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Composition and quality of fresh cow milk offered for sale in Obudu Grass Plateau, Cross River State – Nigeria

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Target Audience: Ruminant nutritionists, milk vendors, milk & milk product consumers and dairy companies

Abstract

The chemical composition and quality of fresh cow milk from Fulani milk vendors in four locations (Utal – ugar, Anape, Gundaha and Keyi) of Obudu grass Plateau–Cross River State were investigated. Methylene blue dye reduction test was used to assess the milk quality while the bacterial load (contamination) was assessed using the agar plate count and the direct microscopic counts. The results showed mean contents of total solids, protein, butterfat, ash and lactose of 160 samples from Utal-ugar (12.78, 5.74, 5.52, 7.26, 0.11, 1.41%), Anape (12.72, 5.71, 5.55, 7.17, 0.13, 1.33%), Gundaha (12.21, 5.98, 4.95, 7.26, 0.16, 1.12) and Keyi (12.34, 5.88, 4.98, 7.36, 0.17, 1.31%) respectively, which did not differ (P>0.05) significantly between locations. The methylene blue reduction for the various locations were 27.5, 40, 32.5; 35, 37.5, 27.5; 15, 47.5, 37.5; 22.5, 42.5, 35% for good, fair and poor samples respectively. No sample merited average or excellent rating. The agar plate count showed a range of 1.95 x10^6 for Utal-ugar to 2.84 x10^6 for Gundaha. The direct microscopic count showed the highest mean bacteria load for Gundaha samples. The high bacterial counts observed were probably indicative of poor milking hygiene and handling. The study concludes that fresh milk sold at the Obudu grass plateau by the Fulani milk vendors may not be 100% wholesome. It is proper that such milk be pasteurized before consumption and the vendors urged to deliver their milk to markets early at source to reduce the time for microbial build-up.

Key words: Fresh cow milk, Composition, Quality, Contamination, Milk vendors.

Description of Problem

Sub-Saharan Africa is home to about 180 breeds of cattle, out of which 150 breeds are indigenous with a few introduced exotic and commercial breeds [1]. In Nigeria, the indigenous cattle population is estimated at about 15.3 Million [2] with the Fulani pastoralists controlling more than 95% of the national herd and has been the major source of domestic milk supply. Milk supply from other animals such as sheep, goats and camels is negligible [3].

The Nigerian dairy industry is highly underdeveloped being very rural/traditional and relying heavily on the importation of dairy products as repackaged powdered milk or evaporated tin milk worth about US$ 300 million per annum, which does not meet the majority of the 1.45 billion litres domestic demand of dairy products [4]. The annual collectable milk from the national herd is approximately 550,000 tonnes as at 1990 [5]. In 2013, it was estimated that Nigeria produced only 591,491 metric tonnes of milk from 2.3 million cows [4]. The average daily yield per cow is 0.5 – 2 litres from our indigenous breeds in Nigeria, which is very low in comparison to 35- 40 litres in South

Africa, 50 litres in New Zealand and 70 litres in the United States [4].

Pastoral communities produce the bulk of milk consumed in the rural and urban areas of Nigeria. Within the environs of the Obudu grass Plateau, milking is usually carried out every morning and after the household and calf requirements are met, the excess enters the traditional market as fresh or sour milk, cheese, ghee and butter for human consumption. However, within the Plateau there are no milk collection centres, so milk is delivered to the market mostly in covered calabashes by the Fulani women/children. The preference for calabash is due to its insulating quality [3]. However, the Tanzanian Maasai pastoralists also use natural calabashes that are smoke – treated by burning a variety of selected local plant materials and this significantly prolongs milk keeping qualities despite high temperatures in their arid climate. The plants used were identified to have strong aroma and astringent tastes suggestive of a role played by secondary metabolites [6]. Milk sales facilitate and contribute significantly to the upliftment of Nigeria's food security and improve the livelihood of most households as an income portfolio. However, women are more beneficial because among the Fulani communities, cattle sales belongs to the man while daily sales of milk and other dairy products is an exclusive preserve for women which boost their sustainable livelihood where ever there are settlements.

The gap between supply and demand for dairy products is widening as a result of increase in population and urbanization. Imports used to bridge part of the gap have been declining as a result of the devaluation of the Nigerian naira (₦) (US$ 1 = ₦375 in 2017) and reduction in the importation of milk powder and butter oil on which the local dairy plants depended. Consequently, local collection, processing and marketing of milk is becoming increasingly competitive, such that only few Nigerians can afford the imported reconstituted dairy products. This scenario has prompted a major shift in consumption pattern from imported to local sources by a greater populace especially in areas where these local products are available. From the supply side, most of the available supply of fresh milk is in Northern Nigeria due to its larger population of cattle and some semi-temperate areas around Plateau state, Mambilla and Obudu grass Plateau in Cross River State because of their conducive weather conditions.

In Nigeria, the major challenge to the consumption of these locally available dairy products is the poor state of sanitation associated with the milking and handling processes, considering the highly perishable nature of dairy output especially within our tropical conditions. Dairying in Nigeria is a family business often operated at subsistence level without regard to quality control [3]. Milk, being a perishable commodity demands strict hygienic control. Small quantities of milk produced by smallholders or pastoral herds can be collected, processed and supplied to urban centres. However, there are still some problems regarding seasonal fluctuations in production and objection to consumption due principally to hygienic control. The lactating cows of the Fulani's and a few elite pastoralists are usually under poor veterinary care and are not vaccinated against disease under the prevailing pastoral systems. Eka and Ohaba [7] had shown that "nono" (sour milk) fermented milk sold by Fulani milk vendors were highly contaminated with microorganisms. Another report by Umoh [8] had it that about 99% of fura-da-nono, a cereal food made from fermented milk is contaminated with staphylococci. Ibeawuchi and Dalyop [3] also reported high contamination of fresh milk sold by Fulani milk vendors around Jos Plateau. The present

study was carried out to assess the quality of fresh cow milk within the Obudu grass Plateau – Cross River State.

Materials and Methods

Description of the study area

This study was carried out at Obudu grass Plateau. The Plateau is found on the Oshia ridge of the Sankwala Mountains in Obanliku Local Government Area of Cross River State, South-South Nigeria. It lies between 6^0 15^1N; 6^0 30^1N and $9^0 15^1$E; 9^0 30^1E with an approximate area of 24 km^2 and an elevated height of 1,576 m above sea level [9]. Obudu grass Plateau is bounded in the North by Benue State, Northeast by the Republic of Cameroon, and Southwest by Boki Local Government Area in Cross River State. The Plateau is situated within the tropics with Gotel mountains with grassland mixed with leguminous woodlands to form a distinctive sub-montane vegetation on a Precambrian Basement Complex with tall grasses interspersed with trees, while riparian forest with tall trees occupy river valleys [10]. The climate on the Plateau is comparatively cold, being semi-temperate with temperature range of 15 – 23^0C during the dry season of November to February and 4 – 10^0C during the rainy season from June to September. The Plateau has a mean rainfall of 2000 – 3100 mm/annum. The Plateau is hosted by a group of villages administratively called the Obudu Mountain Resort Support Communities. The communities are divided into two blocks. The first block is those communities located at the top of the mountain (Belegete, Baggo, Anape, Kotele, Utal-ugar and Kigol). The second block consists of these communities that are host to the Resort's ancillary infrastructure such as the Bebi Airstrip, Utanga Safari lodges and the water park (Utanga, Bebi 1,2,3 Keyi, Gundaha and old Ikwette). The communities are mainly agrarian and hunters who depend on what the land and forest offers.

Animal Management

Majority of cattle in the study area is the Bunaji (White Fulani), which is the predominant breed kept by the Fulanis within the Plateau. However, there exist some crosses between White Fulani, Sokoto Ghudali and some exotic breeds kept by the Ranching Company. The management system is strictly extensive (pastoral) as practiced including a few elite pastoralists who are locals and have ventured into cattle keeping as a business from interaction with the Fulanis over the years. The animals are taken out for grazing on natural pasture early in the morning and herded to their holding pens within the kraals in the evening. In some ranges, animals are allowed to graze all night and only come back to the kraal for milking/suckling of calves in the morning.

Animals that are detected to be sick, very young calves and probably those too weak to graze are left behind in the kraal under the supervision of children or watch dogs. Calves are not allowed to run with the dams for increased milk yield and are also confined to holding pens or tethered until after milking in the morning. Milking is usually carried out every morning by women/children and at times assisted by the men before allowing the animals go out for grazing. Women thereafter take the excess milk (after household use) and deliver to the market either as fresh or locally processed products. Generally, animals received no form of supplementary feeding besides grazing and are usually not vaccinated against diseases. They are rarely dewormed but occasionally sprayed with mild acaricides to control ticks and other ectoparasites. With the poor veterinary care, antibiotics are commonly abused with rampant cases of injection abscesses.

Milk sampling

Milk samples were taken in the rainy season (20^{th} – 25^{th} August, 2017). A total of 160 fresh samples were obtained from different milk vendors in four locations of the Obudu grass Plateau. Forty 250 ml samples were obtained from each location within the Plateau (Utal-ugar, Anape, Gundaha and Keyi). All sampling was carried out within 5 days due to the number of fresh milk vendors in these locations. Samples were collected in properly labeled sterile plastic bottles between 8:00 and 9:30am each day because of the distance and stored immediately in ice-packed coolers before transferring to a deep freezer at - 5^0C. The samples were later transported to the Department of Animal Production and Livestock Management Laboratory, Michael Okpara University of Agriculture, Umudike and stored in a deep freezer (frozen at -5^0C) until required for analysis.

Analytical Procedure

Milk samples were analysed for total solids (TS), crude protein (CP), butterfat, solids-non-fat (SNF), ash, lactose and pH. TS were obtained by drying about 5.0 g milk sample to a constant weight at 105^0C for 24 hours. Butterfat was estimated by the Rose-Gottlieb method as described by the [11] procedure. Milk protein (N x 6.38) was determined using the semi-micro distillation method using Kjeldahl and Markham's apparatus. Ash content was obtained by drying and ashing a weighed milk sample (10 ml) to a constant weight at 550 ^{0}C for 48 hours. Lactose content was determined from fresh samples using standard procedure. The difference between TS and butterfat gives the SNF. The pH of milk samples was determined using a pH meter (Pocket sized, pH–107 ROHS).

Milk samples were assessed for bacteriological quality using the Standard plate count, the Methylene blue dye reduction test [12] and the direct microscopic count. In the Standard plate count, colonies of bacteria were counted after incubation of a diluted milk sample in a petri-dish containing a standard agar at 37 ^{0}C for 48 hours. One ml of diluted solution of methylene blue dye was added to 10 ml of milk in a test tube; this was set in the incubator at 37.6 ^{0}C and examined at 2 minutes intervals for colour change. The Direct microscopic count was carried out using 0.01 ml of the milk sample spread uniformly over a ruled area of 1cm^2 on a glass slide. This was examined under oil immersion objective previously calibrated to determine the area of the field. Data were subjected to analysis of variance (ANOVA) using the SAS system [13] and significant means were separated using Duncan's Multiple Range Test (DMRT) [14].

Results and Discussion

The result of mean values (%) of chemical composition of TS, CP, fat, SNF, ash, Lactose and pH of milk samples from the four locations (Utal-ugar, Anape, Gundaha and Keyi) is presented in Table 1. Analysis of variance showed that the CP, fat, SNF, ash, Lactose as well as the pH of the samples did not differ ($P > 0.05$) significantly between the locations. This result is in line with the report of Ibeawuchi and Dalyob [3]. However, mean values for TS did not differ significantly ($P> 0.05$) between locations. Utal-ugar and Anape values 12.78 ±1.14 and 12.72 ±1.8% respectively were higher compared to that of Gundaha and Keyi which was 12.21 ±1.12 and 12.34 ±1.19% respectively. Utal –ugar and Anape enjoy the complete semi-temperate weather of the Obudu hills, while Gundaha and Keyi are the adjoining ranges to the Plateau. However, comparable values of TS have been reported for cows reared in the Jos Plateau and its environs [15; 16]. These results are however comparable but numerically lower to that obtained in this study for Obudu grass Plateau which is in line with the report of [17].

The TS (%) values obtained for the Obudu grass Plateau were comparable to that reported by [18] 12.65 and 12.55% for Sokoto Ghudali and Bunaji cattle respectively, in New Bussa, Niger State. Butterfat is useful in the production of butter, cheese and other milk products such as yoghurt etc. The fat values varied from 5.52% for Utal-ugar location to 4.98% for that of Keyi. The butterfat, CP, ash and lactose values were similar to those reported for Bunaji cattle [15; 3; 17; 18] and Bunaji X Friesian cattle [16]. The slight variation in protein content between the locations may have resulted from the metabolic activities of bacteria present in the milk. Gundaha recorded the highest value for protein content (5.98%) compared to other locations, 5.74% (Utal-ugar), 5.71%, (Anape) and 5.88% (Keyi). This could be attributed to the location of Gundaha (Bebi) which is slightly down the Plateau while other locations were really up the Plateau. As such the temperature or weather conditions are not cool enough and will definitely encourage more metabolic activities in milk samples compared to other locations within the Plateau. This report is in line with that of Ibeawuchi and Dalyop [3] within the Jos Plateau environs. The absence of major changes in the percentage fat content of milk is not expected as fat is the last major milk constituent to be used as substrate for micro biota of milk. It has been reported [19; 3] that fat is usually not destroyed until the slower growing fungi must have replaced bacteria, by which time complete spoilage and rancidity occurs, making it impossible to identify the original medium as milk. However, in cattle, fat seem to be the most variable component while minerals and lactose are the least variable [20]. However, genetic differences, within breed differences, plane of nutrition etc. are several factors that affect milk composition. Milk fat from Utal-ugar and Anape locations/markets were higher than those of Gundaha and Keyi. Cattle in the first two locations are exposed to available green pasture all year round because these locations exist on top of the Plateau, thus, are in a better plane of nutrition; while Gundaha and Keyi are adjoining ranges as you get up the Plateau. Also majority of the cattle breeds in and around the Plateau, though predominantly Bunaji, but several crosses exist between Bunaji X Sokoto Ghudali as well as some exotic breeds (South Devon) managed by the Ranching company.

Results of the bacteriological quality test of the milk samples from the various locations or markets are presented in Tables 2 and 3. Milk quality was assessed and classified on the basis of methylene blue dye reduction time. The results showed that only 27.5, 35, 15 and 22.5% of the Utal-ugar, Anape, Gundaha and Keyi market/location samples respectively were rated good samples, while 32.5, 27.5, 37.5 and 35 % in the same order as locations respectively were rated poor. Hence, Anape, Utal-ugar, Keyi and Gundaha in that order were poor. Gundaha recorded the highest percentage of poor samples; this could probably be due to the time interval involved in trekking to point of putting the samples into a deep freezer compared to other locations within the grass Plateau. However, the values obtained for the poor location were slightly lower compared with that of [3] for milk within the Jos Plateau area. Also the total number of good samples obtained in this study was encouraging and better compared to that obtained by Ibeawuchi and Dalyop [3], which one can deduce that fresh milk sampled from Obudu grass Plateau was probably hygienically collected and handled better and could be of better quality compared to that of Jos Plateau. The mean values for total bacteria counts are presented in Table 3. The high mean bacterial count values could be responsible for the poor quality of the milk samples from the

various locations. John [21], [16] and [3] had reported that in the methylene blue dye reduction test, the relationship between reduction time and viable counts was greatest with high count milk. The bacteria counts obtained by the agar plate in Gundaha and Keyi locations were high compared to Utal-ugar and Anape markets. Also the direct microscopic count method also showed the same trend as the agar plate count, which points to the same direction of confirming the poor quality of the milk samples in the various locations or markets. The pH of milk samples were similar and did not show any variation in this study. However, the pH of milk is an indicator of quality, because milk tends to become acidic principally due to high microbial load [22].

Further investigations through oral interviews revealed that most milk harvesters did not bother to consciously wash the udder of cows before commencing milking. This could be a viable source of high bacterial load, which reduces quality. In the study of milk handling by [23], only 11% of milk vendors practiced hand and udder drying; a percentage too low and concluded that udder swaps are a major source of contamination of milk which corroborates the result of this study. Poor hygiene of utensils and handling further aggravates this problem of compromising quality. The mean agar plate count obtained in this study compared favourably with the value of 2.48×10^6 reported by [24] in milk samples stored at $4\ ^0C$ and 2.54×10^6 reported by [3] for milk samples stored at $-\ 5^0C$ which indicates clearly that the high bacterial counts was a reflection of poor hygiene observed in this study. The values for the direct microscopic count is actually higher than the values obtained by the agar plate count which is in agreement with the reports of [7], [8], [3] and [23].

Results of this study have shown that fresh cow milk sold by Fulani milk vendors in Obudu grass Plateau – Cross River State is highly contaminated with several microbes. However, this could probably be due to poor milking hygiene was well as poor handling of harvested milk. Ibeawuchi and Dalyop [3] had advised that the interval between milking and delivery to market/selling points be reduced as this could limit the time for microbial growth and multiplication. This study also accept this position, but it could take plenty of extension efforts to convince the Fulani vendors on this aspect since milk sales is controlled by women and the distance to markets without adequate transportation in most cases not motorable possess a challenge like was observed in the Obudu grass Plateau. Fresh cow milk should be pasteurized by boiling before consumption (3). It is common practice among the nomads found in Obudu grass Plateau that animals are not vaccinated against diseases, deworming is rarely practiced, and the control of ticks and other ectoparasites is poor. Poor health of the animals despite the conducive semi-temperate climate in the Obudu grass Plateau would translate to poor quality milk. However, the acceptable viable count for pasteurized milk that should be consumed should not exceed 30,000 organisms/ml of milk [12; 3; 16]. Milk is known to harbour a lot of disease causing microbes including toxigenic fungi that are of public health concern, notably brucellosis a worldwide zoonotic disease [25; 26]; staphylococcal food poisoning that causes foodborne intoxication worldwide [27] and mycotoxins [28]. Transmission to humans is by the consumption of contaminated milk or milk products. These diseases could be threatening because of mobility of pastoralists. In Nigeria several pastoralists have been displaced from their settlements due to terrorism, numerous conflicts and raids.

Table 1: Chemical composition of fresh milk samples taken from four (4) locations

	Milk constituents (Mean +SD)						
Location (market)	%Total solids (TS)	%Crude protein (CP)	%Fat	% Solids non-fat (SNF)	%Ash	%Lactose	pH
Utal-ugar	12.78±1.14	5.74± 0.10	5.52±0.25	7.26±1.02	0.11±0.03	1.41±0.07	6.88±0.26
Anape	12.72±1.18	5.71±0.17	5.55±0.27	7.17±0.98	0.13±0.05	1.23±0.11	6.81±0.34
Gundaha	12.21±1.12	5.98±0.13	4.95±0.24	7.26±1.03	0.16±0.07	1.12±0.13	6.98±0.32
Keyi	12.32±1.19	5.88±0.11	4.98±0.25	7.36±0.92	0.17±0.02	1.31±0.15	6.75±0.21

Table 2: Methylene blue dye reduction test of fresh milk sampled from four (4) locations

Location (Market)	N	Good	%	Fair	%	Poor	%
Utal-ugar	40	11	27.50	16	40.00	13	32.50
Anape	40	14	35.00	15	37.50	11	27.50
Gundaha	40	6	15.00	19	47.50	15	37.50
Keyi	40	9	22.50	17	42.50	14	35.00

N = Number of samples

Table 3: Bacterial count (Mean) of fresh milk sampled from four (4) locations

Location (Market)	Agar plate count*	N	Direct Microscopic Count	N
Utal-ugar	1.95×10^6	15	3.24×10^6	40
Anape	1.55×10^6	15	2.98×10^6	40
Gundaha	2.84×10^6	15	4.31×10^6	40
Keyi	2.23×10^6	15	3.55×10^6	40

n = Number of samples
* = Number of cells per ml

Conclusion and Application

1. It can be concluded that the Obudu grass Plateau could serve as a potential business hub for procuring fresh milk by dairy companies.
2. The chemical composition and quality of fresh cow milk from the four locations in the grass Plateau were not 100% wholesome, due to poor milking hygiene and handling.
3. The Fulani milk vendors and consumers are strongly advised to pasteurize fresh milk before consumption.
4. Early morning delivery of the fresh milk in cool chambers to the market locations by the milk vendors should be encouraged.
5. Further investigations should be carried out on milk samples in various milk producing locations in Nigeria, so as to ascertain the microbial status of milk and milk products in relation to zoonoses especially the milk from local Fulani vendors.

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