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RESEARCH ARTICLE

MICROBIOLOGICAL EVALUATION OF MADARA, KINDRIMO, NONO, AND MANSHANU; MILK PRODUCTS SOLD IN ABUJA, NIGERIA

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ABSTRACT

Background: Raw milk (Madara) and its products namely, Kindrimo, Nono and Manshanu sold in Abuja are ready-to-eat meals which do not readily undergo minimal processing. Thus, it could possibly be contaminated with food-borne pathogens. This microbial contamination could pose public health risk. **Methods:** Three hundred milk samples were microbiologically examined using appropriate culture media for isolation and enumeration of bacteria pathogens associated with milk contamination. **Results:** The counts of *E. coli* for Madara, Kindrimo, Nono and Manshanu were 1.75, 1.63, 1.56, and 1.31 x10^7 cfu/ml, *Staphylococcus aureus;* 1.7, 1.04, 1.29 and 1.41 x 10^7cfu/ml, *Salmonella* sp;1.05, 0.61, 1.15 and 0.50 x 10^7cfu/ml, *Shigella*sp;.0.65, 0.68, 0.26 and 0.35 x 10^7cfu/ml, coliforms; 2.25, 1.92, 2.11 and 1.98 x 10^7cfu/ml, and 2.59, 2.31, 2.02 and 2.43 x 10^7cfu/ml for Total Viable Count (TVC). There was no statistically significant difference ($p > 0.05$) in the counts of *E. coli* and Total Viable Counts across the six Area Councils and milk types, there was no statistically significant difference ($p>0.05$) in the counts of *Staphylococcus aureus* and *Salmonella* sp across the six Area Councils but there was statistically significant difference of *Staphylococcus aureus* and *Salmonella* sp ($p < 0.05$) in the milk types. There was statistically significant difference ($p < 0.05$) in the counts of *Shigella* sp across the six Area Councils and milk types, and in the coliform counts across the six Area Councils but there was no statistically significant difference of coli forms ($p > 0.05$) in the milk types. **Conclusion:** The milk products are nutritious dairy meals consumed by the populace but the presence of bacteria pathogens in these milk products is an indication of risk to public health. Standard hygiene practice and processing in all stages is important to improve microbiological quality of these milk products.

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INTRODUCTION

Milk has distinct physical, chemical and biological characteristics. Its colour, odour, taste and consistency present a favourable environment for the multiplication of bacteria of various genera (Lues *et al*., 2010). Previous studies have detected food-borne pathogens such as *Campylobacter jejuni*, shiga-toxin *Escherichia coli* (STEC), *Salmonella* sp, *Staphylococcus aureus*, *Escherichia coli*, *Micrococcus* sp, *Pseudomonas* sp, *Enterobacter* sp, *Klebsiella* sp, *Listeria monocytogenes, Brucella* sp, *Proteus* sp and *Yersinia enterocolitica* from raw milk (Adesiyun *et al.,* 1997; Oliver *et al*., 2005; Mailafia *et al*., 2017). Milk borne human infections and diseases ranging from mild to bloody diarrhoea, diarrhoea-associated hemorrhagic colitis, hemolytic uremic syndrome (HUS) caused by *Escherichia coli* (STEC), food poisoning caused by *Staphylococcus aureus*. septicaemia meningitis in humans and spontaneous abortion or stillbirth in pregnant women, caused by *Listeria monocytogenes*, infectious diarrhea, gastritis and septicaemia caused by *C. jejuni* which have been reported (Evans *et al*., 1996; Adesiyun *et al*., 1997; Karmali, 2004). Poor sanitary practices on dairy farms and water quality are believed to contribute to the contamination of milk and poor milk quality (Adesiyun *et al*., 1997). Nono, Kindrimo, Manshanu and Madara are local dairy products that are widely consumed as food in many parts of Nigeria, especially in the Northern part where there is plenty of cow and other milk producing animals. Raw milk is drawn from cow at the homestead in their settlements as the quality and shelf-life of the milk and its products are not given serious thought. The raw milk (Madara) itself is usually sold on demand to consumers and the bulk of it is processed into constituent products (Nono, Kindrimo and Manshanu) and transported through long distances where these products are sold to rural and urban dwellers as food. Nono is a watery fermented milk product prepared from unpasteurised cow milk collected in a calabash or plastic container where the milk undergoes natural fermentation for 24 hours (Olasupo *et al*., 1996). Kindrimo is a semi-solid fermented milk prepared by heating raw milktoboiling point, then overnight milk portion is added to it and left to coagulate (Odunfa, 1988). Manshanu is produced by boiling raw milk, the milk is left to cool and the cuddled portion is extracted which has a buttery flavor and yellowish. (Olasupo*et al*., 1996). Madarais the freshly collected unfermented cow milk obtained from healthy or asymptomatic animals that may habour various proportions of microorganisms that could cause human diseases (Ogbonna *et al*., 2012). The study seeks to determine the microbiological quality of raw milk and its products sold in Abuja by screening for the presence of prevalent bacteria pathogens associated with food-borne diseases.

MATERIALS AND METHODS

Sample collection: A total of 300 milk samples were collected at different points across the six Area Councils in Abuja. Fifty milliliters (50ml) each were collected under aseptic conditions in clean sterile bottles. They were kept in an ice box, taken to the laboratory for analysis immediately. Ten milliliters of each milk samples were aseptically transferred into 90ml of peptone water broth, homogenized by hand shaking for 5minutes followed by further serial dilutions up to 10^7 concentrations. A 0.1mlquantity of the diluted sample was used to inoculate freshly prepared media for the isolation and enumeration of the organisms.

Isolation and enumeration of *Escherichia coli:* Eosin methylene blue Agar(EMBA) media was sterilized by autoclaving at 121^0C for 15minutes. The serially diluted samples were inoculated on the agar plate by spread method and incubated at 37^0C for 24hours.Typical colonies with greenish metallic sheen were identified as *Escherichia coli*. Colonies were further sub-cultured by streak method to obtain pure bacterial isolates followed by Gram staining and biochemical characterization (Macfaddin, 2000).

Isolation and enumeration of *Staphylococcus aureus:* Baird Parker Agar(BPM)was sterilized by autoclaving at 121^0C for 15minutes. The serially diluted samples were inoculated on the sterile BPM plate by spread method and incubated at 37^0C for 24hours.Typical colonies with Grey-black with or without halo were presumptively identified as *Staphylococcus* sp and coagulase test was done to further characterize *Staphylococcus aureus* (Macfaddin, 2000).

Isolation and enumeration of *Salmonella* sp *and Shigella* sp*:*** Deoxycholate Citrate Agar (DCA) media was sterilized over a gauze as specified by the manufacturer. The serially diluted samples were inoculated on the DCA plate and incubated at 37^0C for 24hours. Typical colonies with black centres were identified as *Salmonella* sp. Pinkish colonies were identified as *Shigella* sp and each subjected to further biochemical screening (Macfaddin, 2000).

Isolation and enumeration of coliforms: The serially diluted samples were inoculated on sterile MacConkey agar plates and incubated at 37^0C for 24hours.Typical pinkish colonies were identified as coliforms.

Total Viable Count (TVC): The serially diluted samples were inoculated on sterile nutrient agar plates and incubated at 37^0C for24hours and subsequently examined for visible aerobic colonies.

Biochemical characterization of isolates: Biochemical tests for identification of the isolates were, Indole test, Methyl-red, Voges-Proskauer test, Citrate utilization test, Triple Sugar Iron (TSI) test, Urease test, Oxidase test, Coagulase and Catalase tests as described by Cheesbrough (2006) and confirmatory tests were done according to Holt (1994).

Statistical analysis: The data in this study was analyzed using the statistical package for social sciences (SPSS) version 20.0. The value of $P \leq 0.05$ was considered statistically significant difference (SPSS, 2012).

RESULTS

Escherichia coli* count (x 10^7cfu/ml):** The counts of ***Escherichia coli for Madara, Kindrimo, Nono and Manshanu were between 1.03 and 2.51, 1.08 and 2.15, 1.17and 2.31, 1.02 and 1.84 across the Area Councils (Table 1) with overall counts of 1.75, 1.63, 1.56 and 1.31 respectively(Table 1).There was no statistically significant difference of *E. coli* across the Area Councils and milk types (AC's $F_{5,15}$ = 2.66, P=0.065 and Milk Types $F_{3,15}$ = 1.414, P= 0.278).

***Staphylococcus aureus* count (x 10^7cfu/ml):** The counts of *Staphylococcusaureus* for Madara, Kindrimo, Nono and Manshanu were between 1.15 and 2.14, 0.65 and 1.73, 0.56 and 1.73, 0.96 and 2.09 across the Area Councils with overall counts of 1.7, 1.05, 1.18 and 1.41 respectively (Table2). There was no statistically significant difference of *Staphylococcus aureus* across the Area Councils while there was statistically significant difference of *Staphylococcus aureus* in the milk types (AC's $F_{5,15}$ = 2.33, P= 0. 093 Milk Types $F_{3,15}$= 3.642, P=0.037).

***Salmonella* sp count (x 10^7cfu/ml)**: The counts of *Salmonella* sp for Madara, Kindrimo, Nono and Manshanu were between 0.41 and 1.70, 0.19 and 1.18, 0.50and 1.65, 0.10 and 0.93 across the Area Councils with overall countsof1.05, 0.61, 1.15 and 0.50 respectively (Table 3).There was no statistically significant difference of *Salmonella* spa cross the Area Councils while there was statistically significant difference in the milk types (AC'sF $_{5,15}$ = 1.652, P= 0.207, Milk Types $F_{3,15}$=4.335, P= 0.022).

***Shigella* sp count (x 10^7cfu/ml):** The counts of *Shigella* sp for Madara, Kindrimo, Nono and Manshanu were between 0.32 and1.17, 0.22and 1.31, 0.15 and 0.39, 0.00 and 1.15 acrossthe Area Councils with overall counts of 0.65, 0.68, 0.26 and 0.35 respectively (Table 4). There was statistically significant difference of *Shigella* spa cross the Area Councils and milk types (AC's =$F_{5,15}$ = 4.136, P= 0.015, Milk Types $F_{3,15}$ =3.666, P= 0.031).

Coliform count (x 10^7cfu/ml): The coliform counts for Madara, Kindrimo, Nono and Manshanu were between 1.41 and 3.19,1.05 and 2.91, 1.01 and 3.33, 1.00 and 3.08 across the Area Councils with overall counts of 2.25, 1.92, 2.11 and 1.98 respectively(Table5).There was statistically significant difference of coliforms across the Area Councils but there was no statistically significant difference in the milk types (AC**'s** $F_{5,15}$ = 3.299, P= 0.033, Milk Types $F_{3,15}$= 0.307, P= 0.820).

Total Viable Counts (TVC)(x 10^7cfu/ml): The TVC for Madara, Kindrimo, Nono and Manshanu were between 1.62 and 3.48, 1.57 and 4.10, 1.70 and 2.37, 2.11 and 3.01 across the Area Councils (Table 6) with overall TVC of 2.59, 2.31, 2.02 and 2.43 respectively.

Table 1. Counts of *Escherichia coli* (cfu/ml) from milk samples across the six Area Councils of FCT

Escherichia coli				
Area Council	Madara	Kindrimo	Nono	Manshanu
Abaji	1.50×10^7	1.22×10^7	1.42×10^7	1.61×10^7
Abuja Municipal	2.51×10^7	1.98×10^7	2.31×10^7	1.84×10^7
Bwari	2.24×10^7	2.01×10^7	1.17×10^7	1.02×10^7
Gwagwalada	1.03×10^7	2.15×10^7	1.28×10^7	1.29×10^7
Kuje	1.80×10^7	1.08×10^7	1.72×10^7	1.03×10^7
Kwali	1.39×10^7	1.34×10^7	1.45×10^7	1.07×10^7
Total	1.75×10^7	1.63×10^7	1.56×10^7	1.31×10^7

Key: FCT = Federal Capital Territory, AC = Area Council AC's $F_{5,15}$ = 2.66, P=0.065Milk Types $F_{3,15}$ = 1.414, P= 0.278

Table 2. Counts of *Staphylococcus aureus* (cfu/ml) from milk samples across the six Area Councils of FCT

Staphylococcus aureus				
AC	Madara	Kindrimo	Nono	Manshanu
Abaji	1.15×10^7	1.11×10^7	1.04×10^7	1.26×10^7
Abuja Municipal	2.14×10^7	1.73×10^7	1.65×10^7	1.13×10^7
Bwari	1.44×10^7	1.00×10^7	1.59×10^7	1.27×10^7
Gwagwalada	1.84×10^7	1.00×10^7	1.73×10^7	2.09×10^7
Kuje	1.77×10^7	0.8×10^7	1.01×10^7	1.74×10^7
Kwali	1.86×10^7	0.65×10^7	0.56×10^7	0.96×10^7
Overall	1.7×10^7	1.05×10^7	1.18×10^7	1.41×10^7

Key: FCT = Federal Capital Territory, AC = Area Council **AC's** $F_{5,15}$ = 2.33, P= 0. 093 Milk Types $F_{3,15}$= 3.642, P=0.037

Table 3.Counts of *Salmonella* sp (cfu/ml) from milk samples across the six Area Councils of FCT

Salmonella sp				
AC	Madara	Kindrimo	Nono	Manshanu
Abaji	1.24×10^7	1.12×10^7	1.03×10^7	0.10×10^7
Abuja Municipal	1.70×10^7	1.18×10^7	1.65×10^7	0.57×10^7
Bwari	1.27×10^7	0.31×10^7	0.50×10^7	0.93×10^7
Gwagwalada	1.11×10^7	0.19×10^7	1.15×10^7	0.60×10^7
Kuje	0.41×10^7	0.28×10^7	1.18×10^7	0.40×10^7
Kwali	0.55×10^7	0.59×10^7	1.38×10^7	0.42×10^7
Overall	1.05×10^7	0.61×10^7	1.15×10^7	0.50×10^7

Key: FCT = Federal Capital Territory, AC = Area Council, AC'sF $_{5,15}$ = 1.652, P= 0.207, Milk Types $F_{3,15}$=4.335, P= 0.022

Table 4.Counts of *Shigella* sp (cfu/ml) from milk samples across the six Area Councils of FCT

***Shigella* sp**				
AC	**Madara**	**Kindrimo**	**Nono**	**Manshanu**
Abaji	0.46×10^7	0.49×10^7	0.21×10^7	0.40×10^7
Abuja Municipal	1.17×10^7	1.31×10^7	0.35×10^7	1.15×10^7
Bwari	0.51×10^7	1.10×10^7	0.39×10^7	0.21×10^7
Gwagwalada	0.32×10^7	0.42×10^7	0.26×10^7	0.00×10^7
Kuje	0.38×10^7	0.55×10^7	0.20×10^7	0.24×10^7
Kwali	1.06×10^7	0.22×10^7	0.15×10^7	0.11×10^7
Overall	0.65×10^7	0.68×10^7	0.26×10^7	0.35×10^7

Key: FCT = Federal Capital Territory, AC = Area Council AC's **=**F $_{5,15}$ = 4.136, P= 0.015, Milk Types $F_{3,15}$ =3.666, P= 0.031

Table 5. Counts of Coliforms (cfu/ml) from milk samples across the six Area Councils of FCT

Coliforms				
AC	**Madara**	**Kindrimo**	**Nono**	**Manshanu**
Abaji	2.07×10^7	1.19×10^7	1.08×10^7	1.00×10^7
Abuja Municipal	3.00×10^7	2.13×10^7	1.01×10^7	2.49×10^7
Bwari	3.19×10^7	2.91×10^7	3.33×10^7	3.08×10^7
Gwagwalada	2.00×10^7	1.63×10^7	2.22×10^7	1.94×10^7
Kuje	1.41×10^7	1.05×10^7	3.10×10^7	2.19×10^7
Kwali	1.85×10^7	2.63×10^7	1.90×10^7	1.18×10^7
Overall	2.25×10^7	1.92×10^7	2.11×10^7	1.98×10^7

Key: FCT = Federal Capital Territory, AC = Area Council(AC**'s** F $_{5,15}$ = 3.299, P= 0.033, Milk Types $F_{3,15}$= 0.307, P= 0.820).

Table 6. Total Viable Count of Bacteria Isolates (cfu/ml) from milksamples across the six Area Councils of FCT

Total Viable Counts				
AC	**Madara**	**Kindrimo**	**Nono**	**Manshanu**
Abaji	2.23×10^7	1.91×10^7	1.85×10^7	2.49×10^7
Abuja Municipal	3.03×10^7	4.10×10^7	1.70×10^7	2.11×10^7
Bwari	1.62×10^7	2.49×10^7	2.00×10^7	2.23×10^7
Gwagwalada	3.48×10^7	1.79×10^7	2.05×10^7	3.01×10^7
Kuje	2.90×10^7	1.57×10^7	2.37×10^7	2.48×10^7
Kwali	2.31×10^7	2.01×10^7	2.16×10^7	2.27×10^7
OVERALL	2.59×10^7	2.31×10^7	2.02×10^7	2.43×10^7

Key: FCT = Federal Capital Territory, AC = Area CouncilAC**'s** F $_{5,15}$ = 0.713, P= 0.623, Milk Types $F_{3,15}$ = 0.891 P= 0.469

There was no statistically significant difference of total viable counts across the Area Councils and milk types (AC**'s** $F_{5,15}$ = 0.713, P= 0.623, Milk Types $F_{3,15}$ = 0.891 P= 0.469).

DISCUSSION

Milk quality and food safety are very essential in the prevention and control of food borne pathogens commonly associated with raw milk and milk products. Unpasteurised milk is known to habour pathogens which may be present in counts high enough to cause health hazards to consumers (Adesiyun *et al*., 1997). Raw milk, Local yoghurt, fermented milk and butter ('Madara', 'Kindrimo', 'Nono', 'Manshanu'-local names) were investigated microbiologically for the presence of food pathogens such as *Escherichia coli*, *Staphylococcus* sp, *Shigella* sp, *Salmonella* spand other probable coliforms commonly associated with dairy products and milk borne diseases. The presence of *E. coli* in milk is usually associated with faecally contaminated milk and is a measure of unhygienic conditions and insanitary practices during the processing and handling of the milk products (Tharker *et al*., 2012).The counts of *E. coli* for Madara was greater than Kindrimo, and Nono was greater than Manshanu across the six Area Councils. Previous studies have reported counts of *E. coli* in raw milk (Adesiyun *et al*., 1997; Ogbonna *et al*., 2012; Meshref, 2013; Gundogan and Avci, 2014) (Trinidad and Tobago, Nigeria, Egypt and Turkey). The variations in the counts of *E. coli* are likely to be associated with factors such as season, geographical locations, hygiene, farm management practices, variation in types of samples evaluated and sampling techniques(Oliver *et al.,* 2005).

The counts of *E. coli* for Madara obtained in the study was higher than the counts of *E. coli* isolates that relates to raw milk (Madara) obtained by Lues *et al.* (2010) in South Africa, and higher than the South African standards for milk (absence of *E. coli* in 1ml of milk). The *E. coli* counts in this study was lower than the counts obtained by Ali and Abdegadir (2011) in Sudan. There was no statistically significant difference (P= 0.065) of the counts of *E. coli* across the Area Councils and milk types (P=0.278).Contrastingly, Ekici *et al*. (2004) and Uzeh *et al*. (2006) in (Turkey and Nigeria) respectively reported that *E. coli* was not detected in raw milk (Madara) sourced from cow and fermented milk (Nono). The present study revealed that *E.coli* was the predominant bacteria. This agrees with the reports obtained by Okonkwo (2011), Ogbonna *et al*. (2012) and Makut *et al*. (2014).*Staphylococcus aureus* are part of normal flora, and are primarily found in the nose and skin (Sivapalasingams *et al.,* 2004). Infections of the mammary gland (mastitis) represent a significant reservoir of toxigenic strains in raw milk (Meshref, 2013). *Staphylococcus aureus* have been commonly isolated from raw milk, milk products and meat products, and its isolation from the milk samples was not unexpected. The isolation of *S. aureus* is of public health significance due to its production of enterotoxin which causes intoxication and food poisoning in humans. Previous studies have reported the isolation of *Staphylococcus aureus* in milk products (Ekici *et al*., 2004; El- Zubeir and Ahmed, 2007; Meshref, 2013; Gundogan and Avci, 2014; Okeke *et al*., 2014; Mailafia *et al*., 2017). The counts of *Staphylococcus aureus* in this study agrees with the counts reported by El- Zubeir and Ahmed (2007). The counts of *Staphylococcus aureus* for Madara in this study waslower than the counts as it relates to fresh milk obtained by Okeke *et al*. (2014).Gundogan and Avci (2014) reported higher values than the limits of Turkish Food Codex (TFC). The counts of *Staphylococcus aureus* in Kindrimo in the present study was lower than the counts for Kindrimo obtained by Okeke *et al*. (2014). The counts of *Staphylococcus aureus* for fermented milk ('Nono') in this study conforms to the counts previously reported by Okonkwo (2011). The counts of *Staphylococcus aureus* in fermented milk ('Nono') was lower than counts obtained by Okeke *et al*. (2014). The counts of *Staphylococcus aureus* in the Manshanu related to cream was lower than counts of *Staphylococcus aureus* obtained by Meshref (2013). The variation in the counts could be attributed to geographical locations, sampling techniques, season, storage temperature and personal hygiene of the milk handlers. There was no statistically significant difference (P=0.093) of *Staphylococcus aureus* across the Area Councils while there was significant difference (P=0.037) of the *Staphylococcus aureus* in the milk types. Robinson (2002) stated that *S. aureus* counts in raw milk should not exceed the limit of 100 cfu/ml. The results generated in this study indicated that all of the samples tested would fail this criterion which highlights the factors that could contribute to the microbial contamination of the milk products. *Salmonella* spare ubiquitous in the environment. *Salmonella* sp live in the intestinal track of various animal species, including cattle, and therefore represent a major reservoir for human food-borne disease. Studies have reported the isolation of *Salmonella* sp in raw milk and milk products (Okonkwo, 2011; Ogbonna *et al*., 2012; Makut *et al*., 2013; Mailafia *et al.,* 2017). The counts of *Salmonella* sp for raw milk (Madara) and fermented milk (Nono) in the present study agrees with the counts of *Salmonella* sp previously obtained by Okonkwo (2011). In contrast, previous studies (Ekici *et al*., 2004; Uzeh *et al*., 2006; Hosein *et al*., 2008) (Turkey, Nigeria, Trinidad and Tobago) reported that *Salmonella* spwas not detected in raw milk (Madara). There was no statistically significant difference (P=0.207) of *Salmonella* sp across the six Area Councils while there was statistically significant difference (P=0.022) of *Salmonella* sp in the milk types. *Shigella* spis one of the enteric bacteria and a coliform used as an indicator for unhygienic practices in food. The isolation and counts of *Shigella* sp have been previously reported by Okonkwo (2011), and Ogbonna, *et al*.(2012).

The counts of *Shigella* sp for fermented milk (Nono) and butter (Manshanu) in the present study agrees with the counts of *Shigella* spfor fermented milk previously obtained by Okonkwo (2011). There was statistically significant difference (P=0.015) of *Shigella* sp across the six Area Councils and milk types (P= 0.031). Coliforms are often used as indicator microorganisms, the existence of coliforms may not necessarily indicate a direct faecal contamination of milk and cream, however it is an indicator of poor hygiene and sanitary practices during milking and further handling, and presents potential hazard for people consuming such products (Meshref, 2013). Coliforms in dairy products are associated with taste and texture failure, and their presence can affect the quality of the final product intended for selling or immediate consumption (Wessels *et al*., 1988). Studies have reported coliform counts in raw milk and milk products (Uzeh*et al*., 2006; El Zubier and Ahmed 2007; Lues *et al.,* 2010; Ogbonna *et al*., 2012; Meshref, 2013; Okeke *et al*., 2014). The coliform counts forKindrimo andManshanu obtained in the present study is similar with the Coliform counts for raw milk obtained in Egypt by Meshref (2013). Higher coliform counts were obtained in the previous studies by Uzeh *et al*. (2006) for Nono and Okeke *et al*. (2014) in fresh milk (Madara), Nono and Kindrimo. Lower coliform counts was obtained by Lues*et al*. (2010) which was still high when referenced with the South African standards of 20 cfu/ml (South Africa, 2001). Coliforms contribute significantly to the bacterial counts of milk and these organisms are predominantly associated with the environment and unhygienic practices (Boor *et al*., 1998; Murphy and Boor, 2000). There was statistically significant difference (P=0.033) of coliforms across the six Area Councils while there was no statistically significant difference (P= 0.820) of coliforms in the milk types. Total Viable Counts of raw milk and milk products have been reported (Uzeh *et al*., 2006; Lues *et al*., 2010; Ogbonna *et al*., 2012; Okeke *et al*., 2014). The Total Viable Counts for raw milk reported by Meshref (2013)partly agrees with the TVC for raw milk (Madara) in this study. Higher values of TVC for Nono were obtained by Uzeh *et al*.(2006) and Okeke *et al*. (2014). Lower values of TVC in raw milk was obtained by Lues *et al*.(2010) compared to the values in this study. The results of relatively high counts of microbes indicates contamination of raw milk and milk products. Possible reasons for the high counts could be attributed to the health state of the milk producing cows, lack of knowledge about clean milk production, use of unclean equipment, poor hygiene, lack of cooling after milking and lack of heat treatment, which contributes to the poor quality of raw milk and milk products (Meshref,2013). There was no statistically significant difference (P=0.623) of the Total Viable C count across the six Area Councils and milk types (P=0.469).

Conclusion

The raw milk (Madara) and milk products (Kindrimo, Nono and Manshanu) studied have revealed the presence of probable food-borne pathogens that are of public health concerns. It is important to develop basic hygienic measures for locally produced raw milk and milk products. Sensitizing the milk handlers on strict hygienic practices, adequate processing and proper storage are important steps in the process of milking, production and slaughtering to prevent food contamination and forestall deterioration.

Key Points

- Food of bovine origin are contaminated with food borne pathogens associated with outbreaks, thus the need for Good Agricultural Practices (GAP).
- Food producing animals are reservoirs of pathogenic microorganisms, providing information on the ecological niche and epidemiological insights of the pathogens.
- Adequate processing of milk products is important in the elimination of these pathogens in food.
- Establishment of acceptable microbial limits in food produce that are commonly consumed raw in developing nations.

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