

ORIGINAL ARTICLE

Bacteriological Quality of Raw Milk in Beni-Suef Governorate, Egypt

Arafa M.S. Meshref¹ · Gamal M. Hassan¹ · Mostafa A. Tamam^{2*}

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1 Food Hygiene Department,
Faculty of Veterinary
Medicine, Beni-Suef
University, Beni Suef 62511,
Egypt.

2 Postgraduate at Food
Hygiene Department, Faculty
of Veterinary Medicine, Beni-
Suef University, Beni Suef
62511, Egypt.

Correspondence

Mostafa A. Tamam,

Postgraduate at Food Hygiene
Department, Faculty of
Veterinary Medicine, Beni-Suef
University, Beni-Suef 62511,
Egypt.

Email:

mostafaagamy1908@gmail.com

Abstract

The aim of the study was directed to investigate the bacteriological quality of raw milk in Beni-Suef governorate, Egypt by conventional bacteriological methods. A total of 125 raw milk samples including 25 bulk tank milk of large dairy herds, 25 bulk tank milk of large dairy herd (after improving the environmental and pre milking sanitation), 25 milk samples from smallholder dairy herds, and 50 samples from milk shops, were collected from Beni Suef governorate, Egypt. All samples were examined for Total Bacterial Count (TBC), Psychrotrophic Count (PC), Total Coliform Count (TCC), Fecal coliform (FC), and *E. coli*. The mean values of TBC were $1.53 \times 10^7 \pm 6.27 \times 10^6$, $2 \times 10^6 \pm 6.58 \times 10^5$, $7.85 \times 10^6 \pm 3.95 \times 10^6$, $1.65 \times 10^7 \pm 4.32 \times 10^6$ cfu/ml, respectively. The mean values of PC were $2.83 \times 10^5 \pm 6.85 \times 10^4$, $8.98 \times 10^4 \pm 2.67 \times 10^4$, $6.85 \times 10^4 \pm 1.24 \times 10^4$, and $1.72 \times 10^5 \pm 3.79 \times 10^4$ cfu/ml, respectively. The mean values of TCC were $3.89 \times 10^5 \pm 1.38 \times 10^5$, $5.3 \times 10^4 \pm 3.07 \times 10^4$, $6.4 \times 10^5 \pm 1.57 \times 10^5$, $2.2 \times 10^6 \pm 6.87 \times 10^5$ MPN/ ml, respectively. The mean values of FC were $9.20 \times 10^3 \pm 1.82 \times 10^3$, $6.36 \times 10^2 \pm 1.9 \times 10^2$, $6.04 \times 10^3 \pm 1.57 \times 10^3$, $6.5 \times 10^3 \pm 1.08 \times 10^3$ MPN/ ml, respectively. The mean values of *E. coli* were $2.57 \times 10^3 \pm 6.11 \times 10^2$, $3.8 \times 10^2 \pm 2.48 \times 10^2$, $3.89 \times 10^3 \pm 7.36 \times 10^2$, $4.15 \times 10^3 \pm 5.44 \times 10^2$ cfu/ml, respectively. The results showed that improving sanitation significantly improved milk quality. High bacterial counts in raw milk especially *E. coli* constitutes a public health hazard to the consumers and emphasize the great need for an improved hygienic standard.

Keywords

E. Coli, Fecal Coliform, Psychotropic Bacteria, Raw Milk, Total Bacterial Count, Total Coliform Count,

1. Introduction

Milk is the most significant part of the human diet, and it is utilized in a variety of ways as food. It is not only natural nourishment for newborns, but also a source for a variety of dairy products consumed by humans. It plays a prominent role in meeting the essential human dietary requirements (protein, lactose, fat, minerals and vitamins) (**Dairy Facts 2003**). The highest demanded perishable food

products worldwide is milk. In 2019, milk global production increased 1.4 %, in total 852 million tones as reported by **FAO (2020)**. Although raw milk from a healthy udder contains very few bacteria, it picks up so many bacteria from the time it leaves the teats of the cow until it is used for further processing (**Tassew and Seifu 2011**).

Raw milk is produced mainly by solitary individuals in small farms that lack proper sanitary measures and

may be either consumed fresh, manufactured into dairy products or sell in retail markets that alarming as a major source of public hazard and represents a serious human health problem (El-Sayed et al. 2011). TBC is used to estimate the quality of raw milk, and has become one of the most accepted criteria for grading milk (Mhone et al. 2011). The legalized limits proposed by the Egyptian standards, recommended by the Egyptian organization for standardization and quality "EOSQ", SPC stated that raw milk must not exceed 1×10^5 cfu/ml (ES 2005).

Psychrotrophic bacterial contamination of raw milk is one of the key factors determining the quality of processed dairy products due to the heat-stable enzymes produced by these bacteria (Zhang 2020). Many countries use coliforms and *E. coli* as indicators of sanitary quality of foods and have set limits for raw milk, world widely. Coliforms and *E. coli* were found in different types of raw milk, with raw milk contained indicator levels $> 10^3$ cfu/ml have been attributed mostly to unsanitary conditions/production (Metz et al. 2020).

High bacterial count in raw milk represents a public health hazard to the consumers and necessitates the need for improving the application of hygienic standards. In this regard, this study was conducted to investigate the bacteriological quality of raw milk in Beni-Suef governorate.

2. Materials and Methods

2.1. Collection of samples

A total of 125 raw milk samples including 25 bulk tank milk of large dairy herds, 25 bulk tank milk of large dairy herd (after improving the environmental and pre milking sanitation), 25 milk samples from smallholder dairy producers and 50 samples from milk shops were collected from Beni-Suef governorate. The sanitation treatment consisted of washing of udder and teats, drying of udder, washing of milker's hand with tap water and soap, teat dipping before milking. Milk was directly cooled after milking, and milk samples were collected in sterilized tubes.

2.2. Preparation of samples

At first, the milk was thoroughly mixed just before sampling using sterile plunger (in case of small tanks) or mechanical agitator (in case of large tank) and the milk samples were taken in sterile sampling bottles under complete aseptic precaution. Each bottle was labeled to denote the date, time of sampling, number and the name of the farm. The samples were transferred directly to the laboratory in an insulated icebox without delay to be immediately examined.

Market raw milk samples were subjected to **storch's test lampert (1975)** to exclude all samples proved to be heat treated.

2.3. Microbiological examination.

2.3.1 Total bacterial count (TBC): was performed according to (APHA 1992a) using plate count agar (Oxoid, UK) for 48 ± 3 h after incubation at 32 ± 1 °C.

2.3.2. Psychrotrophic bacteria count PC: was performed according to (APHA 1992a).

2.3.3. Total coliform count using lauryl sulphate tryptose (LST) broth (APHA 1992a).

2.3.4. Fecal coliform count by using EC broth (APHA 1992a).

2.3.5. E.coli count by using Eosine Methylene Blue agar (EMB) (APHA 1992a).

3. Results

Table 1. Statistical analytical results of Total Bacterial Count (cfu/ml) in the examined samples

Samples	No. of sample	Min.	Max.	Mean	± SEM
Bulk tank milk	25	1.1×10^5	9×10^7	1.53×10^7	6.27×10^6
Bulk tank milk (after sanitation)	25	1.02×10^5	1.1×10^7	2×10^6	6.58×10^5
Smallholder dairy herd	25	5.7×10^4	9.5×10^7	7.85×10^6	3.95×10^6
Milk shops	50	7×10^4	9.5×10^7	1.65×10^7	4.32×10^6

Table 2. Statistical analytical results of Psychrotrophic bacterial count (cfu/ml) in the examined milk samples

Samples	No. of sample	Min.	Max.	Mean	± SEM
Bulk tank milk	25	1.17×10^4	1.5×10^6	2.83×10^5	6.85×10^4
Bulk tank milk (after treatment)	25	1×10^4	7×10^5	8.98×10^4	2.67×10^4
Smallholder dairy herd	25	1.02×10^4	2.97×10^5	6.85×10^4	1.24×10^4
Milk shops	50	1×10^4	9.5×10^6	1.72×10^5	3.79×10^4

Table 3. Statistical analytical results of total coliform count (MPN/ml) in the examined samples

Samples	No. of sample	Min.	Max.	Mean	± SEM
Bulk tank milk	25	1.5×10^3	2.1×10^6	3.89×10^5	1.38×10^5
Bulk tank milk (after sanitation)	25	1.5×10^3	7.5×10^5	5.3×10^4	3.07×10^4
Smallholder dairy herd	25	2.1×10^3	2.1×10^6	6.4×10^5	1.57×10^5
Milk shops	50	1.5×10^3	2.1×10^7	2.2×10^6	6.87×10^5

Table 4. Statistical analytical results of fecal coliform count (MPN/ml) in the examined samples

Samples	No. of sample	Min.	Max.	Mean	± SEM
Bulk tank milk	25	2.1×10	2.4×10^4	9.20×10^3	1.82×10^3
Bulk tank milk (after sanitation)	25	1.5×10	4.3×10^3	6.36×10^2	1.9×10^2
Smallholder dairy herd	25	2.4×10	2.4×10^4	6.04×10^3	1.57×10^3
Milk shops	50	1.5×10^1	2.4×10^4	6.5×10^3	1.08×10^3

Table 5. Statistical analytical results of *E. coli* count (MPN/ml) in the examined samples

Samples	No. of sample	Min.	Max.	Mean	± SEM
Bulk tank milk	25	< 3	9.3×10^3	2.57×10^3	6.11×10^2
Bulk tank milk (after treatment)	25	< 3	9×10^3	3.8×10^2	2.48×10^2
Smallholder dairy herds	25	< 3	9.5×10^3	3.89×10^3	7.36×10^2
Milk shops	50	< 3	1.5×10^4	4.15×10^3	5.44×10^2

4. Discussion.

It is evident from the results recorded in (Table 1) that the mean values of the total bacterial count (TBC) of milk obtained from bulk tank milk, bulk tank milk (after treatment), smallholder dairy herds and milk shops were $1.53 \times 10^7 \pm 6.27 \times 10^6$, $2 \times 10^6 \pm 6.58 \times 10^5$, $7.85 \times 10^6 \pm 3.95 \times 10^6$, $1.65 \times 10^7 \pm 4.32 \times 10^6$ cfu/ml respectively. Lower results of count were previously detected by **Dhuol and Osman 2014; El-Leboudy et al. 2014; Chimuti et al. 2016; Ferdous et al. 2017; Lan et al. 2017; Bousbia et al. 2018; Hahne et al. 2019; Chorfi et al. 2020; Tobar-Delgado et al. 2020; Deepthi and Siriwardhana 2021** for farm raw milk; and **Gomaa et al. 2008; El-Diasty and El-**

Kaseh 2009; Belli et al. 2013; Mekuria et al. 2014; Ntuli et al. 2016; El-Leboudy et al. 2017; Tekilegiorgis et al. 2018; Rai et al. 2020 for market samples. Higher results were mentioned by **Abou-Dawood 2005; El-Zubeir and Ahmed 2007; Worku et al. 2012; Bauzad et al. 2019** for farm raw milk; and **Hossain et al. 2011; Meshref 2013; Tesfay et al. 2013; Banik et al. 2014; Ibrahim et al. 2015; Kuma et al. 2015; Ebissa and Aki 2017; Bouymajane et al. 2019** for markets samples; and agree with **Dahal et al. 2010; Titouche et al. 2016; Yeserah 2019; Ebissa and Aki 2017; El-Shinawy et al. 2020** for farm raw milk; **Ombarak and Elbagory 2015; Senarth et al. 2017; Mchiouer**

et al. 2017; Acharya et al. 2018 for markets milk samples.

The Results illustrated in (Table 2) revealed that the mean values of the Psychrotrophic bacterial count (PC) in raw milk samples were $2.83 \times 10^5 \pm 6.85 \times 10^4$, $8.98 \times 10^4 \pm 2.67 \times 10^4$, $6.85 \times 10^4 \pm 1.24 \times 10^4$, $1.72 \times 10^5 \pm 3.79 \times 10^4$ cfu/ml in the examined milk obtained from bulk tank milk, bulk tank milk (after treatment), smallholder dairy herds and milk shops respectively. Lower results were mentioned by Chye et al. 2004; Pinto et al. 2006; Kumerasan et al. 2007; Ibrahim et al. 2008; Torkar and Teger 2008; Cempírková and Mikulová 2009; Lingathurai and Vellathurai 2013; Yuan et al. 2017; Ribeiro Júnior et al. 2018 for farm raw milk; and Kumerasan et al. 2007; Hossain et al. 2011; Elshaghabee et al. 2017 for market samples. Higher results were recorded by Amer et al. 2008 Nörnerberg et al. 2010 for farm raw milk; and Pinto et al. 2006; Amer et al. 2008 for market milk samples while similar results were recorded by Saad et al. 2013; Hahne et al. 2019.

The obtained results in (Table 3) showed that the mean values of total coliform count (TCC) in raw milk samples were $3.89 \times 10^5 \pm 1.38 \times 10^5$, $5.3 \times 10^4 \pm 3.07 \times 10^4$, $6.4 \times 10^5 \pm 1.57 \times 10^5$, $2.2 \times 10^6 \pm 6.87 \times 10^5$ MPN/ ml in the examined milk obtained from bulk tank milk, bulk tank milk (after treatment), smallholder dairy herds and milk shops respectively. Lower results in farm raw milk were previously recorded by Tesfay et al. 2013; El-Leboudy et al. 2014; M'hamdi et al. 2018; Nordin et al. 2019; Yeserah 2019; El-Shinawy et al. 2020; while Lower results in markets milk recoded by Ibrahim et al. 2015; El-Kholy et al. 2015; Ntuli et al. 2016; El-Leboudy et al. 2017; Tekilegiorgis 2018; Koirala et al. 2018; El-Kholy et al. 2018; higher results were reported by El-Diasty and El-Kaseh 2007; Saleh et al. 2013; Bousbia et al. 2018; Fathi et al. 2019 for farm samples; and El-Diasty and El-Kaseh 2009; Sheha 2014; Oluwafemi and Lawal 2015; Abd El-Ellah 2017 and Senarath et al. 2017 for market raw milk samples. The obtained results agree with those of Ali 2004; Srairi et al. 2006; Ferdous et al. 2017; Mchiouer et al. 2017 for farms; and Tesfay et al. 2013; Meshref 2013; Mohamed and El-Zubier 2007; Bouymajane et al. 2019 for markets sample.

The Results given in (Table 4) revealed that the mean values of the fecal coliform count (FC) in raw milk samples were $9.20 \times 10^3 \pm 1.82 \times 10^3$, $6.36 \times 10^2 \pm 1.9 \times 10^2$, $6.04 \times 10^3 \pm 1.57 \times 10^3$, $6.5 \times 10^3 \pm 1.08 \times 10^3$

MPN/ ml in the examined milk obtained from bulk tank milk, bulk tank milk (after treatment), smallholder dairy herds and milk shops respectively. Lower results were mentioned by Franciosi et al. 2009; Nádia et al. 2012; Belbachir et al. 2015; Titouche et al. 2016 in farm samples; and Dan et al. 2008; Titouche et al. 2016 for markets milk; higher result reported by Ali 2004; Zeinhom 2007; Worku et al. 2012; Ferdous et al. 2017; Bousbia et al. 2018 in farm samples; and Meshref 2013; Seddaoui et al. 2018 for market sample. The results agree with Chorfi et al. 2020 in farm samples and Bouymajane et al. 2019; Mchiouer et al. 2017 for markets sample.

It is evident from the results recorded in (Table 5) that the mean values of *E.coli* were $2.57 \times 10^3 \pm 6.11 \times 10^2$, $3.8 \times 10^2 \pm 2.48 \times 10^2$, $3.89 \times 10^3 \pm 7.36 \times 10^2$, $4.15 \times 10^3 \pm 5.44 \times 10^2$ MPN/ ml in the examined milk obtained from bulk tank milk, bulk tank milk (after treatment), smallholder dairy herds and milk shops respectively. Lower results were reported by Pourhassan and Taravat-Najafabadi 2011; Kuma et al. 2015; Kateřina et al. 2016; Mohamed et al. 2017 in farm raw milk; and Belli et al. 2013; Pyz-ŝukasik et al. 2015; Chimuti et al. 2016; Ntuli et al. 2016; EL-Kholy et al. 2018 in raw market milk; while higher result were mentioned by Ali 2004; Yavarmanesh et al. 2015; Nordin et al. 2019 and Bauzad et al. 2019 in in farm raw milk and Mohamed and El-Zubier 2007; El-Shorbagy et al. 2009; Kassem 2011; Tesfay et al. 2013; Meshref 2013; El nahas et al. 2015; Kuma et al. 2015; Yavarmanesh et al. 2015; Hassan et al. 2021 in market samples; results nearly agree with Tesfay et al. 2013; Mohamed et al. 2017 for farm raw milk; and Ali and Abdelgadir 2011; Fadaei 2014; El-Leboudy et al. 2017 in market samples.

Results of milk samples collected from bulk tank milk of large dairy herds showed TBC ranged from 1.1×10^5 to 9×10^7 with average count $1.53 \times 10^7 \pm 6.27 \times 10^6$ cfu/ml, after improving of the environmental and pre milking sanitation (washing worker hands with soap and clean water before milking, washing the udder with water and drying the udder with a clean dry cloth and teat dipping using iodine component), the TBC of samples showed decrease in count ranging from 1.02×10^5 to 1.1×10^7 with average count $2 \times 10^6 \pm 6.58 \times 10^5$ cfu/ml, the decline of TBC after treatment agree with those of De Silva et al. (2016). Psychrotrophic bacterial count did not show significant variation before and after

treatment as TBC where it changed from $2.83 \times 10^5 \pm 6.85 \times 10^4$ to $8.98 \times 10^4 \pm 2.67 \times 10^4$, while total coliform count, fecal coliform and *E.coli* changed as ($3.89 \times 10^5 \pm 1.38 \times 10^5$ MPN/ml to $5.3 \times 10^4 \pm 3.07 \times 10^4$ MPN/ml), ($9.2 \times 10^3 \pm 1.82 \times 10^3$ MPN/ml to $6.36 \times 10^2 \pm 1.9 \times 10^2$ MPN/ml) and ($2.57 \times 10^3 \pm 6.11 \times 10^2$ MPN/ml to $3.8 \times 10^2 \pm 3.48 \times 10^2$ MPN/ml) respectively.

5. Conclusion

The current results allowed to assuming that the sanitary measures adopted during production, handling and processing of raw milk from farmers' houses were not applied and this represents a public health hazard, where all of examined raw milk samples collected from Beni-Suef governorate were contaminated and exceeded the ES 2005 limits for raw milk. Therefore, the application of HACCP system must be adopted in both milk production units, milk products processing plants and during transportation and displaying the final product.

6. Authors Contributions

All authors contributed equally to study design methodology, interpretation of results and preparing of the manuscript.

7. Conflict of interest

The authors declare no conflict of interest.

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