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Risk assessment of raw milk in dairy collecting centers

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Abstract

Raw milk is highly susceptible to biological, chemical, and physical hazards at milk collection centers (MCCs), posing risks to quality and public health. This study applied a structured risk assessment framework to identify, characterize, and prioritize major hazards associated with raw milk collected from five MCCs in El-Gharbia Governorate, Egypt, and to propose HACCP- and ISO 22000–based control measures. A total of 100 raw milk samples, along with surface and workers'hand swabs, were subjected to physicochemical, microbiological, and sensory evaluation. Antibiotic residues and elevated urea levels were identified as the most critical chemical hazards in the present study. Antibiotic residues were detected in up to 40% of MCC1 samples and classified as high risk. (risk score = 9). Similarly, increased urea levels were categorized as high-risk hazards (risk score = 6). Palm oil adulteration and increased somatic cell counts were ranked as medium-risk hazards, while formaldehyde was not detected. Physical hazards were assessed as low risk due to their visibility and effective removal by filtration. Among biological hazards, elevated aerobic plate counts and *Staphylococcus aureus* were classified as high risk, particularly in MCC4 and MCC2, where microbial loads exceeded permissible limits, indicating inadequate hygiene and insufficient temperature control. *Bacillus cereus* was ranked as a medium-risk hazard, while *Clostridium perfringens*, *Salmonella* spp., and *Listeria monocytogenes* were considered low risk, as they were not detected in the analyzed samples. Swab analysis revealed high microbial loads on equipment surfaces and workers' hands in MCC2 and MCC4, further confirming sanitation deficiencies. Based on risk

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characterization, targeted control measures, including rapid antibiotic screening, strict supplier control, routine compositional monitoring, immediate cooling, validated sanitation programs, and enforcement of worker hygiene were recommended. Overall, the risk assessment matrix proved to be highly effective in prioritizing hazards and strengthening HACCP-based controls, leading to significant improvements in the safety and quality of raw milk at the MCCs.

Introduction

Raw milk is very nutritious. It can go bad quickly. It goes through stages from the farm to the person who drinks it. When raw milk is being collected, handled and stored it can be exposed to biological, chemical and physical hazards. These hazards can make the raw milk bad reduce its shelf life and pose public health risks if they are not properly controlled **(Owusu-Kwarteng *et al*., 2020).**

Risk assessment is a way to find out what hazards are present in milk and to figure out how bad they are and how likely they are to happen. It is a way to identify the hazards in raw milk handling and to carefully look at how bad they're how likely they are to happen. The hazards that can make people very sick or are very likely to happen need to be stopped. This is done by using measures to prevent and control the hazards and this is in line with what is called Hazard Analysis and Critical Control Point or raw milk HACCP principle **(Codex Alimentarius, 2019).**

When raw milk is being collected risk assessment is done in a way that follows food safety standards. These standards are set by the Codex Alimentarius Commission and the FAO/ WHO. By finding out what hazards are present and how bad they are the people in charge can focus on the important risks and use special measures to control them. This helps to make sure that raw milk is safe to drink and that it is of quality all the way through the dairy supply chain (**Codex Alimentarius, 2004).** The use of milk HACCP-based systems has been very effective in making raw milk safer to drink **(Cusato *et al*., 2013)**. By monitoring and controlling milk at key stages such as when it is received, cooled and stored raw milk HACCP can reduce the presence of bad microbes and chemicals in raw milk. Many studies have shown that raw milk quality and hygiene are better after raw milk HACCP is used **(Nada *et al*., 2022; Atteya *et al*., 2023 and Ahmed, 2025).**

To make sure that raw milk HACCP is used correctly there need to be programs in place, such as Good Manufacturing Practices, Good Hygienic Practices and Sanitation Standard Operating Procedures. These programs help to keep milk safe and of good quality **(U.S. Food and Drug Administration, 2017).**

Even though milk collection centers are very important in the dairy supply chain there are not studies that look at the risks present, at this level especially in developing countries. So this study uses a risk assessment matrix to look at raw milk collected from El-Gharbia Governorate, Egypt. The study looks at how likely and how bad the biological, chemical and physical hazards suggests ways to prevent and control them to make raw milk safer and of better quality.

Materials and Methods

Risk assessment was conducted in five milk collection centers to identify physical, chemical, and biological hazards associated with raw milk handling, collection, and storage. The identified hazards were evaluated based on their likelihood of occurrence and severity of impact, in accordance with the principles of Rish Assessment Strategy and HACCP Included in **ISO 22000: 2018 requirements.**

Collection of milk samples

A total of 100 raw cow milk samples were collected from suppliers and bulk tanks (50 samples each) at the examined milk collection centers (MCCs). In addition, swab samples were obtained from receiving tanks, collection tanks, milk pipelines, and workers' hands. All collected samples were subsequently subjected to sensory, physicochemical, and microbiological evaluation.

Physicochemical evaluation of the collected milk samples

Milk fat, protein, lactose, solids-not-fat (SNF), total solids (TS), acidity, density, formaldehyde, added water, and urea contents were determined using a calibrated milk analyzer (Milkoscan FT1, 91831098) as described by **(Coitinho *et al.*, 2017).** pH was measured with a digital pH meter (AD1030) following to **AOAC (2019).** The somatic cell count was determined with the aid of an automated system called Lactoscan 1, 18-2131, following **ISO 13366-2 (2006)**. Adulteration with palm oil was carried out by following the procedure described by **(Sharma *et al.*, 2020)**. Lastly, the presence of drug residues was determined using Delvotest according to **ISO 13969 (2003)**.

Microbiological evaluation

The sample preparation was done according to ISO 6887-1: 2017. The counting of the APC, *S. aureus*, *E.coli*, and fungal colonies were done according to ISO 4833-1: 2013, ISO 6888 -1: 2003, ISO 1664. In addition, the detection of Salmonella spp., *Listeria monocytogenes*, *Bacillus cereus*, and *Clostridium perfringens* was performed according to **ISO 6579: 2017, ISO 11290-1: 2017, ISO 7932: 2020, and ISO 7937: 2004,** respectively. Also Total coliform count was determined according to **ISO 4832: 2006.**

Sensory evaluation

Sensory analysis of the raw milk samples was conducted to evaluate color, appearance, odor, texture, and overall acceptability, following the procedure described by **Clark *et al.* (2009).** The assessments were carried out by a trained panel of scientists and students under standardized conditions. Each sensory attribute was rated using a ten-point hedonic scale, with classifications of excellent (9–10), good (8–9), fair to good (7–8), and poor (6). The results were reported as mean ± standard error (SE) and served as an initial measure of milk quality and potential risks associated with collection and handling.

Risk assessment

Risk Assessment includes four main steps:

1- Hazard Identification: Identify the f potential hazards (biological, chemical, or physical).

2- Followed by hazard characterization (meaning differentiate for example biological hazard into bacterial, microbial or Chemical toxins, parasitic, Viral)

3– Exposure assessment (Dose X response)

4- Risk characterization through determination of Risk levels through the Risk Matrix (Probability X Consequence)

Table (1). Risk Assessment (3×3) Matrix based on Likelihood of Occurrence and severity level.

Severity of Hazards / Likelihood	1(Low severity)	2 (Moderate severity)	3 (High severity)
1 (Low Likelihood)	1	2	3
2 (Moderate Likelihood)	2	4	6
3 (High Likelihood)	3	6	9

Risk scores were calculated as likelihood × severity and classified as follows: 1–2 (low risk), 3–4 (moderate risk), and 6–9 (high risk)

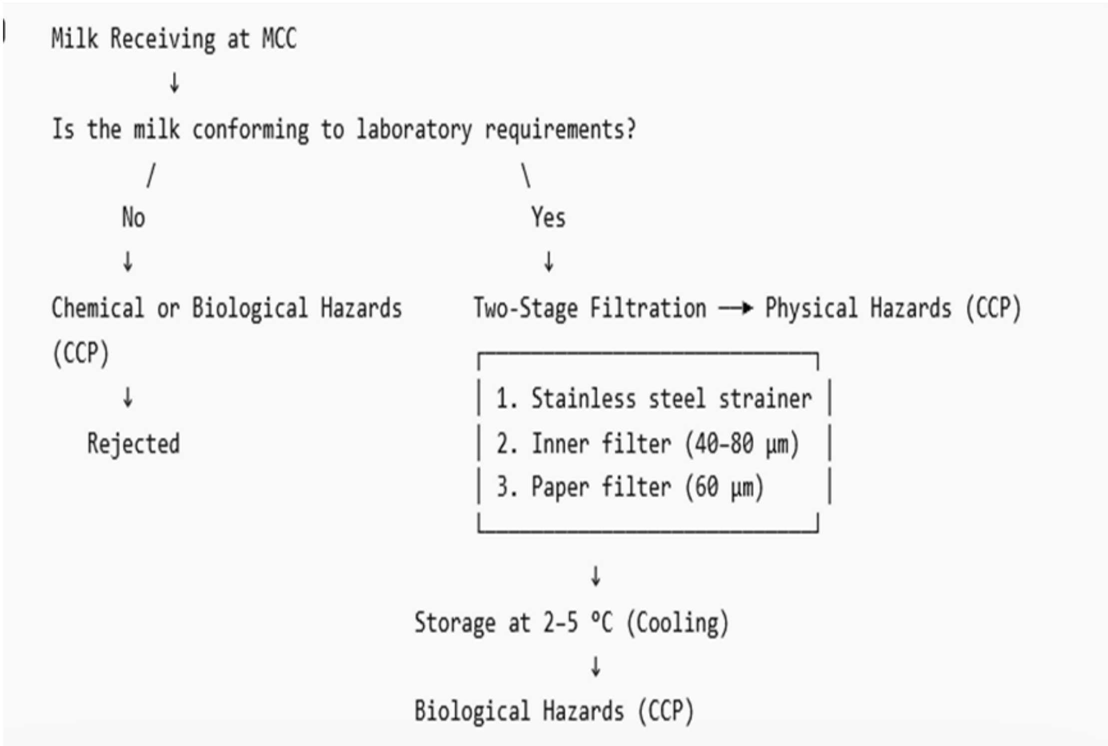

Fig. (1). Flowchart of milk receiving and processing.

Risk **evaluation:**
Data from microbiological, chemical, and physical testing used to perform a structured risk analysis.
Result

Table (2). Mean value of physicochemical parameters of raw milk samples from suppliers across milk collection centers.

Physicochemical / Milk parameters collecting centers	No. of examined milk samples	Physicochemical parameters of raw milk								
		pH	Fat (%)	Protein (%)	Lactose (%)	SNF (%)	TS (%)	Density (%)	Acidity (%)	Somatic cell ($\times 10^3$/ml)
MCC1	10	6.80± 0.06	3.30 ± 0.06	3.11 ± 0.05	4.50 ± 0.06	8.74 ± 0.09	12.03 ± 0.15	1030 ± 0.58	0.14 ± 0.006	153.3 ± 3.18
MCC2	10	6.50 ± 0.06	3.80 ± 0.06	2.93 ± 0.06	4.80 ± 0.06	8.29 ± 0.10	12.13 ± 0.12	1025 ± 0.58	0.18 ± 0.006	371.7 ± 1.45
MCC3	10	6.70 ± 0.06	3.30 ± 0.06	3.22 ± 0.10	4.63 ± 0.03	8.67 ± 0.03	11.89 ± 0.07	1028 ± 0.58	0.15 ± 0.006	176 ± 5.20
MCC4	10	6.40 ± 0.06	3.83 ± 0.09	3.30 ± 0.06	4.70 ± 0.06	9.15 ± 0.09	12.93 ± 0.03	1026 ± 0.58	0.21 ± 0.012	338 ± 9.61
MCC5	10	6.60 ± 0.06	3.60 ± 0.06	3.20 ± 0.06	4.60 ± 0.06	8.20 ± 0.06	11.8 ± 0.07	1015 ± 0.58	0.17 ± 0.006	118 ± 2.65

Mean value ± standard error

Table (3). Incidence of milk adulteration with palm oil, formaldehyde, urea, Antibiotic residue and added water in the examined raw milk samples from suppliers across milk collection centers (10 each)

Milk adulteration parameters / Milk collecting center	No. of examined milk samples	Milk adulteration parameters of collected raw milk samples				
		Palm oil (%)	Formalde-hyde (%)	Urea mg/100ml	Antibiotic residue (%)	Added water (%)
MCC1	10	0.0	0.0	37.23 ± 0.61	40 (4/10)	0.0
MCC2	10	30 (3/10)	0.0	27.07 ± 0.16	0.0	0.0
MCC3	10	0.0	0.0	44.11 ± 1.18	30 (3/10)	0.0
MCC4	10	20 (2/10)	0.0	36.91 ± 0.79	0.0	0.0
MCC5	10	40 (4/10)	0.0	34.32 ± 0.64	0.0	30 (3/10)

Table (4). Sensory evaluation of raw milk samples (Mean± SE) across different milk collection centers.

Sensory attributes / Milk collecting center	No. of examined milk samples	Sensory evaluation of raw milk samples			
		Color & Appearance	Odor	Texture	Overall acceptability
MCC1	10	$8.6^{a} \pm 0.16$	$8.5^{a} \pm 0.18$	$8.7^{a} \pm 0.16$	$8.6^{a} \pm 0.15$
MCC2	10	$8.1^{b} \pm 0.20$	$7.9^{b} \pm 0.22$	$8.0^{b} \pm 0.19$	$8.0^{b} \pm 0.20$
MCC3	10	$8.4^{a} \pm 0.14$	$8.5^{a} \pm 0.16$	$8.6^{a} \pm 0.15$	$8.5^{a} \pm 0.15$
MCC4	10	$7.6^{c} \pm 0.12$	$7.5^{c} \pm 0.14$	$8.0^{b} \pm 0.13$	$7.7^{c} \pm 0.13$
MCC5	10	$8.3^{ab} \pm 0.25$	$8.1^{b} \pm 0.28$	$7.7^{b} \pm 0.26$	$8.1^{b} \pm 0.25$

Mean value ± standard error, different superscript letters within the same column indicate significant differences ($p \leq 0.05$)

Table (5). Mean values of APC, *B. cereus*, and *S. aureus* count (log CFU/ml±SD) in Raw Milk samples from milk collection centers (Suppliers and Tanks)

Microbiological analysis / Milk collecting center	No. Of examined raw milk samples		Microbiological examination of collected raw milk samples		
	Milk collecting place	No.	APC	*B. cereus*	*S. aureus*
MCC1	Suppliers	10	3.69±0.02	A*	1.14 ± 0.01
	Tanks	10	3.89±0.02	A*	1.56 ± 0.01
MCC2	Suppliers	10	5.73±0.01	2.09 ± 0.01	2.55 ± 0.01
	Tanks	10	5.93±0.01	2.57 ± 0.01	2.86 ± 0.01
MCC3	Suppliers	10	4.39±0.01	A*	1.75 ± 0.02
	Tanks	10	4.59±0.01	A*	1.98 ± 0.01
MCC4	Suppliers	10	6.36±0.01	2.88 ± 0.01	3.07±0.02
	Tanks	10	6.96±0.01	3.01± 0.01	3.54 ± 0.01
MCC5	Suppliers	10	5.10±0.02	1.36 ± 0.01	1.95 ± 0.01
	Tanks	10	5.55±0.02	1.88 ± 0.01	2.00 ± 0.01

N.B *L. mococytogenes*, *C.perfringens* and **Salmonella** spp were not isolated from Raw Milk samples from Suppliers and Bulk Tanks across Milk Collection Centers
*A= Absent

Table (6). Microbiological counts of surface swabs from bulk tanks, receiving tanks, and pipelines in milk collection centers (log CFU/cm²)

Microbiological analysis of swabs / Milk collecting center	No. of examined swabs samples		Microbiological evaluation of swabs		
	Swab samples	No.	APC	Coliform	Fungal
MCC1	Pipe	5	1.72±0.01	ND**	ND
	Bulk Tanks	10	1.69±0.02	ND	ND
	Receiving tank	1	1.60±0.02	1.10±0.02	ND
MCC2	Pipe	5	2.18±0.01	1.00±0.01	1.13±.02
	Tanks	10	2.23±0.02	1.25±0.02	1.20±.01
	Receiving tank	1	2.15±0.02	ND	1.40±.01
MCC3	Pipe	5	1.40±0.02	ND	<1
	Tanks	10	1.55±0.01	ND	<1
	Receiving tank	1	1.45±0.01	ND	<1
MCC4	Pipe	5	2.33±0.02	1.30±0.02	1.15±.02
	Tanks	10	2.46±0.01	1.11±0.02	1.30±.01
	Receiving tank	1	2.14±0.01	1.30±0.02	1.28±.01
MCC5	Pipe	5	1.26±0.02	ND	<1
	Tanks	10	1.50±0.01	ND	<1
	Receiving tank	10	1.53±0.01	ND	<1

Values are presented as means± SE **ND= not detected

Table (7). Bacteriological counts of workers hand swabs in milk collection centers (log CFU/cm²)

Microbiological analysis / Milk collecting center	No. of examined workers hand swabs	Bacteriological examination of workers hand swabs		
		APC	*Staph aureus*	*E coli*
MCC1	10	1.5 ± 0.02	<1	ND
MCC2	10	2.5 ± 0.02	1.5 ± 0.01	1.0 ± 0.02
MCC3	10	1.2 ± 0.01	<1	ND
MCC4	10	2.4 ± 0.01	1.1 ± 0.02	<1
MCC5	10	1.2 ± 0.02	<1	ND

Values are presented as means± SE

Table (8). Risk assessment matrix of chemical and physical hazards in milk collection centers and corresponding control measures

Hazard	Likelihood	Severity	Risk Score	Risk Level	Control measures
A-Chemical hazard: **1-Antibiotic residues**	3	3	9	High	Rapid screening at reception; training farmers and milk handlers on antibiotic risks and withdrawal periods after antibiotic treatment of animals; Rejection of positive milk samples and source traceability
2-Palm oil addition	2	2	4	Medium	Strengthen supplier control, routinely fat composition, and rejection of non-compliant.
3-Increase urea level	2	3	6	High	Regular monitoring of milk urea; Farmer training programs on proper feeding management. Control of NPN (Non protein nitrogenous) use; Reject milk exceeding physiological limits.
4-Increase somatic cell count	2	2	4	Medium	regular SCC monitoring, hygienic milking practices, isolation of infected animals and Training of milk handlers and farmers
5-Water addition	2	1	2	Low	Density and freezing point testing rejection of adulterated milk, supplier traceability.
B-Physical hazard:- Foreign matter(dust, sediment, staw, sand and insect)	2	1	2	Low	Filtration of milk at reception, regular cleaning of containers; **training of milk handlers** on hygienic handling; use of food-grade containers; Use of covered containers during transport, rejection of milk containing a lot of visible foreign material

This risk assessment matrix was developed based on the evaluated likelihood and severity of identified hazards, (1-2) low, (3-4) Medium & (6-9) High risk hazards.

Table (9). Risk assessment matrix of biological hazards in milk collection centers and corresponding control measure.

Microbiological hazard	Likelihood	Severity	Risk score	Risk Level	Control Measures
APC	3	3	9	high	Improve farm hygiene, immediate cooling, supplier training, Continuous temperature monitoring, proper tank sanitation
Clostridium perfringens	1	3	3	Medium	Improve cleaning and sanitation, Validated disinfectants and enhanced sanitation
Bacillus cereus	1	3	3	Medium	Improve udder preparation and milking hygiene. Strict cold chain control, validated cleaning system and sanitation verification
Staphylococcus aureus	3	3	9	High	Exclude mastitic animals, personnel hygiene, GMP implementation and monitoring.Hand hygiene protocols, gloves and hairnets, routine screening of workers, surface sanitation
Salmonella spp. and *Listeria monocytogenes*	1	3	3	Medium	Supplier approval, Continue routine monitoring and maintain hygienic practices
Fungal	2	3	6	high	monitor humidity, clean equipment regularly
Coliform	2	3	6	high	Improve general hygiene, monitor water quality, regularly disinfect equipment
***E.coli* in hand workers**	1	3	3	Medium	Enforce strict handwashing and glove use, sanitize equipment and surfaces, regular worker hygiene training

This risk assessment matrix was developed based on the evaluated likelihood and severity of identified hazards (1-2) low, (3-4) Medium & (6-9) High

Figure (2). Implementation of Technical and Hygienic Interventions in the Milk collecting center
(A–B) Upgrade of the milk filtration system (traditional filter vs. stainless steel fine-mesh system). (C) Replacement of plastic containers with stainless steel (AISI 304). (D) Implementation of GMP training in accordance with ISO 22000:2018 requirements.

Discussion

The physicochemical quality of raw milk from the five milk collecting centers (MCC1–MCC5) showed noticeable variation, reflecting differences in animal health, handling practices, and hygienic conditions during milking and transportation.

In table (2) the pH of raw milk centers ranged from 6.40 to 6.80, according to the Egyptian Standard for raw milk EOS No 154-1:2005 fresh raw milk should have a pH value between 6.6 and 6.8. Milk samples obtained from MCC1, MCC3, and MCC5 complied with EOS standard, indicating acceptable freshness and proper handling conditions. In contrast, MCC4 and MCC2 exhibited a lower pH value (6.40 and 6.5) and accompanied by the highest titratable acidity (0.21 and 0.18 %) respectively, reflecting early microbial fermentation. The difference in the milk is probably because it was not cooled enough or because the people collecting and transporting the milk did not follow good hygiene rules **(FAO & WHO 2011a)**. Other people like **Gagara *et al.* (2022)** Have also found that when milk is not handled properly it can have a pH and be more acidic.

The amount of fat in the milk was between 3.30 and 3.83 percent which's what you can see in Table (2). This is okay because it meets the requirement of the Egyptian standard EOS No 154-1:2005 which is at least 3.0 percent. Milk fat content was higher in MCC2 and MCC4. This could be because the cows were different breeds or because they were fed differently. The protein in the milk was, between 2.93 and 3.30 percent. MCC2 had the amount of protein, which might mean that the cows were not fed well **O'Connor (1995)**. Lactose content ranged from 4.50 to 4.80%, consistent with values reported for normal raw milk.

In table (2) SNF values (8.29–9.15%) and TS values (11.89–12.93%) showed variability among centers. The milk from MCC4 had the composition. It had the SNF and TS values. On the hand the density of the milk from MCC5 was very low. It was 1015, which's not normal for raw milk. Raw milk is usually between 1028 and 1034. This makes us think that someone may have added water to the milk. This finding aligns with **(Ahmed & El-Zubeir, 2007).** The number of cells in the milk was between 118 thousand and 338 thousand cells per milliliter. These numbers are okay because they are below the limit set by Egypt which's 750 thousand cells per milliliter. This means that the cows are healthy. However MCC2 and MCC4 had a bit somatic cells, which could mean that the cows have a small infection or that the milking equipment is not clean, as supported by findings from **IDF (2011)**, that dirty farms can lead to somatic cells in the milk. Most of the time the milk was good enough according to rules.. Sometimes the milk was too acidic or too watery which can be bad for people who drink it. This is especially true for farms that do not have cooling and cleaning systems. The milk from these farms may not be safe to drink. This is why we should always check the milk before we drink it. This can help us find problems, with the milk before they become issues. MCC4 and other centers should use these parameters to make sure their milk is safe (**FAO & WHO, 2011b**).

Table 3 showed what happened when people added water, antibiotic residues, urea, formaldehyde and palm oil to milk. The people who collected milk from places did things differently. This is because they handled the milk in ways they had different financial problems and the rules were not the same everywhere. The milk from MCC1 to MCC4 was fine no one added water to it. This means they did what they were supposed to do to keep the milk good. The people at MCC5 added water to thirty percent of the milk. They did this to make money. When people add water to milk it is not good for you anymore. The milk does not have the nutrients and some important things about the milk change like how dense it is, what temperature it freezes at and what is in it. This is a problem for people who drink milk because it is not safe. Milk adulteration is a problem because it affects milk quality. Milk quality is important. These findings are consistent with previous studies (**FAO & WHO, 2011b and Karmakar *et al*., 2020).** Antibiotic residues were detected in milk samples from MCC1 (40%), and MCC3 (30%), while MCC2, MCC4 and MCC5 showed no detectable residues. The relatively high incidence in MCC1 and MCC3 raises public health concerns, as the presence of antibiotic residues in raw milk is associated with improper withdrawal periods and unregulated drug use in dairy animals. Similar prevalence rates of antibiotic residues in raw milk have been reported by **(Kang'ethe *et al*., 2005 and Kurwijila *et al*, 2006)**.

Urea was detected in milk samples from all collection centers, with concentrations ranging between 27.07 and 44.11 mg/100 mL table (3). The highest level was recorded in MCC3, which may due to feeding regime or intentional adulteration aimed at artificially increasing the SNF content **(Singh & Gandhi, 2015**). Similar ranges of urea concentration in raw milk have been reported in studies investigating milk adulteration in informal dairy supply chains (**Waikar, 2016).**

Formaldehyde was not detected in any of the analyzed raw milk samples of all five centers which represents a favorable outcome given that this compound is a hazardous chemical preservative. The absence of something like this may mean that people who supply things are more aware of what they're doing or they are using this thing less because they know it is very bad, for people. We have seen this happen before in studies been reported in previous studies **(Atteya *et al*., 2023)** These studies show that people are putting formaldehyde in milk less often because the government is watching more closely and making sure people follow the rules.

Palm oil is getting mixed into milk. That is a problem. They found palm oil in samples from MCC2, thirty percent of the time and in MCC4 about twenty percent of the time and in MCC5 about forty percent of the time. MCC5 had the palm oil in it. People are adding palm oil to milk to make it seem like it has more milk fat. This is something that has been done before. When you add palm oil and other vegetable oils to milk it changes the type of fat that's in the milk. This means the milk is not really what it says it is and it is also not as good, for

you as it should be. Palm oil adulteration is what this is called. It is happening in MCC2 and MCC4 and MCC5. **(Sharma *et al*., 2020).**
The quality of milk is very important and people look at things like how it smells and tastes to see if it is good. These things can be affected by how clean everything's how cold the milk is stored and what kind of tiny living things are in it. If we look at Table 4 we can see that the quality of milk is different at different places. For example, the milk at MCC1 and MCC3 is better and fresher, which means it was handled properly. On the hand the milk at MCC4 did not score as well which could mean that it is starting to go bad. This can happen if the equipment is not clean or if the milk is not cooled down enough when it is collected and transported. We see the same thing happen when the milk is not handled cleanly. The quality is not as good. People do not like it as much. Raw milk quality is affected by things, including hygiene and storage temperature and microbial activity. The quality of milk at MCC1 and MCC3 is good because of better freshness and more appropriate handling practices. The quality of raw milk at MCC4 is not as good, which could be because of the onset of spoilage. Spoilage is often caused by sanitation or delays in cooling during milk collection and transportation. Similar things happen when raw milk is not handled properly. The sensory acceptability is reduced and the quality is not as good. Raw milk quality is very important. It is affected by many things, including hygiene and storage temperature and microbial activity and the quality of raw milk, at different places can be very different **(Ahmed & El-Zubeir, 2007; Kazeminia *et al*., 2023; Mila, 2023 and Sultana *et al*., 2024).**
Raw milk can have things in it like bacteria from the cows udder and teats the equipment used to milk and from infections in the cows mammary gland. When people do not keep things clean when they handle the milk it can have a lot of bacteria in it. This is because they do not follow cleaning procedures and the people working on the farm may not know how to do things properly **(Atteya *et al.* 2023)**. We looked at raw milk samples from places and found that some were cleaner than others. The samples from MCC1 and MCC3 were pretty clean with not many bacteria in them. This means that the people in charge of these places are doing a job of keeping things clean and cool. The numbers were between 3.69 and 4.59 which's what we want to see. Some other places, like MCC2 and MCC5 had more bacteria in their milk. This is not good. Means that they need to do a better job of keeping things clean. The worst place was MCC4, where the numbers were very high between 6.36 and 6.96. This is much too high. Means that they have some big problems to fix, like cleaning the equipment better or keeping the milk cooler. We also looked at another type of bacteria called *Bacillus cereus*. We want to keep this kind of bacteria out of the milk because it can make people sick. Some places, like MCC2, MCC3 and MCC5 had levels of this bacteria, which is good. Mcc4 had high levels, which is not good. This means that they need to do a job of keeping the equipment clean and making sure the milk is handled properly. The high levels of bacteria in MCC4 are a problem and need to be fixed. It could be because they are not cleaning the equipment right or because they are not keeping the milk cool. Whatever the reason they need to make some changes to keep the milk safe for people to drink. Raw milk is what we are talking about here. We need to make sure it is clean and safe. MCC4 needs to do a job, with their raw milk.
The *S. aureus* counts were really low at all the centers. They were much lower than the limit set by Egypt which's 2 log10 CFU/ml. Our results are similar to **Tobar-Delgado *et al.* (2020),** They discovered that the bacterial counts were higher in the milk collection centers than in the milk from the farms. Our results do not match **Meshref *et al.* (2021),** they said that the milk samples from the farms had bacterial counts. The quality of the milk from the Farms is greatly affected by how the farmers managed. The way the farms are run plays a part in deciding how many microbes are in the raw milk, at the farm.
When it comes to *Clostridium perfringens, L. Monocytogenes* and Salmonella spp all the milk samples we tested did not have these bacteria, which's what the Egyptian rules say the milk should be like. This is the same as **Assy *et al.* (2022) and Atteya *et al*. (2023).**
We wanted to see how clean the milk collection centers were. So we took swabs from the

pipes, tanks and the tanks where the milk is received at five of these centers. The results in table 6 which is for MCC1 to MCC5 showed that the amount of microbes was different at each place. MCC1 and MCC5 were very clean with no fungi or coliform bacteria and the total number of bacteria was between 1.26 and 1.72 $\log_{10}$ CFU/cm², which is within the allowed limits. The rules say that the fungi should be less than or equal to 1 $\log_{10}$ CFU/cm² the coliform bacteria should be less than or equal to 1 $\log_{10}$ CFU/cm² and the total bacteria should be less than or equal to 2 $\log_{10}$ CFU/cm² as stated by **(FAO/WHO, 2011b and Codex Alimentarius, 2019)**. MCC3 had fungi and coliform bacteria and the total bacteria were at a moderate level but still within the allowed limits. On the hand MCC2 and MCC4 had fungi, coliform bacteria and a lot of other bacteria, which means they were not very clean. Overall MCC2 was the dirtiest and MCC1 and MCC5 were the cleanest. This shows that MCC2 and MCC4 need to do a job of cleaning and sanitizing to meet the standards, for hygiene.

Hand washing primarily works by mechanically removing transient microorganisms, while antimicrobial soaps provide the additional effect of killing or inhibiting both transient and resident microbes. Insufficient hand hygiene can therefore result in higher bacterial counts, as thorough washing and sanitization would normally reduce contamination significantly **(Aa *et al.*, 2014)**. Table (7) showed the results of bacteriological analysis of swabs collected from workers'hands across five Milk Collection Centers (MCC1–MCC5). At MCC1, MCC3, and MCC5, *E. coli* Was not detected and *S. aureus* Was below 1 $\log_{10}$ CFU/cm², while APC ranged from 1.2 to 1.5 $\log_{10}$ CFU/cm², all within acceptable limits *E. coli* ≤ 1 $\log_{10}$ CFU/cm, *S. aureus* ≤ 1 $\log_{10}$ CFU/cm², APC ≤ 2 $\log_{10}$ CFU/cm²) **(FAO/WHO, 2011a and Codex Alimentarius, 2019)**. MCC2 and MCC4 had some problems. They had much of some bad things like *E. coli* and *S. aureus*. For example MCC2 had *E. coli* at a level of 1.0 CFU/cm². It also had *S. aureus* at 1.5 CFU/cm² and APC at 2.5 $\log_{10}$ CFU/cm². MCC4 was also not good. It had *S. aureus* at 1.1 CFU/cm² and APC at 2.4 $\log_{10}$ CFU/cm². This means that the people working in MCC2 and MCC4 did not do a job of keeping their hands clean. MCC1 MCC3 and MCC5 were much better. They had the amount of bad things like microbial contamination. MCC2 and MCC4 need to do a better job of keeping things clean. They need to follow the rules, for hygiene so they can be safe.

Risk assessment

The milk supply chain faces risks. These risks can be physical, chemical or biological. They can happen at any stage from milking to handling, distribution and when people finally drink the milk. These risks can make milk unsafe and harm food safety. For example **Owusu-Kwarteng *et al.* (2020)** found out that these risks are real. So we need to find and evaluate all the hazards. We must also understand how likely they are to happen. How severe they can be. This helps us to take steps to prevent or reduce the risks. **Abbas *et al.* (2023)** suggested that we should have a plan to manage risks. This plan should help us to find and fix problems before they happen. It should also help us to make sure that milk is safe to drink. We can use this plan to make the milk supply chain safer. A risk-based management framework is a tool. It helps us to identify risks and take steps to prevent or reduce them. This way we can make sure that milk is safe for everyone to drink. The milk supply chain is very important. Milk safety is a priority. We must take all steps to ensure milk is safe.

Take a look at Table 8. Antibiotic residues are the big one here, highest risk score across the board because they're both likely to show up and nasty when they do. Farmers either skip withdrawal periods or genuinely don't know they exist. Either way, people drinking that milk pay the price, everything from allergic reactions to, down the road, antibiotics that just stop working **(Sachi *et al.*, 2019)**. Our own data in Table 8 tells a similar story. Palm oil adulteration scored a 4, so medium risk. Urea contamination scored a 6, solidly high risk. Both are the same old scam: someone dilutes the milk, then panics you'll notice, so they dump in oil to fake the creaminess or urea to fake the protein content. Here's the thing though, this isn't just about cheating buyers. That palm oil shifts the fatty acid profile in ways that quietly pile saturated fat into people's diets, and we already know where that road leads: heart disease, atherosclerosis, the works **(Mancini *et al.*, 2015; Sharma *et al.*, 2020)**. Urea's arguably worse in some ways because it doesn't just lie about protein quality, it can actually wreck your kidneys and tear up your gut if there's enough of it **(Sultana *et al.*, 2024; Khomane *et al.*, 2024)**. These findings align with the observed results and support the assigned risk levels in Table (8), underscoring the need for applying risk mitigation and performance programs included in risk management system supported by application of preventive HACCP measures, such as routine compositional monitoring, strengthened supplier control, and rejection of milk exceeding physiological limits.

An elevated SCC was identified as a medium-risk hazard in the present study (Table 8). Increased SCC is mainly associated with subclinical mastitis resulting from inadequate milking hygiene, poor udder health management, and insufficient sanitation of equipment. The thing about SCC is that it is not really a hazard that you need to worry about. It is a big deal when it comes to the health and safety of milk. This is because milk that has SCC in it is more likely to have things like pathogens and toxins that can make people sick. So it is really important to have habits when it comes to milking cows and taking care of the milk. This includes things like making sure everything is clean checking the milk for SCC on a basis keeping cows that are sick away, from the healthy ones and teaching the people who handle the milk how to do their job properly. The SCC is a part of the HACCP system and it is something that needs to be taken care of to make sure the milk is safe to drink **(Ruegg, 2017).**

Water addition is a type of milk cheating that makes milk less nutritious and changes what its made of. This was seen as not a risk in our study because its more, about making a profit than directly harming people. But if the water added is dirty this could become a bigger problem bringing in bad germs, chemicals or heavy metals into the milk. So we need to be very careful when we get milk and check who we're buying it from to stop this from getting worse **(FAO & WHO 2011b and Codex Alimentarius Commission, 2004).**

Things like dust and sediment and straw and sand and insects are not a problem. We can see them. They can be removed easily. If we filter the milk when it arrives and clean the containers properly and handle the milk in a way then the milk will be safe from these kinds of problems. This is what the evidence shows. Physical things, like dust and sediment and straw and sand and insects are not likely to contaminate the milk if we do these simple things **(Afzal *et al.*, 2011 and FAO & WHO, 2011b)**. These milk hazards are mostly taken care of by programs that're already in place but they keep happening over and over. So milk reception needs to have controls in place to always reduce these hazards. Other people have said that milk companies should do things like keep everything and follow good rules when making milk products. They should also check everything regularly. Have clear rules, about what to reject. This makes the whole system of keeping milk safe which is called HACCP work better for dairy systems that're not very formal **(Afzal *et al.*, 2011).**

The risk of getting sick from milk is different depending on what is in the milk. If we look at the results in Table (9) we can see that some things are more likely to make us sick than others. The APC and *S. aureus* in the milk are very bad for us so we need to be very careful. The *B. cereus* is not as bad but still something we should worry about. On the hand the *Clostridium perfringens* and Salmonella spp. *Listeria monocytogenes* in the raw milk are not as much of a risk. There are reasons why raw milk can be bad, for us. Raw milk can have things in it like microbes. If the milk is not kept cold it can be bad. If the people milking the cows do not keep everything it can also be bad. All these things can make the raw milk have bad bacteria in it **(Kakati *et al.*, 2021).** Moreover milk vendors not taking care of the cold chain helps microbes grow. This is because raw milk is a place for them to thrive. It has the acidity level, lots of water and plenty of nutrients **(Atteya *et al.*, 2023).** The thing with *E. coli* and *S. aureus* on workers hands is a problem when it comes to raw milk. *E. coli* and *S. aureus* can easily get into the milk when people are milking, handling and processing it especially if they do not wash their hands properly. If workers do not wash their hands enough or if they do not wear gloves *E. coli* and *S. aureus* can get into the milk fast. This can also happen when people who have *E. coli* and *S. aureus* in their noses touch things and then touch the milk. This is a deal because it can make people who drink the milk really sick with foodborne illnesses, from *E. coli* and *S. aureus.* Consequently, worker hygiene represents a critical control point in the management of milk safety **(Aa *et al*., 2014).**

As showed in Figure (1): After identifying the physical hazards, deficiencies in infrastructure, and improper hygienic practices particularly those related to personal hygiene and hand washing corrective actions were initiated.

These interventions included technical improvements in the facility layout and equipment maintenance, enhancement of cleaning and sanitation procedures, reinforcement of personal hygiene standards, and the introduction of hand washing protocols in accordance with HACCP principles.

So we took steps to reduce the risk of contamination and make sure we follow the rules for keeping food safe. We used something called HACCP to help us do this. The milk collection process is really important so we made sure our staff knew what they were doing we kept an eye on things and we kept good records. This way we can always try to get better and make sure the milk collection process is safe. We paid attention to the critical points, in the milk collection process to make sure everything is good.

They made a lot of changes to make food safer. These changes included things to improve hygiene and make sure the buildings and equipment were in good shape. The old filters were not good enough so they got ones. The new filters are made of steel and have very small holes. They also have paper parts that can be thrown away. This helps get rid of dirt and stop things like germs from getting into the food. They also replaced plastic barrels, with new stainless steel containers. These containers are very smooth and easy to clean. They are made of a kind of stainless steel called 304 **(Błażejewski *et al*., 2021).** We also swapped out any equipment that could leach chemicals, think porous plastics or worn surfaces, for food -grade stainless steel (Figure C). Easy to scrub down properly, no weird residues seeping into the milk. For hand washing, we installed an elbow-operated tap, no hands touching anything, and paired it with automatic dispensers for soap and alcohol disinfectant, both sourced from certified suppliers (Figure D). The goal was simple: stop cross-contamination before it starts. Storage got an overhaul too. We mounted stainless steel racks on the walls for hoses and dairy tools, keeping everything off the damp floor and letting air circulate. Basic hygiene, but you'd be surprised how often it's ignored. Over the reception area, we put in proper corrugated roofing. Sounds obvious, but it keeps rain, dust, and whatever pests are crawling around from dropping straight into the milk during offloading. Finally, we ran structured GMP training and put formal hand-washing guidelines in place, not just to tick the ISO 22000:2018 compliance box, but to make sure people actually stick with this stuff long after the inspectors leave.

Conclusion

The problem of milk is getting worse because of health concerns. This study looks at the quality of milk at places where dairy farmers take their milk. It found out that raw milk has a lot of problems like chemicals, germs and physical issues. The biggest problems are leftover antibiotics many bad bacteria and a type of bacteria called *Staphylococcus aureus*. These things make raw milk not safe for people to drink. The people doing the study used a way to figure out what the problems are and how to fix them. They found out that if they follow some rules and teach the workers how to do things they can make the milk safer. This means the people, in charge of the milk collection centers need to make sure everything is clean the milk is cooled properly they check the milk often. The workers know what they are doing. If they do all these things they can keep the milk good. People will not get sick from drinking it. Overall, these findings underscore the critical role of systematic hazard evaluation in achieving safe, high-quality raw milk suitable for processing and human consumption.

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