.033 mg/mL, sheep milk at 1.037 mg/mL, and cattle milk at 1.036 mg/mL, the density of the milk samples varies very little. Sheep milk's slightly higher density corresponds with its higher solid content, confirming research showing a positive correlation between density and the amount of dissolved and suspended solids in milk (Park et al., 2007). Sheep milk's distinct texture and appropriateness for processed dairy products may also be attributed to its increased density. Compared to sheep (6.304%) and goat milk (6.530%), the percentage of SNF in cattle milk is substantially higher (8.354%). Protein, lactose, and minerals that are not found in the fat fraction are provided by milk with high SNF values, adding to its nutritional value. Given that protein and minerals are dietary goals, the higher SNF of cattle milk is consistent with its extensive use as a staple food (Stobiecka et al., 2022). Sheep milk has a far lower pH (5.52) than goat or cattle milk, which have similar pH values (6.79 and 6.50, respectively). The pH levels reveal how acidic or alkaline the milk is. Sheep milk with a lower pH indicates greater acidity, which makes it better suited for goods like yogurt that thrive in acidic settings. In line with research by Kevin (2006), which supports the use of sheep milk in rapid-fermentation dairy products, this low pH also implies faster coagulation periods. All of the components of milk—fat, protein, lactose, and minerals—are represented in the total solids content. The highest total solid content is found in cattle milk (17.194%), which is followed by goat milk (16.770%) and sheep milk (15.878%). Cattle milk with high total solids has a richer mouthfeel and is ideal for making concentrated milk products (Morand-Fehr and Sauvant 1978). The smoother, lighter texture of goat milk—which is frequently favored when consumed fresh—may be attributed to its somewhat lower total solids content.

Table 2. Physicochemical Composition of cattle, sheep and goat milk

	Samples				
Parameters	**Cattle**	**Sheep**	**Goat**	**SEM**	**P-Value**
Refractive index	1.3445	1.355	1.337	0.00	0.065
TTA (%)	0.250	0.346	0.216	0.02	0.072
Density mg/Ml	1.036	1.037	1.033	0.00	0.066
Solid Non Fats (%)	8.354^{a}	6.304^{b}	6.530^{b}	0.25	0.039
pH @ 20^{0}C	6.79^{a}	5.52^{b}	6.50^{a}	0.15	0.045
Total solid (%)	17.194^{a}	15.878^{c}	16.770^{b}	0.17	0.022

^{abc} means in the same row with different superscripts are significantly different (P<0.05), %=percent)SEM=Standard Error of Mean, mg/Ml=milligrams per millliter

Table 3 examines the amounts of enzymes that are essential for cellular defense against oxidative stress, offering insights into the antioxidant qualities of milk from cow, sheep, and goats. These measures include thiobarbituric acid reactive substances (TBARS), glutathione peroxidase, glutamine transferase, catalase, and superoxide dismutase. Superscripts ($P<0.05$) denote substantial differences in these antioxidant characteristics, highlighting the distinct health benefits of each variety of milk. Cattle milk has the greatest levels of glutathione peroxidase (GSH-Px) (270.84 IU/L), followed by goat milk (235.05 IU/L) and sheep milk (194.70 IU/L).

According to Kurhaluk et al. (2021), this enzyme is essential for lowering hydrogen peroxide and shielding cells from oxidative damage. Because of its increased GSH-Px activity, cattle milk may have a greater ability to lower oxidative stress, which would improve cellular defenses. This is consistent with recent research showing that dairy products with high GSH-Px activity may promote health advantages, especially for those who are exposed to environmental contaminants (Park et al., 2007). Goat milk has the highest activity of superoxide dismutase, an enzyme that breaks down superoxide radicals into oxygen and hydrogen peroxide (4.158 IU/L), followed by sheep milk (3.156 IU/L) and cattle milk (2.596 IU/L). Goat milk may be a good choice for people with inflammation-related disorders since high SOD activity helps reduce oxidative damage and has anti-inflammatory properties (Haenlein and Wendorff, 2006). Higher SOD levels in goat milk may improve its antioxidant qualities and promote cellular health under oxidative stress situations, according to studies (Stobiecka et al., 2022). Goat milk had the highest activity of glutamine transferase (5.682 IU/L), followed by cattle milk (4.104 IU/L) and sheep milk (2.564 IU/L). The metabolism of amino acids and cellular detoxification are mediated by glutamine transferase. In line with research showing that goat milk's distinct profile can improve gut health and metabolism, higher levels in goat milk may increase its capacity to support metabolic processes and promote liver function (Kevin, 2006). since of its lower amount, sheep milk may not be as beneficial in these kinds of applications since it plays a less part in these particular antioxidant pathways. Cattle milk has the highest concentration of catalase, an enzyme that converts hydrogen peroxide into water and oxygen, with 0.846 IU/L. Sheep and goat milk have comparable, lesser concentrations of catalase (0.690 IU/L and 0.704 IU/L, respectively). Cattle milk's high catalase activity indicates a potent defense against oxidative stress caused by hydrogen peroxide, which can promote improved cellular function preservation and strengthen the milk's preventative health advantages (Morand-Fehr and Sauvant, 1978). These results are consistent with studies showing that milk meant for people who require extra protection from oxidative stress benefits from greater catalase activity (Muscolo et al., 2024). A measure of lipid peroxidation, thiobarbituric acid reactive substances (TBARS) levels are lowest in sheep (0.246 IU/L) and goat milk (0.218 IU/L) and highest in cattle milk (0.338 IU/L). Reduced oxidative lipid breakdown is indicated by lower TBARS levels in goat and sheep milk, which is advantageous for increasing milk fat quality and shelf life. Cattle milk with high TBARS levels may undergo a quicker oxidation process and need more stringent preservation guidelines (Kurhaluk et al., 2021). This is consistent with research showing that milk with reduced TBARS is more stable and appealing to customers who are concerned about oxidative health (Stobiecka et al., 2022).

Table 3. Antioxidants properties of cattle, sheep and goat milk

	Samples				
Parameters	**Cattle**	**Sheep**	**Goat**	**SEM**	**P-Value**
Glutathione peroxidase (IU/L)	270.84^{a}	194.70^{c}	235.05^{b}	8.59	0.040
Superoxide Dismutase (IU/L)	2.596^{c}	3.156^{b}	4.158^{a}	0.18	0.022
Glutamine transferase (IU/L)	4.104^{b}	2.564^{a}	5.682^{b}	0.35	0.048
Catalase (IU/L)	0.846^{a}	0.690^{b}	0.704^{b}	0.02	0.046
Thiobarbituric acid reactive subs (IU/L)	0.338^{a}	0.246^{b}	0.218^{b}	0.02	0.048

^{abc} means in the same row with different superscripts are significantly different (P<0.05) SEM=Standard Error of Mean, IU/L=international unit per litter (quantify concentration of substance such as enzymes, vitamins, hormones or drugs)

Table 4's microbiological evaluation of the milk from cattle, sheep, and goats offers vital details on their cleanliness and possible health hazards, especially when consuming raw milk. Total bacterial count, E. coli presence, total coliforms, and total fungal count are important microbiological metrics that show the milk's level of sanitation and microbial safety. Compared to cattle milk (5.552 x 10^3 CFU/100 ml), the total bacterial counts in sheep and goat milk are substantially higher (7.342 x 10^3 and 7.552 x 10^3 CFU/100 ml, respectively). Each species' unique milking methods, environmental exposure, and animal handling circumstances may contribute to this increased bacterial burden (Stobiecka et al., 2022). According to studies, the condition of the udder and local milking practices affect the amount of bacteria in milk; sheep and goats typically have greater numbers because of open grazing and close human interaction (Kumar et al., 2012). In order to make sheep and goat milk safer for human consumption, pasteurization or other microbial control procedures may be necessary if there are high bacterial counts in the milk. Sheep milk had the greatest concentration of E. coli, a fecal indicator, at 1.40 CFU/100 ml, followed by goat milk at 1.20 CFU/100 ml and cattle milk at 0.60 CFU/100 ml. A higher risk of contamination is indicated by the noticeably higher E. coli levels in sheep milk, which could be the result of closer animal-ground contact or inadequate sanitary procedures during milking (Park et al., 2007). Since E. coli bacteria can cause gastrointestinal infections, elevated E. coli numbers can be extremely dangerous to one's health, especially for children or those with weakened immune systems. Since the risks of contamination are higher for sheep and goat milk, proper handling and strict sanitation procedures are crucial to lowering the amount of E. coli in raw milk (Morand-Fehr and Sauvant, 1978). The greatest count of coliform bacteria, which also signal fecal matter contamination, is found in cattle milk (37.93 x 10^2 CFU/100 ml), followed by goat milk (35.94 x 10^2 CFU/100 ml) and sheep milk (27.47 x 10^2 CFU/100 ml). Elevated coliform counts may indicate poor handling or milking practices (Adil et al., 2011). Sheep milk has a comparatively lower coliform count than cattle milk, which may be because they are not exposed to as many aquatic pathogens. All values, however, emphasize how crucial careful processing and sanitation are to reducing health hazards and enhancing milk safety. The greatest fungal count is seen in cattle milk (5.45 x 10^4 CFU/100 ml), which is followed by goat milk (3.26 x 10^4 CFU/100 ml) and sheep milk (4.96 x 10^4 CFU/100 ml). Environmental spores can cause high fungal counts, especially in warm, humid environments that encourage fungal growth (Kevin, 2006). Milk containing fungi may deteriorate and pose health risks, particularly if there are pathogenic species present. Goat milk is preferred in areas where preservation is difficult because of its reduced fungus count, which may make it more stable in storage (Haenlein and Wendorff, 2006). To control fungal contamination, proper storage conditions and routine antifungal treatments are advised.

Table 4. Microbial Assessment of cattle, sheep and goat milk

	Samples				
Parameters	Cattle	Sheep	Goat	SEM	P-Value
Total bacterial Count (CFU/100ml)	5.552 x10^{3b}	7.342 x10^{3a}	7.552 x10^{3a}	0.31	0.023
E. coli (CFU/100ml)	0.60^c	1.40^a	1.20^b	0.42	0.034
Total Coliforms (CFU/100ml)	37.93 x10^{2a}	27.47 x10^{2c}	35.94 x10^{2b}	10.65	0.042
Total fungal Count (CFU/100mL)	5.45x10^{4a}	4.96 x10^{4b}	3.26 x10^{4b}	0.30	0.041

^{abc} means in the same row with different superscripts are significantly different (P<0.05)
SEM=Standard Error of Mean, CFU/100ml=colony-forming units per 100 millilitters

CONCLUSION

In conclusion, different nutritional, physicochemical, antioxidant, and microbiological profiles were compared for milk from cow, sheep, and goats. Each of the milk from the three species studied has a unique advantages. Goat milk is heavy in fats and lactose, sheep milk is high in proteins, and cattle milk has strong antioxidants and comparatively low microbial burdens. Based on. Based on the result of this study consumer and commercial dairy processors can decide on the type of milk to patronize based on safety, health, and nutritional factors. Further research need to be conducted with a larger sample size in order to reduce random error.

Conflict of Interest

The authors have declared that there are no conflict interests.

Authors Contribution

The authors contributed equally to the article.

REFERENCES

Aebi H., 1984. Catalase in vitro. Methods in Enzymology, 105: 121-126.

AOAC., 2000. Association of Official Analytical Chemists. Official Methods of Analysis of AOAC International, 17th ed. AOAC International, Gaithersburg, MD, USA.

Flohé L, Günzler WA., 1984. Assays of glutathione peroxidase. Methods in Enzymology, 105: 114-121.

Bhat MY, Dar TA, Singh LR, 2016. Casein Proteins: Structural and Functional Aspects. InTech. http://dx.doi.org/10.5772/64187

Muscolo A, Mariateresa O, Giulio T, Mariateresa R. 2024. Oxidative Stress: The Role of Antioxidant Phytochemicals in the Prevention and Treatment of Diseases. International Journal of Molecular Sciences, 25(6): 3264. https://doi.org/10.3390/ijms25063264

Adil MA, Salman, Iman MH, 2011. Enumeration and identification of Coliform bacteria from raw milk in Khartoum State, Sudan. Journal of Cell and Animal Biology Vol. 5(7):121-128 http://www.academicjournals.org/JCAB

Gül S, Keskin M, Güler Z, Dursun A, Gündüz Z, Önel SE, Tüney Bebek D., 2018. Effects of Pre-milking Resting on Some Lactation Characteristics in Damascus (Shami) and Kilis Goats. Journal of Animal Production (Hayvansal Üretim Dergisi), 59(1): 17-24.

Griffiths MW., 2010. Improving the Safety and Quality of Milk: Milk Production and Processing. CRC Press.

Haenlein, G.F.W. and Wendorff, W.L., 2006. Sheep milk: production and utilization of sheep milk. In: *Handbook of Milk of Non-bovine Mammals* (eds Y.W. Park and G.F.W. Haenlein), Pp:137–194. Blackwell Publishing Professional, Ames, IA. https://doi.org/10.1002/9780470999738

Jandal JM., 2005. Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, 3rd ed. Wiley-Interscience. Pp: 784, ISBN: 978-0-471-22756-4

Jensen RG., 1995. Handbook of milk composition. Academic Press. Elsevier, Burlington, 1995.

Kumar S, Kumar B, Kumar R, Kumar S, Khatkar SK, Kanawjia SK 2012. Nutritional features of goat milk—A review. Indian Journal of Dairy Science, 65(4): 266-273. [Google Scholar]

Kurhaluk N, Tkachenko H, Czopowicz M, Sikora J, Urba´nska DM, Kawecka A, Kaba J, Bagnicka E. 2021. A Comparison of Oxidative Stress Biomarkers in the Serum of Healthy Polish Dairy Goats with Those Naturally Infected with Small Ruminant Lentivirus in the Course of Lactation. Animals. 11: 1945. https://doi.org/10.3390/ani11071945

Stobiecka M, Król J, Brodziak A. 2022. Antioxidant Activity of Milk and Dairy Products. Animals, 12(3): 245. https://doi.org/10.3390/ani12030245

Marklund S, Marklund G., 1974. Involvement of the superoxide anion radical in the autoxidation of pyrogallol and a convenient assay for superoxide dismutase. European Journal of Biochemistry, 47(3): 469-474.

Morand-Fehr P., Sauvant D. 1978. Nutrition and Optimum Performance of Dairy Goats. Livestock Production Science, 5: 203-212. http://dx.doi.org/10.1016/0301-6226(78)90046-5

Ohkawa H, Ohishi N, Yagi K., 1979. Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. Analytical Biochemistry, 95(2): 351-358.

Oliver SP, Jayarao BM, Almeida RA., 2009. Foodborne pathogens in milk and the dairy farm environment: Food safety and public health implications. Foodborne Pathogens and Disease, 2(2): 115-129.

Kevin D. 2006. Milk minerals (including trace elements) and bone health. International Dairy Journal, 16(11): 1389-1398. 10.1016/j.idairyj.2006.06.017

Varnam AH, Sutherland JP., 2001. Milk and Milk Products: Technology, Chemistry and Microbiology. Springer.

World Atlas and Climate Data Organization., 2015. Climate Data for Taraba State, Nigeria.

Muehlhoff E, Bennett A, McMahon D., 2013. Milk and dairy products in human nutrition, Food and Agriculture Organization of the United Nations (FAO), ISBN (Hardback): 978-92-5-107863-1, (pp:376).

Kebede E., 2018. Effect of Cattle Breed on Milk Composition in the same Management Conditions. Ethiopian Journal of Agricultural Sciences, 28(2): 53-63.

Park YW, Juarez M, Ramos M, Haenleinb GFW., 2007. Physico-chemical characteristics of goat and sheep milk. Small Ruminant Research, 68(68): 88-113. http://dx.doi.org/10.1016/j.smallrumres.2006.09.013

Marri N, Losito F, Le Boffe L, Giangolini G, Amatiste S, Murgia L, Arienzo A, Antonini, G., 2020. Rapid Microbiological Assessment in Raw Milk: Validation of a Rapid Alternative Method for the Assessment of Microbiological Quality in Raw Milk. Foods (Basel, Switzerland), 9(9): 1186. https://doi.org/10.3390/foods9091186.

International Standard Organization ISO., 2013. International Standard Organization ISO. 7218:2007/AMD 1 2013: Microbiology of Food and Animal Feeding Stuffs—General Requirements and Guidance for Microbiological Examinations. Available online: *https://www.iso.org/standard/36534.html*

Roy D, Ye A, Moughan PJ, Singh H., 2020. Composition, Structure, and Digestive Dynamics of Milk From Different Species-A Review. Frontiers in Nutrition, 7: 577759. https://doi.org/10.3389/fnut.2020.577759

ALKaisy QH, Al-Saadi JS, Al-Rikabi AKJ, Altemimi AB, Hesarinejad MA, Abedelmaksoud TG., 2023. Exploring the health benefits and functional properties of goat milk proteins. Food Science & Nutrition, 11(10): 5641-5656. https://doi.org/10.1002/fsn3.3531

Aguirre DB, Mowson R, Versteeg K, Canovas GB., 2009. Composition properties, physicochemical characteristics and shelf life of whole milk after thermal and thermo-sonication treatments. Journal of Food Quality, 32(3): 283-302. https://doi.org/doi/10.1111/j.1745-4557.2009.00250.x

Lynch JM, Barbano DM, Fleming JR., 2007. Determination of the lactose content of fluid milk by spectrophotometric enzymatic analysis using weight additions and path length adjustment: collaborative study. Journal of AOAC International, 90(1): 196-216.

Zahra S, Yodallahi A., 2008. Physicochemical and Microbiological Quality of Raw, Pasteurized and UHT Milks in Shops. Asian Journal of Scientific Research, 1(5). 10.3923/ajsr.2008.532.538