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Evaluation of Physico-Chemical and Microbiological Quality of Pasteurised Milk in Street Milk Stalls Surakarta

Visensia Sekar Dyah Pitaloka[1], Nurliyani[1], Ismiarti[2], Widodo[1]*

[1]Department of Animal Product Technology, Faculty of Animal Husbandry, Gadjah Mada University, Yogyakarta, Indonesia
[2]Animal Husbandry Study Program, Faculty of Animal Husbandry, Universitas Darul Ulum Islamic Centre Sudirman, Regency Semarang, Indonesia

*Corresponding author, email: widodohs@ugm.ac.id

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Abstract

Pasteurized cow's milk stalls with the concept of street vendors become one of the culinary tourism destinations in Surakarta City. Sanitary and hygiene efforts are sometimes difficult to be handled for micro, small and medium enterprises (MSMEs) such as street vendors, and milk adulteration is likely to occur. This study aimed to evaluate the physico-chemical and microbiological quality of pasteurized cow's milk sold at street milk stalls in Surakarta City. Samples were obtained from 30 milk stalls across five sub-districts in Surakarta City with 2 replicates. Parameters observed included physical properties (alcohol, pH, acidity, and density), chemical composition (moisture content, dry weight, fat, and protein) and microbiological quality (Total Plate Count and Enterobacteriaceae). Analysis of data was carried out using analysis of variance (ANOVA) unidirectional pattern, followed by Duncan's new Multiple Range Test (DMRT) to evaluate differences in quality between shops. The results showed the mean of each physical parameter were alcohol negative; pH 6.67; acidity 0.12%; and density 1.0219 kg/l. The average chemical composition of pasteurized milk was : 91.83% moisture content; 1.88% fat; 6.30% lean dry weight; and 2.05% protein. Meanwhile, on microbiological parameters, the average TPC was 4.46 log CFU/ml and Enterobacteriaceae was 0.41 CFU/ml. The results showed that the pasteurized milk between the stalls showed a very significant difference ($P<0.01$) on all physico-chemical and microbiological parameters tested except the alcohol parameter ($P>0.05$). The conclusion of this study is that pasteurized milk sold by Surakarta street vendors is safe for consumption due to low microbiological values, but was not within the standard of nutritional requirements according to SNI and the best physico-chemical.

Keywords: pasteurized milk; street vendors; quality control; food safety.

Introduction

Cow's milk is a livestock product that is highly favored by the public due to its complete essential nutrient content, including 3.5% protein, 3% fat, 5% lactose, 1.2% minerals, and vitamins (Muehlhoff *et al.,* 2013; Zebib *et al.,* 2023). The high nutritional and water content (88%–90%) in milk makes it a perishable food, thus creating a favorable environment for the growth of microorganisms (Karmaker *et al.,* 2020; Priyanto *et al.,* 2021). To prevent milk spoilage, further handling such as pasteurization is required. Pasteurization is a milk processing method involving heat treatment that is commonly applied because it is relatively simple

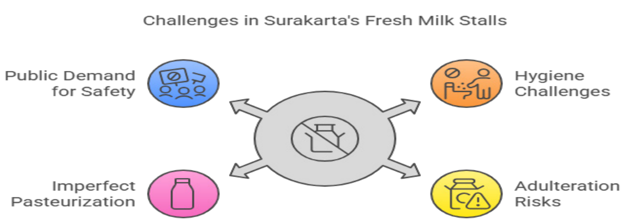

Figure 1. Challenges in Surakarta's Fresh Milk Stalls

in terms of equipment and procedure, and it is effective in slowing down and eliminating spoilage and pathogenic microbes (Smigic *et al.*, 2012; Andriani *et al.*, 2021).

Surakarta City has diverse culinary potential, one of which is fresh milk stalls operating under street tent setups that sell pasteurized milk at affordable prices. Hygiene and sanitation efforts are often difficult to implement by MSME actors such as street vendors due to limited selling facilities and a lack of sufficient knowledge (Rosales *et al.*, 2023). Moreover, milk adulteration using economically advantageous substitute ingredients is highly likely to occur at the street vendor level (Anindita and Soyi, 2017; Nyokabi *et al.*, 2021). In addition, the implementation of pasteurization at the Micro, Small and Medium Enterprises (MSME) level remains conventional, relying on simple equipment, which often leads to imperfect pasteurization processes and becomes a major source of post-pasteurization contamination (Griffiths, 2010). Figure 1 show the challenges in Surakarta's Milk Stalls.

The assurance of milk safety has become a public demand along with the increasing awareness of food health. Given the importance of supervision and quality assurance of fresh milk quality, this study was conducted to evaluate the physico-chemical and microbiological quality of pasteurized milk sold in street-side milk stalls in Surakarta City. The objectives of this study are to evaluate the physico-chemical and microbiological quality of pasteurized milk and to determine the differences in physico-chemical and microbiological quality among street-side milk stalls in Surakarta City.

Material and Method

Sampling

Pasteurized milk samples were collected from 30 milk stalls located across five districts in the city of Surakarta (Banjarsari, Mojosongo, Pasar Kliwon, Serengan, and Laweyan). The milk samples consisted of plain pasteurized cow's milk without added sugar, flavorings, or ice. The milk was purchased in the evening between 6:00 PM and 8:00 PM local time (Western Indonesia Time). Each sample consisted of 500 ml of milk, transported in a cooler box maintained at a temperature of 1–4 °C using ice gel, and immediately delivered to the laboratory with an estimated travel time of approximately 3 hours. Laboratory testing, which included physical, chemical, and microbiological analyses, was conducted the following day.

Physico-chemical Analysis

Physical analysis included alcohol testing using 70% alcohol (Suranindyah *et al.*, 2015), pH testing using a digital pH meter (Hadiwiyoto, 1994), acidity testing using the titration method (AOAC, 1990), and density testing using a lactodensimeter (Suranindyah *et al.*, 2015). Chemical analysis included testing for dry weight and moisture content determined by drying the sample at 105°C until a constant weight was achieved (Syamsi *et al.*, 2018), fat content testing determined by the Babcock method, and protein content testing using the Macro-Kjeldahl method (Sudarmadji, 1997).

Microbiological Analysis

Microbiological analysis included Total Plate Count testing referring to SNI (2008) using serial dilutions and inoculated on Plate Count Agar (PCA), and Enterobacteriaceae testing referring to SNI (2008) using Violet Red Bile Glucose (VRBG) agar medium.

Data Analysis

The study data were analyzed using descriptive analysis methods. Furthermore, statistical analysis of variance (ANOVA) was performed using IBM SPSS Statistics 23. If significant differences were found, Duncan's new Multiple Range Test (DMRT) would be conducted with a significance level of 1% ($P<0.01$).

Result and Discussion

Physical Quality

The physical quality of pasteurized milk from street-side milk stalls in Surakarta City, including alcohol, pH, acidity, and density, was assessed based on the quality level references of the Indonesian National Standard No. 01-3141-2011 concerning the Quality Requirements for Fresh Milk, as presented in Table 1.

Table 1. Physical quality of pasteurized milk at street-side vendors in Surakarta City

Seller	Parameter			
	Alcohol ^{ns}	pH	Acidity (%)	Density (kg/l)
S1	Negative	6,81 ± 0,03 defgh	0,11 ± 0,00 ^{bcd}	1,0242 ± 0,008 ^{cdefg}
S2	Negative	7,11 ± 0,08^{ij}	0,07 ± 0,01^{ab}	1,0211 ± 0,002 ^{cdef}
S3	Negative	7,17 ± 0,13^{j}	0,07 ± 0,01 ^{abc}	1,0214 ± 0,001 ^{cdef}
S4	Negative	6,89 ± 0,10^{efghi}	0,12 ± 0,02^{bcde}	1,0209 ± 0,000 ^{cdef}
S5	Negative	6,66 ± 0,03 ^{bcde}	0,17 ± 0,01^{efg}	1,0278 ± 0,002 ^{defg}
S6	Negative	6,65 ± 0,19 ^{bcde}	0,15 ± 0,05^{defg}	1,0213 ± 0,004 ^{cdef}
S7	Negative	6,65 ± 0,01 ^{bcd}	0,13 ± 0,01^{cdef}	1,0202 ± 0,000 ^{bcd}
S8	Negative	6,95 ± 0,03 ^{hi}	0,10 ± 0,01 ^{abcd}	1,0240 ± 0,001 ^{cdefg}
S9	Negative	6,88 ± 0,01 ^{defghi}	0,11 ± 0,01 ^{bcd}	1,0198 ± 0,000 ^{bcd}
S10	Negative	6,75 ± 0,24^{defgh}	0,14 ± 0,06 ^{defg}	1,0296 ± 0,007 ^{efg}
S11	Negative	6,84 ± 0,14^{defgh}	0,11 ± 0,01 ^{bcd}	1,0207 ± 0,001 ^{cde}
S12	Negative	6,88 ± 0,03 ^{defghi}	0,11 ± 0,01 ^{bcd}	1,0224 ± 0,000 ^{cdefg}
S13	Negative	7,19 ± 0,02^{j}	0,05 ± 0,02 ^{a}	1,0122 ± 0,006^{ab}
S14	Negative	6,92 ± 0,01^{ghi}	0,10 ± 0,00 ^{bcd}	1,0177 ± 0,002 ^{bc}
S15	Negative	6,84 ± 0,06^{defgh}	0,11 ± 0,01 ^{bcd}	1,0174 ± 0,001^{bc}
S16	Negative	6,66 ± 0,28 ^{bcde}	0,14 ± 0,01 ^{defg}	1,0245 ± 0,003 ^{cdefg}
S17	Negative	6,40 ± 0,00 ^{a}	0,19 ± 0,00 ^{g}	1,0093 ± 0,006^{a}
S18	Negative	6,50 ± 0,00 ^{abc}	0,17 ± 0,01 ^{efg}	1,0060 ± 0,000^{a}
S19	Negative	6,91 ± 0,01^{fghi}	0,10 ± 0,01 ^{bcd}	1,0251 ± 0,002 ^{cdefg}
S20	Negative	6,39 ± 0,01^{a}	0,19 ± 0,01 ^{fg}	1,0305 ± 0,000 ^{g}
S21	Negative	6,93 ± 0,03 ^{ghi}	0,12 ± 0,01 ^{bcde}	1,0230 ± 0,001 ^{cdefg}
S22	Negative	6,67 ± 0,01 ^{bcdef}	0,15 ± 0,01 ^{defg}	1,0283 ± 0,003 ^{defg}
S23	Negative	6,44 ± 0,07 ^{ab}	0,17 ± 0,02 ^{efg}	1,0189 ± 0,001 ^{bc}
S24	Negative	6,77 ± 0,01^{defgh}	0,12 ± 0,01 ^{bcde}	1,0231 ± 0,002 ^{cdefg}
S25	Negative	6,70 ± 0,00^{cdefg}	0,12 ± 0,00 ^{bcde}	1,0213 ± 0,002 ^{cdef}
S26	Negative	6,80 ± 0,13^{defgh}	0,12 ± 0,03 ^{bcde}	1,0297 ± 0,001 ^{fg}
S27	Negative	6,64 ± 0,01 ^{bcd}	0,15 ± 0,01^{defg}	1,0244 ± 0,000 ^{cdefg}
S28	Negative	6,73 ± 0,06^{cdefgh}	0,12 ± 0,01 ^{bcde}	1,0202 ± 0,004 ^{bcd}
S29	Negative	6,78 ± 0,01^{defgh}	0,13 ± 0,00^{cdef}	1,0280 ± 0,003 ^{defg}
S30	Negative	6,89 ± 0,02^{efghi}	0,10 ± 0,00 ^{bcd}	1,0239 ± 0,002 ^{cdefg}
Average	Negative	6,78 ± 0,21	0,12 ± 0,03	1,0219 ± 0,006
SNI	Negative	6,3-6,8	0,1-0,26	Min 1,027

Description: ^{a,b,c,d,e,f,g,h,I,j} Different superscripts in the same column indicate a highly significant difference (P<0.01).
^{ns} non-significant

Alcohol

The results of the analysis of pasteurized milk alcohol test at street vendors in Surakarta City showed a negative reaction, namely there was no coagulation in the milk sample. This result is in accordance with the Indonesian National Standard Number 3141 of 2011 concerning Fresh Milk Quality Requirements which states that the milk quality requirements in the 70% alcohol test are negative, indicating that the milk is still fresh. A negative alcohol test indicates that the milk sample is still fresh and there has been no lactic acid production by bacteria that cause the milk to become sour. This is in accordance with the opinion of Sutrisna *et al.* (2014) that curdling in milk indicates low milk quality so that it is not suitable for consumption because of the possibility that the acid content in the milk is high. Based on Wiranti *et al.* (2022), the results of alcohol tests are greatly influenced by hygiene and sanitation because unclean environmental conditions can cause pollution from the livestock themselves, humans, milking equipment, and air throughout the milk distribution stage, from farmers, distributors to milk sellers.

pH

The results of pH quality analysis showed that 13 out of 30 street milk stalls did not meet the quality standards for fresh milk, as the pH values exceeded 6.80. According to the Indonesian National Standard (SNI) Number 3141 of 2011 concerning the Quality Requirements for Fresh Milk, high-quality milk should have a pH ranging from 6.3 to 6.8. The elevated pH levels are suspected to be caused by adulteration through the addition of certain substances that can stabilize the milk's pH. This is in line with the statement by Zebib *et al.* (2023), which suggests that an increase in milk pH may result from the addition of various adulterating agents. The addition of 20% water to milk can increase its pH value to 6.72 (Memon *et al.*, 2018). In addition to water, neutralizing agents are sometimes added to milk to extend its shelf life. This is consistent with the statement by Zagorska and Ciprovica (2013), who reported that the addition of sodium bicarbonate at a concentration of 0.1% can raise the pH value of milk to above 7. The addition of sodium bicarbonate can prevent milk spoilage by neutralizing the increase in lactic acid content (Gondim *et al.*, 2015; Singh and Gandhi, 2015; Chakraborty and Biswas, 2018). However, the consumption of milk containing carbonate/bicarbonate used to neutralize pH and acidity can pose health risks to consumers, such as gastritis, diarrhea, colitis, and electrolyte imbalances (Barham *et al.*, 2014).

Acidity

Acidity is one of the indicators of milk quality, reflecting its freshness, microbial activity, taste, and shelf life under various storage temperatures (Ziyaina *et al.*, 2018; Karmaker *et al.*, 2020). According to the Indonesian National Standard (SNI) Number 3141 of 2011 concerning the Quality Requirements for Fresh Milk, the acidity of fresh milk ranges from 0.10% to 0.26%. The average acidity test results of pasteurized milk sold by street vendors in Surakarta met the established standards and were deemed suitable for consumption. Nevertheless, three out of thirty samples (10%), they are samples S2, S3, and S13, showed acidity levels below 0.1%. The low acidity may be attributed to adulteration with excessive amounts of water, as indicated by the moisture content of the three samples, which exceeded 92.5%. This is consistent with the findings of Lai *et al.* (2016), who stated that high water content in milk samples can reduce the precipitation of tricalcium phosphate, resulting in a lower titratable acidity value. Acidity is inversely related to pH value, meaning that when the pH value decreases, the acidity level increases, and vice versa (Fauziah *et al.*, 2020). The pH values of the three samples were high, exceeding (>) 7, which contributed to the low acidity levels of the milk samples from the street vendors in Surakarta.

Density

Density is used to determine milk quality based on dry matter content. The density values of pasteurized milk from street-side stalls in Surakarta City showed that the average density of the pasteurized milk samples ($P<0.01$) was below the minimum value of the Indonesian National Standard Number 3141 of 2011 concerning the Quality Requirements for Fresh Milk, which is a minimum of 1.027 kg/l, and only six out of thirty samples (20%) were within the normal SNI range. The low-density values in the street milk stalls may be caused by the addition of water. The addition of water can reduce the density of milk (Finete *et al.*, 2013). According to Memon *et al.* (2018), the addition of 20% water can decrease the density of milk to 1.024 kg/L. There are several factors that contribute to the low density of cow's milk, including livestock factors (such as breed and stage of lactation), diseases like mastitis, the type of animal feed, and adulteration, such as the addition of water (Gwandu *et al.,* 2018). The quality requirement for milk density at the Agro Niaga Cooperative in Jabung Sub-district, Malang Regency, is 1.024 kg/L, which is below the standard value set by the Indonesian National Standard (SNI) (Utami *et al.*, 2014). In addition, low milk density values (<1.027 kg/L) have been found throughout the supply chain in Indonesia, including among farmers, cooperatives, and retail vendors (Anindita and Soyi, 2017; Wulandari *et al.*, 2017; Syamsi *et al.*, 2018). The milk supply chain in Indonesia involves many stakeholders and diverse handling practices for milk products, which increases the risk and potential for adulteration (Arwani *et al.*, 2018).

Chemical Quality

The chemical quality of pasteurized milk from street milk stalls in Surakarta City including water content, dry weight, fat, and protein were assessed based on the quality level references of Indonesian National Standard No. 01-3141-2011 concerning Fresh Milk Quality Requirements and Indonesian National Standard No. 01-3951-1995 concerning Pasteurized Milk Quality Requirements, as presented in Table 2.

Water Content

The results of the analysis showed that there was a difference (P<0.01) in the percentage of water content of pasteurized milk at street stalls in Surakarta City. The results of the water content test at 24 out of 30 street milk stalls (80%) showed that the water content of the milk did not meet the fresh milk quality

Table 2. Chemical quality of pasteurized milk at street stalls in Surakarta City

Seller	Parameter (%)		
	Water Content	Fat	Protein
S1	91,01 ± 0,76 ^{bcde}	2,05 ± 0,01^{efghijk}	2,40 ± 0,01 ^{fgh}
S2	93,38 ± 0,48 ^{ghi}	1,10 ± 0,14 ^{ab}	1,96 ± 0,18 ^{bcde}
S3	92,62 ± 0,06 ^{efgh}	1,50 ± 0,28 ^{abcde}	1,91 ± 0,00 ^{bcde}
S4	93,32 ± 0,30 ^{ghi}	1,35 ± 0,07 ^{abcd}	2,20 ± 0,06 ^{efg}
S5	89,64 ± 0,57 ^{ab}	1,85 ± 0,35 ^{defghij}	2,77 ± 0,06 ^{hi}
S6	90,58 ± 1,38 ^{bcd}	1,50 ± 0,14 ^{abcde}	2,11 ± 0,36 ^{cdef}
S7	93,08 ± 0,03 ^{fgh}	1,80 ± 0,14 ^{defghi}	1,74 ± 0,09 ^{bcd}
S8	91,90 ± 0,25 ^{defg}	1,90 ± 0,14 ^{defghij}	2,01 ± 0,20 ^{bcdef}
S9	93,06 ± 0,04 ^{fgh}	1,65 ± 0,21 ^{bcdefg}	1,79 ± 0,00 ^{bcde}
S10	89,92 ± 0,76 ^{abc}	2,45 ± 0,21 ^{jkl}	2,62 ± 0,08 ^{ghi}
S11	91,86 ± 0,24 ^{defg}	2,05 ± 0,07 ^{efghijk}	1,94 ± 0,07 ^{bcde}
S12	92,56 ± 0,39 ^{efgh}	1,55 ± 0,07 ^{abcdef}	1,85 ± 0,14 ^{bcde}
S13	94,97 ± 0,75 ^{i}	1,00± 0,14 ^{a}	1,25 ± 0,09 ^{a}
S14	92,30 ± 0,22 ^{defgh}	2,30 ± 0,14^{hijk}	1,67 ± 0,08 ^{bc}
S15	93,06 ± 0,20 ^{fgh}	2,10 ± 0,14^{fghijk}	2,02 ± 0,18 ^{bcdef}
S16	91,42 ± 0,10 ^{cdef}	1,90 ± 0,28 ^{defghij}	2,17 ± 0,06 ^{def}
S17	93,82 ± 0,52 ^{hi}	1,10 ± 0,14 ^{ab}	1,66 ± 0,25 ^{ab}
S18	93,59 ± 0,19 ^{ghi}	1,20 ± 0,00 ^{abc}	1,57 ± 0,09 ^{ab}
S19	91,35 ± 0,60 ^{cdef}	2,15 ± 0,07^{ghijk}	2,22 ± 0,03 ^{efg}
S20	89,56 ± 0,21 ^{ab}	2,85 ± 0,07^{l}	2,22 ± 0,25 ^{efg}
S21	90,76 ± 0,89 ^{bcd}	2,40 ± 0,42 ^{ijkl}	2,13 ± 0,18 ^{def}
S22	89,54 ± 0,18 ^{ab}	2,40 ± 0,00^{ijkl}	2,71 ± 0,17 ^{hi}
S23	92,29 ± 1,04 ^{defgh}	1,85 ± 0,21 ^{defghi}	1,80 ± 0,09 ^{bcde}
S24	91,11 ± 0,34 ^{bcde}	2,30 ± 0,14^{hijk}	1,93 ± 0,04 ^{bcde}
S25	92,15 ± 0,54 ^{defgh}	1,20 ± 0,14 ^{abc}	1,93 ± 0,16 ^{bcde}
S26	89,77 ± 0,27 ^{abc}	2,55 ± 0,21^{kl}	2,41 ± 0,00 ^{fgh}
S27	91,44 ± 0,11 ^{cdef}	1,75 ± 0,07 ^{cdefgh}	2,19 ± 0,10 ^{efg}
S28	93,60 ± 0,21 ^{ghi}	1,20 ± 0,00 ^{abc}	1,66 ± 0,08 ^{ab}
S29	88,37 ± 0,08^{a}	3,35 ± 0,07^{m}	2,88 ± 0,04 ^{i}
S30	92,86 ± 0,98 ^{fgh}	1,95 ± 0,21^{efghij}	1,84 ± 0,17 ^{bcde}
Average	91,83 ± 1,60	1,88 ± 0,57	2,05 ± 0,38
SNI	88-90% $^{(2)}$	Min. 2,8% $^{(1)}$	Min 2,5% $^{(1)}$

Description: ^{a,b,c,d,e,f,g,h,I,j,k,l} Different Superscripts in the same column shows very real difference (P<0,01)
$^{(1)}$SNI 3941.1:1995, $^{(2)}$SNI 3141.1:2011

standards, namely having a water content value of >90%. Based on the Indonesian National Standard Number 3141 of 2011 concerning Fresh Milk Quality Requirements, the water content of milk ranges from 88% to 90%. The high water content in pasteurized milk samples from street stalls in Surakarta City is thought to be caused by the practice of milk adulteration by adding water. The addition of water aims to increase the volume of milk so that sellers obtain higher profits (Swathi and Kauser, 2015). This condition has a bad impact if the water comes from unclean sources such as water sources around farms or open water reservoirs that cause pathogen contamination and pose a public health risk to consumers (Ameeta *et al.,* 2017; Nyokabi *et al.,* 2021). Milk adulteration with water has been widely reported in many developing countries such as Ethiopia (Zebib *et al.,* 2023), Pakistan (Barham *et al.,* 2014), China and Sudan (Salih and Yang, 2017).

Fat

Milk fat contains many nutrients that are beneficial to humans, such as fat-soluble vitamins (A, D, E, and K) and essential fatty acids (Le *et al.,* 2015). The results showed that 28 out of 30 street milk stalls in Surakarta City (93.33%) did not meet the milk fat content standards. Indonesian National Standard Number 3951 of 1995 concerning Quality Requirements for Pasteurized Milk with a minimum fat content of 2.8%. According to Javaid *et al.* (2009) and Lai *et al.* (2016) that the total fat content in milk is caused by genetic factors of dairy cattle, feed, season, processing process to the alleged occurrence of adulteration. Fat content is lower in summer compared to winter milk (Heck *et al.,* 2009). Mariana *et al.* (2016) reported that in the long dry season in the highlands of Indonesia the quality of milk fat was only 2.14%. The fat content of pasteurized milk products is determined by the condition of the raw materials and the accuracy of the processing process. Pasteurization using a pasteurization machine produces better products compared to traditional pasteurization. This is because the conditions of the pasteurization machine have a more controlled and stable environment, with a constant and aseptic heating temperature and are closed. In contrast, traditional pasteurization causes unstable temperatures, because the heat from the gas stove continues to change which is influenced by external factors such as wind (Arief *et al.,* 2020). The low levels of fat, SNF, and specific gravity in different samples imply the possibility of water adulteration in pasteurized milk (Ahmed *et al.,* 2019).

Protein

The protein content of pasteurized milk in street milk stalls in Surakarta City as many as 26 out of 30 samples (86.67%) showed a protein value lower than the Indonesian National Standard Number 3951 of 1995 concerning Pasteurized Milk Quality Requirements, which is a minimum of 2.5%. Milk in street stalls experienced a decrease in protein content due to the heating process for a long period of time until a thin coating appeared on the surface of the milk indicating destruction of the milk protein. Most sellers pasteurize milk from home and reheat it before serving it to consumers. Although heating is done using low heat, repeated heating treatment for a time not specified by the seller can potentially cause a decrease in protein content in milk. This is supported by the opinion of Alimi (2016) that the heating process for a long time can cause loss of nutrients such as protein. Heat treatment is important in the processing of various products in the dairy industry. The pasteurization process at the right temperature and time actually only causes damage to amino acids in milk protein in small amounts (1% to 4%) so that this damage does not affect the nutritional composition of pasteurized milk (Anema, 2008; Chavan *et al.,* 2011).

The cow's milk is composed of two main proteins, namely casein at 80% and whey at 20% (Gai *et al.,* 2021) which have different levels of stability to heat. Unlike casein, whey protein is susceptible to heat treatment (Brick *et al.,* 2017). Heating these proteins promotes processes such as denaturation and aggregation which result in structural changes that can lead to loss of functionality (Chen *et al.,* 2005). Especially immunologically active whey proteins, such as lactoferrin and immunoglobulins, are sensitive to heat (Zhang *et al.,* 2016). Fang *et al.* (2017)

argue that almost all whey proteins are denatured when milk is heated at 95°C for 10 minutes. This decrease in protein content in milk can be detrimental to milk consumers (Moughan, 2014).

Microbiology Quality

The chemical quality of pasteurized milk at street stalls in Surakarta City including the Total Plate Count (TPC) and Enterobacteriaceae (EB) is presented in Table 3.

Total Plate Count

The Total Plate Count (TPC) becomes a parameter to measure the total number of microorganisms in dairy products (Ismiarti *et al.,* 2019). The TPC level in pasteurized milk from street milk stalls in Surakarta City showed an average value of 4.46 log CFU/ml (P<0.01) which meets the TPC level requirements according to Indonesian National Standard Number 3951 of 1995 concerning Pasteurized Milk Quality Requirements, namely a maximum

Table 3. Microbiological quality of pasteurized milk at street stalls in Surakarta City

Seller	Parameter	
	Total Plate Count (log CFU/ml)	Enterobacteriaceae (CFU/ml)
S1	3,46 ± 0,25 ^{bcd}	0 ^{a}
S2	3,38 ± 0,08 ^{abcd}	1 ± 0,00 ^{ab}
S3	3,30 ± 0,04 ^{abc}	1 ± 0,00 ^{ab}
S4	3,94 ± 0,15 ^{fgh}	0 ^{a}
S5	3,68 ± 0,28^{cdefg}	2 ± 1 ^{bc}
S6	3,92 ± 0,06^{fgh}	0 ^{a}
S7	3,73 ± 0,08^{defgh}	0 ^{a}
S8	3,68 ± 0,06^{bcdefg}	1,5 ± 0,50 ^{ab}
S9	3,29 ± 0,08 ^{ab}	0 ^{a}
S10	4,04 ± 0,10 ^{gh}	0 ^{a}
S11	4,85 ± 0,08^{k}	0 ^{a}
S12	5,47 ± 0,16 ^{l}	2 ± 1 ^{bc}
S13	4,61 ± 0,25 ^{jk}	0 ^{a}
S14	5,62 ± 0,11 ^{l}	2,5 ± 0,50 ^{c}
S15	3,47 ± 0,21 ^{bcd}	0 ^{a}
S16	3,52 ± 0,05 ^{bcde}	0 ^{a}
S17	3,07 ± 0,11 ^{a}	0 ^{a}
S18	3,90 ± 0,04^{efgh}	0 ^{a}
S19	4,06 ± 0,11 ^{gh}	0 ^{a}
S20	4,12 ± 0,04 ^{hi}	0 ^{a}
S21	4,02 ± 0,08 ^{fgh}	0 ^{a}
S22	3,98 ± 0,11 ^{fgh}	0 ^{a}
S23	4,75 ± 0,05^{jk}	1 ± 0,00 ^{ab}
S24	3,66 ± 0,08 ^{bcdefg}	0 ^{a}
S25	4,47 ± 0,06 ^{ij}	1 ± 0,00 ^{ab}
S26	3,75 ± 0,06 ^{defgh}	0 ^{a}
S27	5,77 ± 0,08 ^{l}	0 ^{a}
S28	3,62 ± 0,16 ^{bcdef}	1 ± 0,50
S29	5,51 ± 0,15 ^{l}	0 ^{a}
S30	4,46 ± 0,04 ^{ij}	0 ^{a}
Average	4,46 ± 0,04	0,41 ± 0,70
SNI	4,48$^{(1)}$	10$^{(2)}$

Description: ^{a,b,c,d,e,f,g,h,I,j} Different superscripts in the same column showed the real difference (P<0,01)
$^{(1)}$SNI 3941.1:1995, $^{(2)}$ *The Serbian Rulebook on food hygiene requirements*

of 4.48 log CFU/ml (3x104 CFU/ml). The average TPC value of pasteurized milk samples show the right sanitation quality according to the provisions, this occurs because the pasteurization temperature treatment is correct and the milk is reheated before being served to consumers. Pasteurization of fresh milk is carried out so that milk is safe for consumption and has a long shelf life by reducing the content of microorganisms in milk, especially pathogenic microbes and preventing foodborne diseases (Quigley *et al.,* 2013; Ritota *et al.,* 2017). Heat treatment of milk can reduce the population of psychotropic and mesophilic microbes (Andriani *et al.,* 2021).

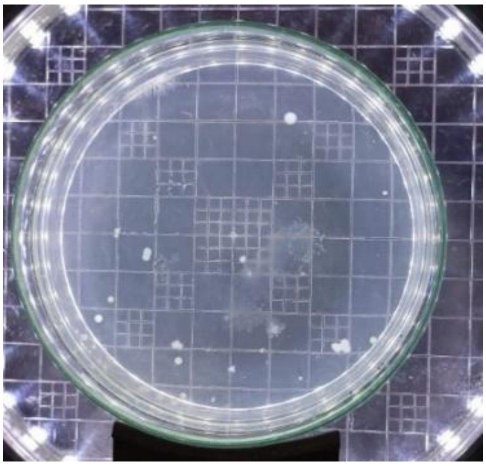

Figure 2. Bacterial colony growth (red arrow) on PCA media

However, seven out of thirty samples (23.33%) had TPC values above the maximum standard of less than 4.48 log CFU/ml. Pasteurized milk no longer contains pathogenic microorganisms because it has gone through a heating process, but post-pasteurization contamination can occur after processing and packaging (Figure 2). The location of the street milk stalls is on the side of a major road and the milk heating process is carried out openly without using a cover to protect the milk so that dirty and dusty floors can be a source of indirect contamination of post-pasteurized milk. Omemu and Aderoju (2008) argue that food sellers often cook some of the food beforehand, prepare it, and reheat it before serving it to consumers. This final cooking stage is often not enough to destroy existing microbes.

Likewise, data found in the study of Yadav *et al.* (2014) seven out of ten (70%) pasteurized milk from street stalls in Prayagraj, India were contaminated by pathogenic bacteria such as E. coli (40.85%), S. aureus (28.57%), S. typhi (14.28%), and P. aeruginosa (14.28%). The high TPC value in fresh milk raw materials allows the pasteurization process not to run optimally. These results are supported by research by Arjadi *et al.* (2017) which shows that fresh milk obtained from farmers, loopers and cooperatives in Boyolali has a high TPC value so that it does not meet the SNI for fresh milk, which is <1x106 CFU/ml.

Enterobacteriaceae

Enterobacteriaceae (EB) is an indicator of enteric microbial contamination and an effective measure for environmental sanitation programs (Buchanan and Oni, 2012). The level of EB in pasteurized milk from street milk stalls in Surakarta City is in accordance with the standards of the Serbian Regulation Book on food hygiene requirements, the number of Enterobacteriaceae in pasteurized milk is <10 CFU/ml (Figure 3). The low number of EB in pasteurized milk from street milk stalls in Surakarta City indicates the implementation of proper sanitation, especially in the pasteurization process. Owen *et al.* (2010) explained that EB can be easily removed from the production environment with proper pasteurization processes. Therefore, the presence of EB in heat-treated dairy products generally indicates a problem with process hygiene, such as inadequate heat treatment or post-process contamination from raw materials or the environment. EB testing is a more comprehensive indicator of the hygiene status of dairy products and processing environments than

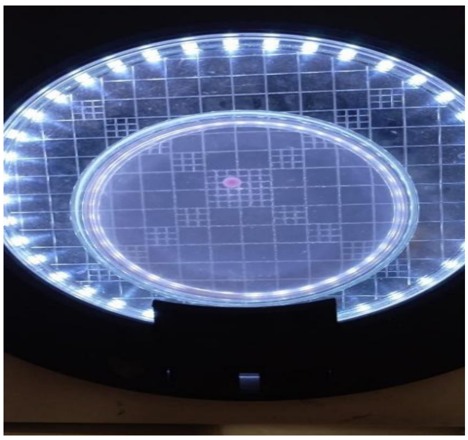

Figure 3. Enterobacteriaceae colony growth (red arrow) on VRBG agar media

coliform testing because it can detect a broader set of organisms representing taxonomically consistent groups, including Salmonella that cannot be detected by coliform testing (Hervert *et al.,* 2016; Knezevic *et al.,* 2021).

Conclusion

Based on the results of the study, it can be concluded that of the 30 samples tested, the milk stalls in sample 5, sample 10, and sample 22 has the best physico-chemical and microbiological quality even though it has not been able to meet the minimum standard of fat content according to SNI. Thus, pasteurized milk in street milk stalls in Surakarta City is safe for consumption because of its low microbiological value, but has not met the nutritional requirements according to SNI.

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References

Ahmed, S., Zim, A.F.M.I.U., Rahman, S., Ghosh, S., Chhetri, A. and Ali, M.S. (2019). Quality and Safety Assessment of Bangladeshi Pasteurized Milk. *Journal of Food Quality and Hazards Control*.

Alimi, B.A. (2016) Risk factors in street food practices in developing countries: A review. *Food Science and Human Wellness* 5, 141–148.

Ameeta, S., Ankita, S. and Anjali, G. (2017). Evaluation of Adulterants Commonly Found in Milk Samples. *International Journal of Agriculture and Food Science Technology* 8, 13–18.

Andriani, D.P., Mashito, R.B. and Handayani, M.L.W. (2021). Offline quality control for optimization of pasteurized milk production parameters. *IOP Conference Series: Earth and Environmental Science* 743.

Anema, S.G. (2008). Heat and/or high-pressure treatment of skim milk: Changes to the casein micelle size, whey proteins and the acid gelation properties of the milk. *International Journal of Dairy Technology* 61, 245–252.

Anindita, N.S. and Soyi, D.S. (2017). Studi kasus: Pengawasan Kualitas Pangan Hewani melalui Pengujian Kualitas Susu Sapi yang Beredar di Kota Yogyakarta. *Jurnal Peternakan Indonesia* 19, 96–105.

Arief, I.I., Wulandari, Z., Soenarno, M.S. and Murtini, D. (2020). Raw and pasteurized milk quality of D-farm milk processing unit at Faculty of Animal Science, IPB University. *Jurnal Ilmu-Ilmu Peternakan* 30, 103–108.

Arjadi, L., Nurwantoro and Harjanti, D. (2017). Evaluasi Cemaran Bakteri Susu yang Ditinjau Melalui Rantai Distribusi Susu dari Peternak hingga KUD di Kabupaten Boyolali. *Jurnal Ilmu-Ilmu Pertanian* 13, 1–10.

Arwani, M., Santoso, I. and Rahmatin, N. (2018). A dynamic model for managing adulteration risks of dairy industry supply chain in Indonesia. *Advances in Food Science, Sustainable Agriculture and Agroindustrial Engineering (AFSSAAE)* 1, 1–8.

Badan Pusat Statistik. (2020). Produksi telur unggas dan susu sapi. Badan Pusat Statistik. 2020.

Badan Pusat Statistik Jawa Tengah, 2020. Produksi produksi telur unggas dan susu sapi menurut Kabupaten/Kota dan jenis unggas di Provinsi Jawa Tengah, 2018 dan 2019. Jawa Tengah

Badan Pusat Statistik. (2020). Kabupaten Boyolali dalam Angka 2018. BPS, Jawa Tengah.

Badan Standardisasi Nasional. (1995). Standar Nasional Indonesia. Susu Pasteurisasi. SNI 01-3951-1995.

Badan Standardisasi Nasional. (2011). Standar Nasional Indonesia. Susu Segar Bagian 1. SNI 01-3141-2011.

Barham, G.S., Khaskheli, M., Soomro, A.H. and Nizamani, Z.A. (2014). Extent of extraneous water and detection of various adulterants in market milk at Mirpurkhas, Pakistan. *IOSR Journal of Agriculture and Veterinary Science* 7, 83–89.

Brick, T., Ege, M., Boeren, S., Böck, A., Von Mutius, E., Vervoort, J. and Hettinga, K. (2017). Effect of processing intensity on immunologically active bovine milk serum proteins. *Nutrients* 9, 1–14.

Buchanan, R.L. and Oni, R. (2012). Use of microbiological indicators for assessing hygiene controls for the manufacture of powdered infant formula. *Journal of Food Protection* 75, 989–997.

Chakraborty, M. and Biswas, K. (2018) Limit of Detection for Five Common Adulterants in Milk : A Study With Different Fat Percent. *IEEE Sensors Journal* 18, 2395–2403.

Chavan, R.S., Chavan, S.R., Khedkar, C.D. and Jana, A.H. (2011). UHT milk processing and effect of plasmin activity on shelf life: A review. *Comprehensive Reviews in Food Science and Food Safety* 10, 251–268.

Chen, W.L., Hwang, M.T., Liau, C.Y., Ho, J.C., Hong, K.C. and Mao, S.J.T. (2005). B-Lactoglobulin Is a Thermal Marker in Processed Milk As Studied By Electrophoresis and Circular Dichroic Spectra. *Journal of Dairy Science* 88, 1618–1630.

Fang, Q., Sun, J., Cao, D., Tuo, Y., Jiang, S. and Mu, G. (2017). Experimental and modelling study of the denaturation of milk protein by heat treatment. *Korean Journal for Food Science of Animal Resources* 37, 44–51.

Fauziah, R., Malaka, R. and Yuliati, F.N. (2020). Titratable acidity and pH changes of pasteurized milk by addition of Roselle flower extract in the refrigerator storage. *IOP Conference Series: Earth and Environmental Science* 492, 0–4.

Finete, V.D.L.M., Gouvêa, M.M., de Carvalho Marques, F.F. and Netto, A.D.P. (2013). Is it possible to screen for milk or whey protein adulteration with melamine, urea and ammonium sulphate, combining Kjeldahl and classical spectrophotometric methods? *Food Chemistry* 141, 3649–3655.

Gai, N., Uniacke-lowe, T., O'regan, J., Faulkner, H. and Kelly, A.L. (2021). Effect of protein genotypes on physicochemical properties and protein functionality of bovine milk: A review. *Foods* 10, 1–23.

Gondim, C.D.S., Cesar, R., Souza S De, Paula M De, Junqueira RG, Vitorino S and Souza C De (2015). Analytical Methods detection of adulterants in milk : starch , chlorides and sucrose. *Analytical Methods* 7, 9692–9701.

Griffiths, M. (2010). *Improving the Safety and Quality of Milk: Milk Production and Processing*. Elsevier.

Gwandu, S.H., Nonga, H.E., Mdegela, R.H., Katakweba, A.S., Suleiman, T.S. and Ryoba, R. (2018). Assessment of Raw Cow Milk Quality in Smallholder Dairy Farms in Pemba Island Zanzibar, Tanzania. *Veterinary Medicine International* 2018.

Hadiwiyoto, S. (1994). *Teori Dan Prosedur Pengujian Mutu Susu Dan Hasil Olahannya*. Penerbit Liberty.

Heck, J.M.L., Van Valenberg, H.J.F., Dijkstra, J. and van Hooijdonk, A.C.M. (2009). Seasonal variation in the Dutch bovine raw milk composition. *Journal of Dairy Science* 92, 4745–4755.

Hervert, C.J., Alles, A.S., Martin, N.H., Boor, K.J. and Wiedmann, M. (2016). Evaluation of different methods to detect microbial hygiene indicators relevant in the dairy industry. *Journal of Dairy Science* 99, 7033–7042.

Ismiarti, Suranindyah, Y.Y. and Widodo (2019). Microbiological qualities of goat milk obtained under different milking systems at a smallholder dairy farm in Yogyakarta, Indonesia. *International Journal of Dairy Science* 14, 29–35.

Javaid, S., Gadahi, J., Khaskeli, M., Bhutto, B., Kumbher, S. and Panhwar, A. (2009).

Physical And Chemical Quality of Market Milk Sold at Tandojam, Pakistan. *Pakistan Veterinary Journal* 29, 27–31.

Karmaker A, Das PC and Iqbal A (2020). Quality assessment of different commercial and local milk available in the local markets of selected area of bangladesh. *Journal of Advanced Veterinary and Animal Research* 7, 26–33.

Knezevic, S.V., Vranesevic, J., Pelic, M., Knezevic, S., Kureljusic, J., Milanov, D. and Pelic, L. (2021). The significance of Enterobacteriaceae as a process hygiene criterion in yogurt production. *IOP Conference Series: Earth and Environmental Science* 854.

Lai, C.Y., Fatimah, A.B., Mahyudin, N.A., Saari, N. and Zaman, M.Z. (2016). Physico-chemical and microbiological qualities of locally produced raw goat milk. *International Food Research Journal* 23, 739–750.

Le, T.T., Phan, T.T.Q., Van Camp, J. and Dewettinck, K. (2015). *Milk and Dairy Polar Lipids: Occurrence, Purification, and Nutritional and Technological Properties*. AOCS Press.

Mariana, E., Hadi, A.D.N. and Qoim, N. (2016). Respon Fisiologis dan Kualitas Susu Sapi Perah Friesian Holstein pada Musim Kemarau Panjang di Dataran Tinggi. *Jurnal Agripet* 16, 131–139.

Memon, M.A., Khaskheli, M., Kamboh, A.A., Soomro, N.A., Mangsi, A.S., Barham, G.S. and Korejo, N.A. (2018). Surveillance of milk adulteration and its influence on physico-chemical characteristics of milk in Hyderabad, Pakistan. *Journal of Animal Health and Production* 6, 5–12.

Moughan, P.J. (2014). *Milk Proteins: A Cornucopia for Developing Functional Foods*. Elsevier Inc.

Muehlhoff, E., Bennett, A. and McMahon D (2013) *Milk and Dairy Products in Human Nutrition*. Rome (Italy): Food and Agriculture Organisation of the United Nations.

Nyokabi, S.N., de Boer, I.J., Luning, P.A., Korir, L., Lindahl, J., Bett, B. and Oosting, S.J. (2021). Milk quality along dairy farming systems and associated value chains in Kenya: An analysis of composition, contamination and adulteration. *Food Control* 119, 107482.

Omemu, A.M. and Aderoju, S.T. (2008). Food safety knowledge and practices of street food vendors in the city of Abeokuta, Nigeria. *Food Control* 19, 396–402.

Priyanto, A.D., Wicaksono, L.A. and Putranto, A.W. (2021). Pengaruh Suhu dan Waktu Pre-Heating pada Kualitas Fisik, Total Mikroba dan Organoleptik Susu Kolagen Sapi yang Dipasteurisasi Menggunakan Pulsed Electric Field. *Jurnal Keteknikan Pertanian Tropis Dan Biosistem* 9, 141–153.

Quigley, L., O’Sullivan, O., Stanton, C., Beresford, T.P., Ross, R.P., Fitzgerald, G.F. and Cotter, P.D. (2013). The complex microbiota of raw milk. *FEMS Microbiology Reviews* 37, 664–698.

Ritota, M., Di Costanzo, M.G., Mattera, M. and Manzi, P. (2017). New Trends for the Evaluation of Heat Treatments of Milk. *Journal of Analytical Methods in Chemistry* 2017.

Rosales, A.P., Linnemann, A.R. and Luning, P.A. (2023). Food safety knowledge, self-reported hygiene practices, and street food vendors’ perceptions of current hygiene facilities and services - An Ecuadorean case. *Food Control* 144, 109377.

Salih, M.A.M. and Yang, S. (2017). Common Milk Adulteration in Developing Countries Cases Study in China and Sudan: A Review. *Advances in Dairy Research* 05.

Singh, P. and Gandhi, N. (2015) Milk Preservatives and Adulterants: Processing, Regulatory and Safety Issues. *Food Reviews International* 31, 236–261.

Standar Nasional Indonesia. 2008. Metode Pengujian Cemaran Mikrobia dalam Daging, Telur, dan Susu Serta Hasil

Olahannya. SNI 2897-2008. Badan Standardisasi Nasional, Jakarta.

Smigic, N., Djekic, I., Tomasevic, I., Miocinovic, J. and Gvozdenovic, R. (2012). Implication of food safety measures on microbiological quality of raw and pasteurized milk. *Food Control* 25, 728–731.

Sudarmadji, S., B. Haryono, dan Suhardi. 1997. Prosedur Analisa Bahan Makanan dan Pertanian. Liberty. Yogyakarta.

Suranindyah, Y., Wahyuni, E., Bintara, S. and Purbaya, G. (2015). The Effect of Improving Sanitation Prior to Milking on Milk Quality of Dairy Cow in Farmer Group. *Procedia Food Science* 3, 150–155.

Sutrisna, D.Y., Suada, I.K. and Sampurna, I.P. (2014). Kualitas Susu Kambing Selama Penyimpanan Pada Suhu Ruang Berdasarkan Berat Jenis, Uji Didih, Dan Kekentalan. *Indonesia Medicus Veterinus* 3, 60–67.

Swathi, J. and Kauser, N. (2015). A study on adulteration of milk and milk products from local vendors. *International Journal of Biomedical and Advance Research* 6, 678–681.

Syamsi, A.N., Astuti, T.Y. and Widodo, H.S. (2018). Kajian keamanan pangan dan tingkat prevalensi cemaran bakteri susu di Sentra Pengembangan Sapi Perah Cilongok Assessment of food security and prevalence rate of milk bacterial contami- nation at Cilongok Dairy Cattle Development Center. *Jurnal Ilmu-Ilmu Peternakan* 28, 224–232.

Utami, K., Lilik, E.R. and Surjowardojo, P. (2014). Kajian kualitas susu sapi perah PFH (studi kasus pada anggota Kope- rasi Agro Niaga. *Jurnal Ilmu-Ilmu Peternakan* 24, 58–66.

Wiranti, N., Wanniatie, V., Husni, A. and Qisthon, A. (2022). Kualitas Susu Sapi Segar pada Pemerahan Pagi dan Sore. *Jurnal Riset Dan Inovasi Peternakan* 6, 123–128.

Wulandari, Z., Taufik, E. and Syarif, M. (2017) Kajian Kualitas Produk Susu Pasteurisasi Hasil Penerapan Rantai Pendingin. *Jurnal Ilmu Produksi Dan Teknologi Hasil Peternakan* 5, 94–100.

Yadav, J., Paul, S., Peter, J.K., Kumar, Y., Singh, A.K., Masih, F. and Masih, H. (2014). Comparative evaluation of pathogenic bacterial incidence in raw and pasteurized milk. *Researchgate.Net* 3, 11–20.

Zagorska, J. and Ciprovica, I. (2013). Evaluation of Factors Affecting Freezing Point of Milk. *International Journal of Nutrition and Food Engineering* 7, 106–111.

Zebib, H., Abate, D. and Woldegiorgis, A.Z. (2023). Nutritional quality and adulterants of cow raw milk, pasteurized and cottage cheese collected along value chain from three regions of Ethiopia. *Heliyon* 9.

Zhang, L., Boeren, S., Smits, M., van Hooijdonk, T., Vervoort, J. and Hettinga, K. (2016). Proteomic study on the stability of proteins in bovine, camel, and caprine milk sera after processing. *Food Research International* 82, 104–111.

Ziyaina, M., Govindan, B.N., Rasco, B., Coffey, T. and Sablani, S.S. (2018). Monitoring Shelf Life of Pasteurized Whole Milk Under Refrigerated Storage Conditions: Predictive Models for Quality Loss. *Journal of Food Science* 83, 409–418.