

Physico-chemical Studies on Some Commercially Available Milk Samples Sold Within Lokoja Metropolis of Kogi State, Nigeria

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Abstract

Physico-chemical analysis were conducted on four commercially available milk samples sold in retail shops in Lokoja, Nigeria and a control raw fresh cow milk sample from vendors with a view to assessing their nutritional quality and safety for consumption. Sample A was a sweetened condensed liquid milk while sample B was an unsweetened one. Sample C was an instant cream powdered milk while sample D was non-cream milk powder. Standard analytical procedure of Association of Analytical Chemists (AOAC) (2005) [1] were used throughout the experiment to check physical parameters like temperature, pH, specific gravity, titratable acidity, moisture content, and chemical properties like fats, proteins, and lactose. The raw cow milk sample which serves as control expectedly gave higher values in all the parameters tested. All the sample show pH values between 6.60 ± 0.04 and 6.78 ± 0.07 which are within normal range of 6.5-6.8 by WHO and FAO. Sample A has a higher moisture content of 85.65 ± 0.08 %, while the lowest moisture content for the samples was that from sample C at 2.20 ± 0.03 %. Specific gravity of 1.046 ± 0.005 was recorded as the highest and was found in sample D. Titratable acidity was more in the powdered milk samples with the highest value of 14.50 ± 0.08 coming from sample C. However, liquid milk samples had higher values of total solid and solid not fat. The chemical composition of the milk samples shows the highest protein concentration of 22.80 ± 0.01 % in the powdered sample C with a corresponding fat content of 25.83 ± 0.09 % in sample D respectively. Lactose was also observed to be higher in the powdered samples. This work has shown the effect of different formulation processes for the dried powdered milk which might have accounted for higher values of all the chemical properties analysed. Results gotten from the liquid samples however were within normal limits except for titratable acidity. In all, environmental factors like temperature and storage conditions in the shops where they were kept could have affected some of their nutritional quality. Never the less they are still within safe levels for human consumption.

Keywords: Lokoja; Milk samples; Nigeria; Physicochemical parameters

Introduction

Milk is defined as the normal secretion of the mammary glands of mammals and nature's designed food for the young and adults [2]. It's a complex mixture that supplies human with carbohydrate (lactose), fat, protein, calcium, essential minerals and vitamins. Milk plays an important role in dietary intake as it helps to improve bone and dental health and possibly protect against hypertension and colon cancer. These benefits make human being consume milk from different animal species such as cow, goat, sheep, and camel [3]. The average composition of liquid

milk is 87.3% water, 3.42 - 3.5% protein, 4.78 - 4.90% lactose, 0.75 - 0.7% ash and have a pH 6.6 - 6.8%. To transport milk in rural areas of Africa, farmers use donkeys, donkey - tracted carts and pick - up trucks depending upon availability, cost and the distances involved. Typically, donkeys are used for distances up to 5 - 7 kilometers (kms); donkey, carts for longer distances for 15 to 20 kms, and pick-up trucks for longer distances. There are no refrigerated or cooled transportation facilities which are necessary in a hot climate like that of Nigeria and Sudan. As a result, after several hours, the milk goes bad. Such problems are compounded by presence of bad roads and the bacterial growth in raw milk resulting from absence of sanitary methods of milk production and subsequent handling [4].

Milk is a complex colloidal dispersion containing fat globules, casein micelles and whey proteins in an aqueous solution of lactose, minerals and a few other minor compounds. Its physical and chemical properties depend on intrinsic compositional and structural factors, extrinsic factors such as temperature and post-milking treatments [5]. An understanding of these properties is important in the technological and engineering design and operation of milk processes and processing equipment, the design of modern methods of milk analysis, the determination of milk microstructures and the elucidation of complex chemical reactions that occur in milk. Measurement of some of the physico-chemical properties is used to assess milk Quality. Milk is an important source of all basic nutrients required for mammals including human beings. Milk from various mammals such as cow, buffalo, goat, sheep, camel, etc. is used for different nutritional purposes, e.g., feeding to young ones and preparation of some nutritional products such as milk cream, butter, yogurt, ghee, sour milk, etc. [6]. Physico-chemical analysis is important tool to monitor the quality of milk and other dairy products. Adulteration in food is done either for financial gain or lack of proper hygienic conditions of processing, storing, transportation and marketing. This ultimately leads to the stage that the consumer is either cheated or often becomes victim of diseases. Such types of adulteration are quite common in developing countries. It is equally important for the consumer to know the common adulterants and their effects on health [7]. Increased concentration of hard water in milk showed the adverse effect on quality of milk by increasing the acidity, thereby reducing the shelf life of milk. Usage of hard water leads to high number of coliforms in milk, while the addition of soft water decreased the acidity and reduced the levels of coliforms in raw milk leading to improvement in shelf life. The consumption of boiled milk is necessary, as raw milk adulterated by vendors with water irrespective of its type could be a major source of contamination [8]. The quality of raw milk is a term with a very broad meaning. It encompasses such milk characteristics as chemical composition, physical properties, microbiological and cytological quality, sensory properties, technological suitability and nutritive value [9]. In Nigeria, only a few of the milk and their products are produced from various indigenous sources, majority of others are imported. A number of researchers have investigated trace elements like Na, Cu, Mn and Cr in powder, fresh and processed milk samples. Some reports have it that the levels of some metals (Ca, K, Na, Mg, Cu, Fe, Mn, Zn, Cd, Cr, Pb and Ni) were found in 19 different imported brands of unexpired and expired canned dry milk. To our knowledge, not many studies on the chemical composition of various kinds of milk marketed in Nigeria have been reported. Therefore, in the present study, we investigated some physical and chemical components of commercially available milk samples to assess their nutritional quality. The main goal of this present study therefore was to evaluate various physicochemical properties of some commercially available milk samples sold within Lokoja

metropolis of Kogi State, Nigeria in order to compare with standards for nutritional quality assessment.

Materials and Methods

All reagents and chemicals used in this work are of analytical grade and gotten from authentic sources. Four samples were used for the analysis and subsequently labelled as samples A, B, C, and D respectively. Sample A is a sweetened condensed liquid milk while sample B is an unsweetened one. Sample C is an instant cream powdered milk while sample was non-cream milk powder. Raw cow milk samples were purchased directly from local milk vendors in sterilized containers and used as control.

Sample Preparation

Samples A and B were warmed to between 37°C and 40°C whenever needed for any analysis. This was then transferred into a beaker and maintained within those temperature range with intermittent stirring. Samples were removed from the water bath and allowed to cool to room temperature for further analysis. Samples C and D were homogenized by mixing, shaking and inverting the sample containers. Excessive temperature and humidity were avoided when opening sample containers to prevent absorption of moisture.

Physicochemical Analysis of Milk Samples (AOAC, 2005) [1]

Determination of temperature and pH

The temperature of the milk samples was determined at the collection point using thermometer while the pH of the milk samples was determined in the laboratory using a digital pH-meter (EUTECH, Serial No. 1366514, Model P/N: 54×002606; made in Malaysia) [1]. The pH meter was first calibrated using buffers of pH 7.0 and 4.0 each time before the pH of milk samples were taken.

Moisture determination

The moisture contents the of milk samples were determined according to Pearson (1976) method. Five grams of milk sample were placed into aluminium dish and dried in the oven at 105°C for two hours with the lid alongside. The lid was placed on the dish and transferred to the desiccator, the sample were weighed then when the dish had completely cooled. The moisture percent of the sample was calculated as follows:

$$\text{Moisture \%} = (B - C)/A \times 100$$

Where:

A = sample weight in grams

B = weight of dish + sample prior to drying

C = weight of dish + sample after drying

Titrateable acidity

Titrateable acidity of the milk samples was determined according to the method of the Association of Official Analytical Chemists (AOAC, 2005) [1]. Nine ml of milk sample was pipetted into a beaker and 3 to 5 drops of 1 % phenolphthalein indicator was added. The milk sample were then titrated with 0.1N NaOH solution until a faint pink color persisted. The titrateable acidity, expressed as % lactic acid, was finally calculated using the following formula.

$$\text{Titrateable acidity (\%)} = \frac{0.1\text{N NaOH (ml)} \times 0.009 \times 100}{\text{Weight of milk sample}}$$

Specific gravity

Fresh milk samples were filled sufficiently into a glass cylinder (100 ml capacity). Then lactometer was held by the tip and inserted into the milk. The lactometer was allowed to float freely until it reaches equilibrium. Then the lactometer reading at the lower meniscus was recorded. Immediately, thermometer was inserted into the milk sample and the temperature of the milk was recorded too. The following formula was used to calculate the specific gravity of the milk.,

$$\text{Specific gravity} = \frac{(L/1000) + 1}{\text{Where, L = corrected lactometer reading at a given temperature, i.e., for every degree above } 60^{\circ}\text{F, } 0.2 \text{ was added to the lactometer reading but for every degree below } 60^{\circ}\text{F, } 0.2 \text{ was subtracted from the lactometer reading.}}$$

Determination of Total Solids (Gravimetric method)

Principle

Pre-drying of a test portion on a boiling water bath and subsequent evaporation of the remaining water in a drying oven at a temperature of 102.2°C.

Apparatus

(a) Analytical Balance (b) Dessicator provided with an efficient dessicant (for example freshly dried silica gel with a hydrometric indicator (c) Boiling water bath provided with openings of adjustable size (d) Drying oven, ventilated capable of being maintained thermostatically at 102.2°C throughout the total working space. (e) Flat bottomed dishes of height 20 - 25 mm, dia 50- 75 mm and made of appropriate material (stainless steel, nickel or aluminium) provided with well fitted readily removable lids. (f) Water bath capable of being maintained at 35 - 400°C.

Preparation of sample

Transfer sample to a beaker, warm slowly to 35-400°C on a water bath with careful mixing to incorporate any cream adhering to the sample cooled quickly to room temperature.

Procedure

A dish was heated with its lid alongside in the drying oven for at least 1 hour. The lid was then placed on the dish and immediately transferred to a dessicator. Allowed to cool to room temperature (at least 30 mins) and weighed to the nearest 0.1 mg. Five millitre (5ml) of prepared sample was place on the lid and the dish and weighed again. The dish was then placed without the lid on the vigorously boiling water bath in such a way that the bottom of the dish was directly heated by the steam. The heating continued till most of the water evaporated. Dish was removed from the water bath, wiped on the underside and placed in the oven alongside the lid and dried in the oven for 2 hours. The lid was transferred to the dessicator. Allowed to cool and weigh to the nearest 0.1 mg. Again, the dish was heated with its lid alongside in the oven for 1 hour. The lid was placed on the dish and immediately transferred to the dessicator. Allowed to cool and weighed again. The operation was repeated again until the difference in the two consecutive weighings lied within 1 mg.

Calculation

$$\text{Total Solid Content} = \frac{m_2 - m_0 \times 100}{m_1 - m_0}$$

Where m_0 = mass in gm of dish + lid

m_1 = mass in gm of dish + lid and test portion

m_2 = mass in gm of dish + lid and dried test portion

Round the value obtained to nearest 0.01 % (m/m)

$$\text{Total solids} = \frac{\text{Crucible weight} + \text{Oven dry sample weight} - \text{Crucible weight} \times 100}{\text{Sample weight.}}$$

Fat content

The fat content was determined by the Gerber method according to (Richardson, 1985). Ten ml of sulfuric acid (density 1.815 gm/ml at 20°C) was pipetted into a butyrometer. Then eleven ml of milk sample was added into the butyrometer and mixed with the sulphuric acid. This was followed by addition of 1 ml amyl alcohol into the butyrometer which was then closed with a lock stopper. Then the mixture was shaken and inverted several times until the milk was completely digested by the acid. Finally, the butyrometer was kept in water bath for 5 minutes at 65°C and centrifuged in a Gerber centrifuge for 5 minutes. The butyrometer was placed in water bath again at 65°C for 5 minutes. At the end, the butyrometer reading was recorded.

Solids not-fat

Solids-not-fat (SNF) content was determined by difference as reported by (Getachew, 2003) using the following formula:
$$\text{SNF content (\%)} = \text{TS (\%)} - \text{Fat (\%)}$$

Determination of Fat in Milk

- Gerber Method.

Principle

The milk is mixed with sulphuric acid and iso-amyl alcohol in a special Gerber tube, permitting dissolution of the protein and release of fat. The tubes will be centrifuged and the fat rising into the calibrated part of the tube was measured as a percentage of the fat content of the milk sample. The method is suitable as a routine or screening test. It is an empirical method and reproducible results can be obtained if procedure is followed correctly.

Lactose determination

Lactose was determined by Lane and Eynon method according to AOAC (2005) [1]. 25 ml from liquid milk and 25 g from whole milk powder were dissolved in distilled water, clarified by lead acetate (2 ml), and potassium oxalate (3 ml), then filtrated and made up to (250 ml). 10 - 25 ml of mixed Fehling solution was prepared in 300 ml conical flask. 15 ml of sugar solution was added, and liquid was boiled on asbestos covered gauze, 1 ml of sugar solution was added at (10 - 15 sec) and boiled liquid until the color was nearly discharged. Three drops of methylene blue indicator were added to the boiled liquid. The boiling was continued until the indicator color was completely decolorized. The lactose content was calculated from the lactose table by extrapolation.

Results and Discussion

Physical characteristics such as moisture, total solids, specific gravity, pH, and titratable acidity are important parameters in studying the physicochemical compositions and nutritional aspects of milk. Tables 1-6 shows the various physical/chemical parameters of the different milk samples analysed in this work. The moisture contents of milk samples were in the range of 84 to 86% for liquid and raw milk samples whereas those of powder milk were found to be much lower. This is because there tend to be more water in the liquid already but processing techniques which involves drying has drastically reduced the moisture content in the powdered samples. All these values were close to the earlier findings, from 80% to 90% for liquid samples according to [6]. Water serves as a medium for solution and colloidal suspension for the other components present in milk. The concentration range of total solids from liquid milk was 11% to 13% as given in Table 3. Sample C milk (instant fill cream powdered milk) had the lowest amount of total solids (2.28%) followed by sample D milk (2.32%) and the highest was found in the raw milk sample (13.26%). In the liquid-packed milk samples, the lowest concentration of total solids was seen more. The total solids in all the milk ranged from 2% to 13%, which include fat and non-fat materials. The results show that values for the total solids in all the milk samples are in good agreement with those reported in literature [10]. The specific

gravity and pH of all the milk samples were found to be 1.034 ± 0.02 to 1.056 ± 0.08 and 6.65 ± 0.01 to 6.75 ± 0.05 , respectively (Tables 1 and 2). Slight variations were found for the two parameters in all the milk samples. The specific gravity is mainly due to the water contents present in the sample and pH is the parameter that determines the sample acidity and alkalinity. The pH range found in the current study was comparable with the findings in a previous investigation (6.38 ± 0.60 to 6.77 ± 0.88) [8]. Temperature of milk depends on different environmental factors as such may vary from one geographical location to another. In this work however, temperature values could be attributed mainly to harsh climatic conditions of the study area. The values for the titratable acidity are seen in table 4. The acidity is usually expressed as pH. The pH of milk is more dependent on temperature than that of buffers, such as phosphate; since milk is a complex buffer system and variation in temperature cause many changes. Differences in pH and buffering between individual lots of fresh milk reflect compositional variation [11]. The density and specific gravity of milk depend on composition and temperature. Other factors, such as stage of lactation and nutritional status affect density only in as far as they affect composition. The specific gravity of milk decreases slightly with the increasing temperature; partly because of the effect of temperature on milk fat but also because the contraction of the other solids that occurs on mixing with water decreases slightly. Processing operations such as homogenization and sterilization have negligible effects on density. Environmental and nutritional factors such as season, climate, feed, stage of lactation, water intake have only small effects on the freezing points of milk [11]. The milk samples were also subjected to various chemical analyses and the amount of protein as casein, lactose, and milk fat were determined as presented in tables 5-6. Chemical characteristics of samples showed considerable variations and each sample excelled over other in one or other aspect. Both total protein and casein investigated were within the recommended values, i.e., 2% to 4% for the total protein [12]. The results demonstrate that fresh natural milk is a rich source of protein and casein while in processed samples, some of the proteins might be lost due to the processing methods. In milk generally, proteins have the highest nutritional value and the principal component of the milk proteins is casein, which constitutes about 75% of all milk proteins [13]. Beside casein, the other milk proteins are lactobumin, lactoglobulin, etc. Results gotten in this work are also comparable with the previous work on the ultra-heat treatment (UHT) processed buffalo milk. In the milk samples, lactose was in the range of 3.56% to 3.92% in the liquid samples with even higher values for the powdered ones (Table 6). The reasons are not far from the one earlier given for other physical parameters. Lactose is also known as milk sugar and is composed of galactose and glucose. Among all the tested milk samples, the sample C milk contained the highest amount of lactose.

Samples	Temperature(°C)	pH
A	20.54 ± 1.54	6.65 ± 0.02
B	23.36 ± 1.90	6.55 ± 0.01
C	30.84 ± 1.38	6.50 ± 0.04
D	31.26 ± 1.46	6.70 ± 0.03
Raw milk	27.76 ± 1.06	6.78 ± 0.07

Table 1: Temperature and pH values of the different Milk samples.

Samples	Specific gravity	Moisture content (%)
A	1.034 ± 0.004	85.65 ± 0.08
B	1.036 ± 0.006	84.26 ± 0.06
C	1.041 ± 0.003	2.20 ± 0.04
D	1.046 ± 0.005	2.70 ± 0.03
Raw milk	1.056 ± 0.001	86.46 ± 0.02

Table 2: Specific gravity and moisture contents of the Milk samples.

Samples	Total solid (%)	SNF (%)
A	11.87 ± 0.74	8.07 ± 0.03
B	12.16 ± 0.95	8.97 ± 0.05
C	2.28 ± 0.68	0.14 ± 0.01
D	2.32 ± 0.16	0.25 ± 0.00
Raw milk	13.26 ± 0.06	9.42 ± 0.02

Table 3: Total solid contents and solid not fat (SNF) for the different Milk samples.

Samples	Titrateable acidity (%)
A	2.43 ± 0.07
B	3.20 ± 0.05
C	14.50 ± 0.08
D	12.10 ± 0.01
Raw milk	0.18 ± 0.03

Table 4: Titrateable acidity for the different Milk samples.

Samples	Protein content (%)	Fat content (%)
A	3.05 ± 0.02	3.96 ± 0.001
B	3.55 ± 0.01	4.04 ± 0.02
C	22.80 ± 0.04	25.08 ± 0.09
D	22.30 ± 0.04	25.83 ± 0.09
Raw milk	3.73 ± 0.01	4.52 ± 0.04

Table 5: Protein and fat contents of the different Milk samples.

Samples	Lactose content (%)
A	3.56 ± 0.01
B	3.44 ± 0.01
C	27.18 ± 0.05
D	26.43 ± 0.01
Raw milk	3.92 ± 0.02

Table 6: Lactose contents of the different Milk samples.

In this present study, tables 1-6 data indicate the presence of significant difference ($P < 0.05$) in the total solids (TS) content between milk samples (Table 3). The total solids content of liquid milk samples was significantly ($p < 0.05$) higher than milk samples from powdered samples. Total solids content of raw and processed liquid milk averaged 12.58%. Similar value (12.57%) was reported by [14]. However, slightly lower value of total solids content (12.33%) of cow milk samples were reported by [10]. Different values for total solid content of raw milk samples have been reported by different scholars. The variation could be due to differences in breed, feeding and management practices which have important effects on milk composition and quality. The standard for SNF content of whole cow milk is a minimum of 8.25% (FDA, 1995) and that of fat content $\geq 3.25\%$ (USPHS, 1993). Furthermore, the standards for protein content of unprocessed whole cow milk should not be less than 2.97% while the United States Department of Agriculture and the European Union established standards for total solids content of cow milk not to be less than 12.5% [12]. The differences observed in SNF content of milk could be due to difference in the feeding practices, season, milking method and lactation period exert [10]. On the other hand, the lower value of SNF content of pasteurized milk in the present study could be due to the loss of some chemical components of the milk during heating. No significant difference ($p > 0.05$) in fat content was observed between the three milk types (Table 1). Fat contents of milk obtained from the various milk samples were relatively similar ($P > 0.05$) showing that fat was not affected by source (Table 5). The average fat content of milk obtained raw sample is similar with earlier findings of [11] who reported a fat content of $3.79 \pm 0.18\%$ for raw milk produced in dairy farms. However, higher values of fat content (4.3%) was reported from milk of cows feeding on natural raw pasture by [15] as compared to the present study. Protein content of milk obtained from dairy farms was significantly higher ($P < 0.05$) than milk obtained from vendors and pasteurized (Table 1). The average protein content of raw milk obtained in this study from dairy farms is in agreement with the reported value (3.48%) from Sudan [11]. However, Mirzadeh (2010) [14] reported lower protein content of milk ($3.2 \pm 0.22\%$) in the dairy farms of Lordegan region, Iran, compared

to the present study. The lower protein content of pasteurized milk in this study could be due to excessive heating of milk which causes change in physico-chemical constituents, particularly the protein content [16]. In this study, preliminary investigations were carried out to ascertain the physicochemical characteristics and nutritional quality of various milk samples marketed in Kogi State, North Central Nigeria. The results show that all parameters of the tested milk samples were within the recommended nutritional levels. These findings may be helpful for concerned individuals and parties to continue to monitor the quality of milk products across the markets in Nigeria. It would also be of great interest if further investigations are carried out to examine other organic and inorganic components of the milk in various Nigerian markets.

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