

Effects of different pasteurizers on the microbial quality of raw milk samples

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Abstract

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Introduction. This study was conducted to determine the effect of different pasteurizing temperatures on the microbial quality of raw milk samples from different breeds.

Materials and methods. The raw milk samples were analyzed chemically for pH in the range of 5.670 to 3.240 and microbiologically for Total Viable Counts, Coliform Counts, Fecal Coliform Counts, and Lactobacillus Counts, for all treatment combinations. These samples were pasteurized at pasteurized at 71°C for 15seconds, 66°C for 15minutes and 61°C for 30minutes collected from White Fulani breed, New Jersey breed and the breed mixture (White Fulani and New Jersey) using pasteurizer made of aluminium, stainless steel and galvanized steel

Results and discussion. Mean results of TVC, CC, FCC, LBC for White Fulani before pasteurizing were in the range of 6.833×10^5 -0.000 Cfu/ml and FC (2.433×10^3 Cfu/ml) respectively and that of New Jersey were within 7.800×10^5 -0.000 Cfu/ml and FC (0.115×10^3 Cfu/ml) respectively, also that of the breed mixture were within 9.400×10^5 -0.000 Cfu/ml and FC (5.167×10^3 Cfu/ml). The mean counts was decreased for aluminium, stainless steel and galvanized steel pasteurizer at the temperature and microbial range of 61°C-71°C and for TVC(7.233-1.400 Cfu/ml), CC(5.633-0.000 Cfu/ml), FCC(3.033-0.000Cfu/ml), LBC (3.000-0.000Cfu/ml), FC (5.033-1.000Cfu/ml) for the White Fulani and was also decreased for the New Jersey at the same materials and temperature combinations for TVC(6.533-1.800 Cfu/ml), CC(4.800-1.233 Cfu/ml), FCC(0.000-0.000 Cfu/ml), LBC (1.800-0.000Cfu/ml), FC (3.833-1.033Cfu/ml). Finally, the microbial counts was also decreased for the breed mixture at the same materials and temperature combination for TVC(5.800-1.200 Cfu/ml), CC(4.300-1.000 Cfu/ml), FCC(0.000-0.000 Cfu/ml), LBC(1.033-0.000 Cfu/ml) and FC(3.300-1.200 Cfu/ml).

Conclusion. Raw milk samples should be pasteurized at a temperature of 71°C in a stainless steel for 15 seconds in order to record a low bacterial counts.

Introduction

Milk is a nutritious food for human beings. It also serves as a good medium for the growth of many microorganisms such as Staphylococcus and Coliform. Bacterial contamination of raw milk can originate from different sources, including low quality raw milk, improper refrigeration and an inadequate packaging system. Raw milk deteriorates in few days and pasteurized milk with high temperature short time treatment (HTST) has a shelf life of about seven days. Contaminations of raw milk and the consequent high bacterial count in milk originates from milking wet dirty udders, the milking system used, the cooling and storage temperature and the holding time [1].

Milk harbors a complex microbial community, including microorganisms of industrial importance, that possess health-promoting features and that are of concern from a food quality or safety perspective. Thus, the milk microbiota is the focus of constant attention. The microbial composition of milk is influenced by several different parameters such as, in the case of raw milk, the microorganisms present in the teat canal, on the surface of teat skin, in the surrounding air, in feed, as well as other environmental factors including housing conditions, the quality of the water supply, and equipment hygiene[2].

Raw milk is milk in its natural (unpasteurized) state. Contaminated raw milk can be a source of harmful bacterial, such as those that cause undulant fever, dysentery, salmonellosis and tuberculosis. “Certified” milk, obtained from cows certified as healthy is unpasteurized milk with a bacterial count below a specified standard, but it still can contain significant numbers of disease producing organisms. Different heat and treatments are given to raw milk in order to remove pathogenic organisms to increase the shelf life, to help subsequent processing. For example, for warming before separation and homogenization or as an essential treatment before cheese making, yoghurt manufacture and production and production of evaporated and dried milk products[3]. Batch (or “vat”) pasteurization is the simplest and oldest method for pasteurizing milk. Milk is heated to 154.4°F (63°C) in a large container and held at that temperature for 30minutes. This process can be carried out at home on the stove top using large pot or, for small scale dairies with steam-heated kettles and fancy temperature control equipment. In batch processing the milk has to be stirred constantly to make sure that each particles of milk is heated.

Ultra-high temperature (UHT or ultra-heat treatment) is also used for milk treatment. UHT processing holds the milk at a temperature of 138°C (250°F) for a fraction of a second. Milk simply labeled “pasteurized” is usually treated with the HTST (high temperature short time) method, whereas milk labeled “ultra-pasteurized” or simply “UHT” has been treated with the UHT method [4]. The problem of post treatment contamination of “in container” sterilized product can either be through “poor seal” or through “pin hole” in the container. Post treatment contaminants in UHT milk may be either by spores which would not be expected to be heat resistant enough to survive the heat treatment or non-heat resistance vegetative organisms. Organisms of the first type will probably have entered from the ineffective sterilization of plant downstream from the heat treatment stage of the process, which includes spores of *Bacillus cereus* [5]

Contamination of raw milk from cow can be as a result of the introduction of foreign materials into the milk before or during the milk production, by pathogens through vectors, humans and flies or disease causing organism like bacterial. Also, contamination can occur after the pasteurization of raw milk product through careless handling of the product in an unhygienic environment.

Therefore, certain requirements should be fulfilled in order to produce safe and clean milk. These requirements include: clean milking and cooling of milk immediately after transference of milk to processing in ideal plants with strict quality control [1].

Pasteurization is done locally using temperature which cannot be quantified, therefore there is need for a thermocouple heater which can be used to stabilize and quantify the different pasteurizing temperature, and it will reduce labor cost. This is also expected to lower the microbial counts compared to the unpasteurized milk.

Materials and methods

The various material and devices used in this work and the basis of their selection as well as some of their standard properties are discussed as follow.

Heating Medium. An electric stove with an AC voltage of 220V, a frequency of 50/60Hz and a thermal coil element rating of 1000w was selected for heating the milk at regulated temperatures. The cost of the stove is relatively cheap and it is available and can provide the desired power rating required.

K-type Thermocouple. The thermocouple is a sensor attached to the material and connected to a temperature regulator. It senses the temperature of the milk and conveys this information to the regulator which then adjust the temperature if necessary to a predetermined set point. The K-type (Chromel - Alumel) was selected because of unlike other types of thermocouples (B, C, E, J, N, R, S, T types), it is well suited for oxidizing atmospheres; that is, it resist corrosion and has a useable temperature range of 95⁰C to 1260⁰C. It is has a good degree of sensitivity of 39 μ V/⁰C, durable and readily available (Watlow, 2015).

Temperature Controller. The temperature controller is a device used to maintain the desired temperature for the different pasteurization treatments of the milk. It was selected because of the need to maintain the different temperatures for specific periods. It works on the principles of a temperature control loop. The sensor (k-type thermocouples) measures the temperature of the milk to be controlled and converts the measured value into a travel signal. The information is received by the regulator and compared to the set point (pasteurizing temperature) and make adjustment when necessary.

General Description of the Experimental Setup and the Working Principle. The experimental or design setup consist of different material (aluminium, stainless and steel pots) in which the milk is poured. Stirrers are from the top attached to these mediums to allow uniformity in heat transfer while heating the different raw milk samples to be tested. A K-type thermocouple is also attached to the materials; for the purpose of sensing the temperature difference during the milk heating and to relate the sense heat to the controller. The controller then makes necessary adjustment after comparing it to the preset temperature to prevent over or under heating of the milk. The heater to be used is also connected to the controller in order to regulate the amount of power to be supplied to it when necessary. If the heat transferred by the heater to the materials is high enough that the milk temperature gets to a set point as relayed by the thermocouple, the controller stops the power supply and once there is a slight drop in the temperature, the controller immediately supply power to maintain the set point. The controller terminals are connected to a power source through the socket outlet.

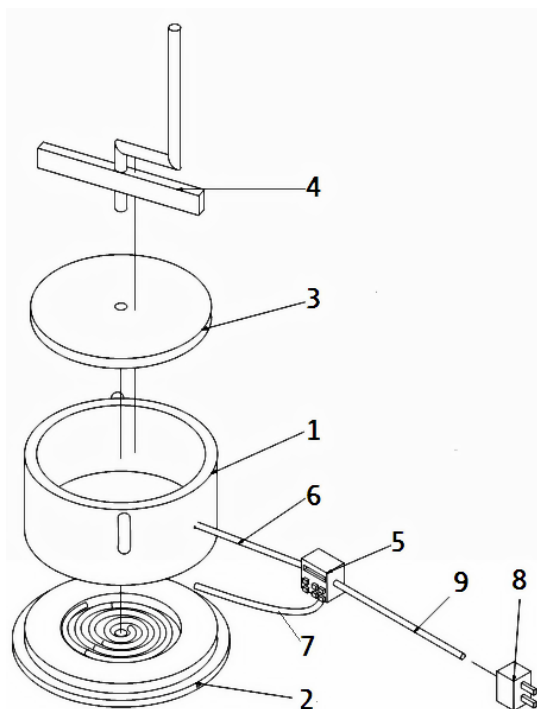


Figure 1. Exploded view of the experimental set up:

1 – Container/Port, 2 – Electric heater, 3 – Lid, 4 – Stirrer, 5 – Temperature regulator, 6 – Thermocouple, 7 – Electric heater cable, 8 – Connecting probe, 9 – Connecting probe wire

Milk from the New Jersey breed already undergo basic preparation process like clarification carried out in a clarifier at shonga farm holdings after being collected from a milking machine. It is transported down in an ice van to maintain it temperature at 3⁰C to 5⁰C.

Preparation of culture Media. The media to be used for this analysis are Nutrient Agar (NA) for total bacteria, Mac Conkey agar for enumeration of coliform bacteria, Eosin Methylene Blue agar for fecal coliform enumeration, Demann Rogossa Sharpe agar for enumeration of lactobacillus, Yeast Extraction agar for enumeration of yeast and Potato Dextrose Agar (PDA) for enumeration of fungi. count. The said culture media were prepared in line with the manufacturer's instruction. The colonies were counted and associated microorganisms were isolated, characterized and identified according to the techniques described by[7] in the laboratory manual of microbiology.

Sensitivity Analysis. The effect of different pasteurizing temperature and materials on the fungi and bacterial counts of raw milk samples would be investigated using ANOVA at $p \leq 0.05$ and the level of significant means would be further evaluated using Duncan's Multiple Range Test (DNMRT).

Results and discussion

It can be deduced from table 1 that after the pasteurization process, aluminium material had high average bacterial count of 7.23×10^5 for TVC, 5.37×10^5 for CC, 0.00 for FCC and LBC and 5.03×10^3 Cfu/ml for FC respectively at 71°C. This indicates an increase in the microbial load of the raw sample which had an initial average count of 6.83×10^5 for TVC, 5.3×10^5 for CC, 0.00 for FCC and LBC and 2.43×10^3 Cfu/ml for FC respectively. This post treatment contamination could be through “poor seal” or through “pin hole” in the container used in conveying the milk samples to the laboratory after pasteurization or ineffective heat treatment of heat resistance organisms [5].

Also, comparing the raw and control samples from table 1, it shows that besides aluminium material which shows contamination at 71°C for White Fulani breed only, the remaining samples had a decreased microbial load, showing the effect of pasteurization. Furthermore, it can be added that the reason for the very high microbial counts in the raw milk samples was due to the microorganisms present in the teat canal, on the surface of teat skin, in the surrounding air, in feed, as well as other environmental factors including housing conditions of the dairy animal [2], while that of the locally pasteurized samples (nono) could be due to the quality of the water supply, and equipment hygiene used in milking. The results in table 1 also showed that depending on the materials and the temperature applied in the pasteurization process, there are variations in total viable count of the pasteurized milk from the various source. Similarly, variances were also observed in coliform count of the pasteurized milk from the different source along the various levels of applied temperature and materials. Similar observation also exist for faecal coliform count, LB count and fungi count. These may imply that fungal count of milk pasteurized using the selected applied temperature and in the different materials were not same with regard to the milk source. Raw milk pH ranges from 6.4 to 6.8, with an average pH of 6.6 making it slightly acidic. It is a complex biological fluid and by its nature, a good growth medium for many microorganisms. Most bacteria especially in milk normally grow within the neutrophilic pH. The pH of raw milk therefore plays an important role as it has an effect on the distribution and growth rate of microorganisms in the milk [8]. In this research work, the pH ranges within 5.67 to 3.240 which would also have supported the total growth of microorganisms present.

Table 1

Summary statistics of the data generated

Materials	Temperatures	Source	pH	TVC	CC	FCC	LBC	FC
Aluminium	61	White Fulani	4.640	4.233	2.500	3.033	0.000	3.200
		New Jersey	4.760	4.200	3.000	0.000	0.000	2.833
		Mixture	4.950	4.267	1.133	0.000	0.000	1.300
	66	White Fulani	4.600	6.300	5.633	0.000	0.000	3.133
		New Jersey	4.950	6.533	4.800	0.000	0.000	3.167
		Mixture	4.370	1.233	1.100	0.000	1.033	1.233
	71	White Fulani	4.550	7.233	5.367	0.000	0.000	5.033
		New Jersey	5.010	3.767	2.100	0.000	0.000	3.833
		Mixture	5.120	2.100	1.500	0.000	0.000	3.300
Stainless Steel	61	White Fulani	5.400	1.400	1.133	0.000	0.000	1.800
		New Jersey	4.530	1.800	1.233	0.000	0.000	1.833
		Mixture	4.730	5.200	3.800	0.000	2.400	1.200
	66	White Fulani	4.870	3.033	2.233	0.000	3.000	1.233
		New Jersey	4.620	2.700	2.000	0.000	1.800	1.033
		Mixture	4.600	1.600	1.000	0.000	0.000	1.500
	71	White Fulani	4.490	3.500	2.867	0.000	0.000	2.067
		New Jersey	4.420	2.033	1.400	0.000	0.000	1.200
		Mixture	5.060	1.400	1.033	0.000	0.000	1.233
Galvanized Steel	61	White Fulani	3.510	2.800	2.133	0.000	0.000	1.000
		New Jersey	3.240	3.067	2.500	0.000	2.833	1.633
		Mixture	4.250	2.333	1.700	0.000	0.000	2.100
	66	White Fulani	4.080	1.800	1.200	0.000	0.000	2.067
		New Jersey	5.630	4.233	3.367	0.000	0.000	2.700
		Mixture	4.130	5.800	4.300	0.000	0.000	2.800
	71	White Fulani	4.640	3.700	2.433	0.000	0.000	2.467
		New Jersey	3.290	2.500	1.800	0.000	2.667	1.167
		Mixture	4.560	1.200	1.000	0.000	0.000	1.633
Control	Raw	White Fulani	6.833	5.300	0.000	0.000	2.433	5.670
		New Jersey	7.800	5.533	0.000	0.000	3.800	4.520
		Mixture	9.400	6.833	0.000	0.000	5.167	4.750
	Fermented	White Fulani	9.567	7.900	0.000	0.000	3.500	3.420
		New Jersey	8.700	6.200	0.000	1.867	3.733	3.480
		Mixture	9.800	8.233	0.000	0.000	3.300	4.390

Materials (M1 = Aluminium, M2= Stainless steel, M3= Galvanized Steel), Temperature (T1=71°C, T2=66°C, T3=61°C) and Source (S1=White Fulani, S2= New Jersey, S3=Mixture), RAW S1 =White Fulani Breed Raw Milk Sample, RAW S2= New Jersey Breed Raw Sample, RAW S3= Mixture of White Fulani and New Jersey Breed Raw Sample, FM S1 =Fermented/Nono Milk for White Fulani Breed, FM S2 =Fermented/Nono Milk for New Jersey Breed, FM S3 =Fermented/Nono Milk for the Mixture of White Fulani and New Jersey Breed, TVC =Total Viable Counts, CC= Coliform Counts, FCC= Fecal Counts, LBC=Lactobacillus Counts, FC= Fungi Counts, Cfu= Colony Forming Unit, R1, R2 and R3= First, Second and Third replicates respectively.

Table 2

Multivariate analysis of variance for measured parameters

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
M	TVC	52.572	2	26.286	1936.000	0.000*
	CC	18.631	2	9.316	5390.000	0.000*
	FCC	2.045	2	1.022	8281.000	0.000*
	LBC	6.763	2	3.382	9130.000	0.000*
	FC	33.745	2	16.873	2485.000	0.000*
T	TVC	5.844	2	2.922	215.164	0.000*
	CC	8.889	2	4.445	2571.000	0.000*
	FCC	2.045	2	1.022	8281.000	0.000*
	LBC	1.886	2	0.943	2546.000	0.000*
	FC	4.290	2	2.145	315.873	0.000*
S	TVC	13.460	2	6.730	495.555	0.000*
	CC	13.603	2	6.802	3935.000	0.000*
	FCC	2.045	2	1.022	8281.000	0.000*
	LBC	3.737	2	1.868	5044.000	0.000*
	FC	5.429	2	2.714	399.764	0.000*
MT	TVC	7.458	4	1.865	137.300	0.000*
	CC	10.610	4	2.653	1535.000	0.000*
	FCC	4.089	4	1.022	8281.000	0.000*
	LBC	15.401	4	3.850	10400.000	0.000*
	FC	15.796	4	3.949	581.591	0.000*
MS	TVC	43.203	4	10.801	795.323	0.000*
	CC	38.434	4	9.608	5559.000	0.000*
	FCC	4.089	4	1.022	8281.000	0.000*
	LBC	17.862	4	4.465	12060.000	0.000*
	FC	12.399	4	3.100	456.518	0.000*
TS	TVC	53.066	4	13.267	976.905	0.000*
	CC	22.067	4	5.517	3192.000	0.000*
	FCC	4.089	4	1.022	8281.000	0.000*
	LBC	7.628	4	1.907	5149.000	0.000*
	FC	4.815	4	1.204	177.273	0.000*
MTS	TVC	56.320	8	7.040	518.402	0.000*
	CC	33.580	8	4.198	2429.000	0.000*
	FCC	8.179	8	1.022	8281.000	0.000*
	LBC	28.387	8	3.548	9581.000	0.000*
	FC	3.448	8	0.431	63.477	0.000*
Error	TVC	0.733	54	0.014		
	CC	0.093	54	0.002		
	FCC	0.007	54	0.000		
	LBC	0.020	54	0.000		
	FC	0.367	54	0.007		
Total	TVC	1131.990	81			
	CC	604.820	81			
	FCC	27.610	81			
	LBC	102.640	81			
	FC	450.210	81			

*Significant at 5% level

M=Materials (M1=Aluminium, M2=Stainless steel, M3=Galvanized Steel), T=Temperature (T1=71°C, T2=66°C, T3=61°C) and S=Source (S1=White Fulani, S2= New Jersey, S3=Mixture), MT= Material and and Temperature Combination, MS= Material and Source Combination, TS=Temperature and Source Combination, MTS= Material, Temperature and Source Combination, TVC=Total Viable Counts, CC=Coliform Counts, FCC=Feecal Counts, LBC=Lactobacillus Counts, FC=Fungi Counts, df= degree of freedom

Table 2 showed the analysis of variance test. The analysis of variance test shows the effect of the measured parameters on microbial counts of pasteurized milk. The test shows that pasteurized milk using the three selected materials (aluminum, stainless and steel) under the three selected applied temperature had significantly different total viable count, coliform count, faecal coliform count, LB count and fungal count at 5% level. The source of the milk was also a function of the variances observed and lastly the interactions between study parameters were also significant at 5%. The bacterial count is a useful method to measure milk quality, a bacterial count ranging between 9×10^5 - 9×10^6 Cfu/ml is acceptable[9], and the mean standard plate count of raw milk is 1.29×10^6 cfu/ml (Ramanjaneyulu, 1985). From the summary statistics, i.e. table 4.3 and table 4.4, the mean results of TVC, CC, FCC, LBC, FC and pH for White Fulani breed before pasteurizing were 6.833×10^5 , 5.300×10^5 , 0.000×10^5 , 0.000×10^5 , 2.433×10^3 Cfu/ml and 5.670 respectively and that of New Jersey breed were 7.800×10^5 , 5.533×10^5 , 0.000×10^5 , 0.000×10^5 , 3.800×10^3 Cfu/ml and 4.520, also that of the breed mixture were 9.400×10^5 , 6.833×10^5 , 0.000×10^5 , 0.000×10^5 , 5.167×10^3 Cfu/ml and 4.750. Therefore, according to [10], it shows that the average initial count before pasteurizing is within acceptable range. The mean counts was decreased for aluminium, stainless steel and galvanized steel pasteurizer at the temperature and microbial range of 61°C - 71°C within range of 7.233×10^5 to 0.000 Cfu/ml for the bacterial count and 5.67×10^3 Cfu/ml to 1×10^3 Cfu/ml for the fungi count. Also, the pH was decreased in the range of 5.67 to 3.240. Therefore, according[9] it is acceptable at significant difference of 5%.

The new Duncan multiple range test on Table.3 shows the different mean values of the fungal counts in the materials assuming all other parameters were fixed. It can be inferred from Table 3 that the total viable count of pasteurized milk in aluminum was significantly higher than those of stainless steel and galvanized steel irrespective of the applied temperature and or source of the milk. The total viable count observed in stainless steel was statistically different from that observed in galvanized steel material. The mean coliform count of pasteurized milk in aluminum material was 3.015×10^5 Cfu/ml and this value was significantly higher than the coliform count of 2.270×10^5 Cfu/ml and 1.856×10^5 Cfu/ml observed in galvanized steel and stainless steel respectively. Fecal coliform count was only observed in milk pasteurized in aluminum material. Milk pasteurized using galvanized steel and stainless steel material had significantly higher LB count than milk pasteurized in aluminum. Lastly, fungal count was higher in milk pasteurized in aluminum than those of stainless steel and galvanized steel.

The total viable count of pasteurized milk at temperature of 66°C (3.693×10^5 Cfu/ml) was significantly higher than the total viable count observed 61°C (3.256×10^5 Cfu/ml) and that observed at 71°C (3.048×10^5 Cfu/ml) on the average irrespective of the source and material used. Milk pasteurized at 66°C also had higher coliform count compared to those pasteurized at the other two levels of the temperature use (see Table 4.5). Similarly, milk pasteurized at 66°C had statistically higher LB count (0.648×10^5 Cfu/ml) than those pasteurized at 61°C and 71°C respectively. Also the fungal count of milk pasteurized at 71°C was significantly higher (2.437×10^3 Cfu/ml) compared to the fungal count of milk pasteurized at 66°C and at 61°C .

The white Fulani had significantly higher total viable count (3.778×10^5 Cfu/ml) than all other milk used in the experiment after pasteurization and this was followed by the New Jersey total viable count of 3.426×10^5 Cfu/ml. The mixture of the two milk sourced from white Fulani and the New Jersey had the lowest total viable count. Table 4.3 also shows that white Fulani milk had significantly higher coliform count when pasteurized compared

to New Jersey and the mixture of the two. Again this was followed by the New Jersey with a coliform value of 2.467×10^5 Cfu/ml. The coliform value of mixture was 1.841×10^5 Cfu/ml. Similar trend was also observed for the faecal count. However, the LB count of New Jersey was significantly higher than all Fulani and the mixture.

Table 3

Multiple comparison using the new duncan range test

		TVC	CC	FCC	LBC	FC
Materials	Aluminum	4.430a	3.015a	0.337a	0.115a	3.004a
	Stainless steel	2.519b	1.856b	0.000b	0.800b	1.456b
	Galvanized Steel	3.048c	2.270c	0.000b	0.611c	1.952c
Temperature	61	3.256a	2.126a	0.337a	0.582a	1.878a
	66	3.693b	2.848b	0.000b	0.648b	2.096b
	71	3.048c	2.167c	0.000b	0.296c	2.437c
Source	White Fulani	3.778a	2.833a	0.337a	0.333a	2.444a
	New Jersey	3.426b	2.467b	0.000b	0.811b	2.156b
	Mixture	2.793c	1.841c	0.000c	0.382a	1.811c

Mean with the same alphabet are not significantly different from each other

TVC =Total Viable Counts, CC= Coliform Counts, FCC= Faecal Counts, LBC=Lactobacillus Counts, FC= Fungi Counts

Graphical illustrations of the fungal counts of pasteurized milk disaggregated by temperature and milk source.

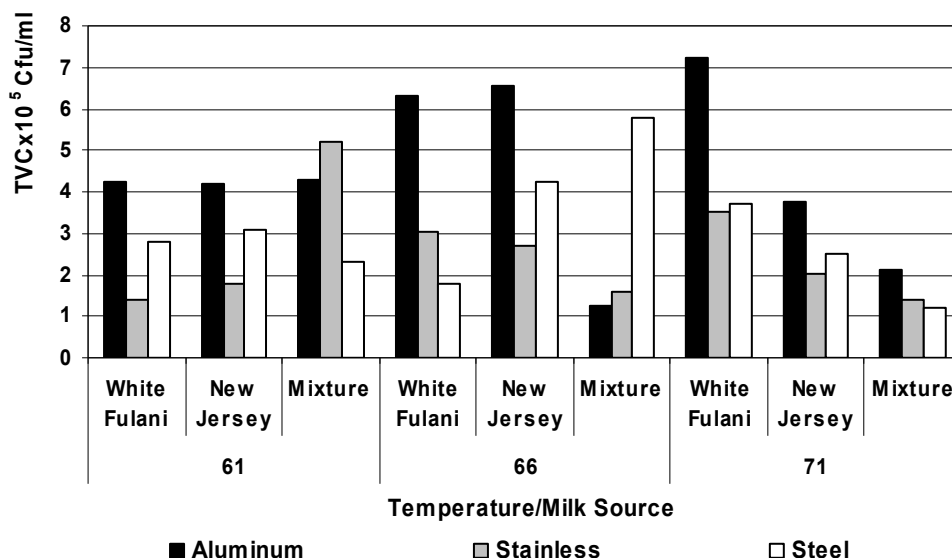


Figure 1. Chart showing the graphical illustration of the total viable count in applied temperature and milk Source

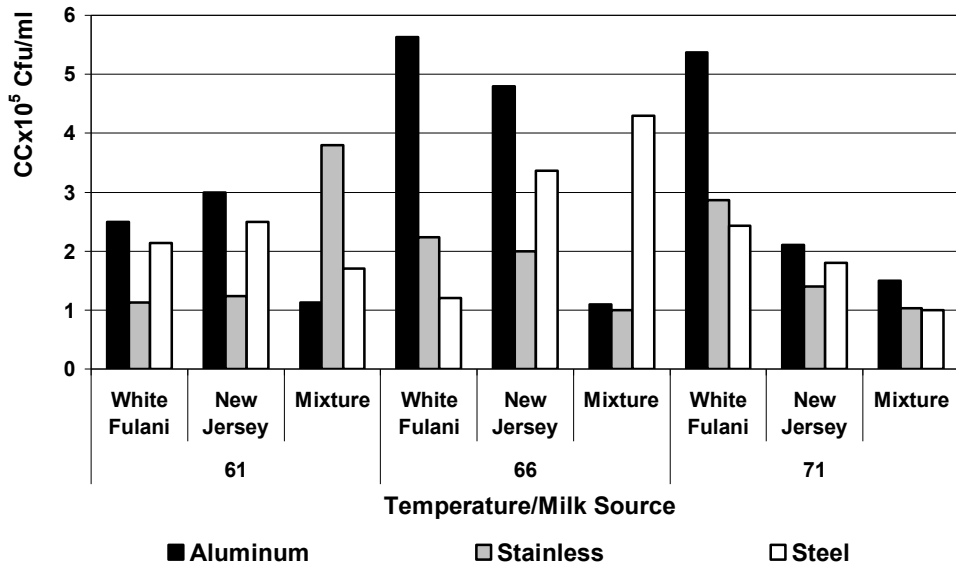


Figure 2. Chart showing the graphical illustration of the coliform count in applied temperature and milk source

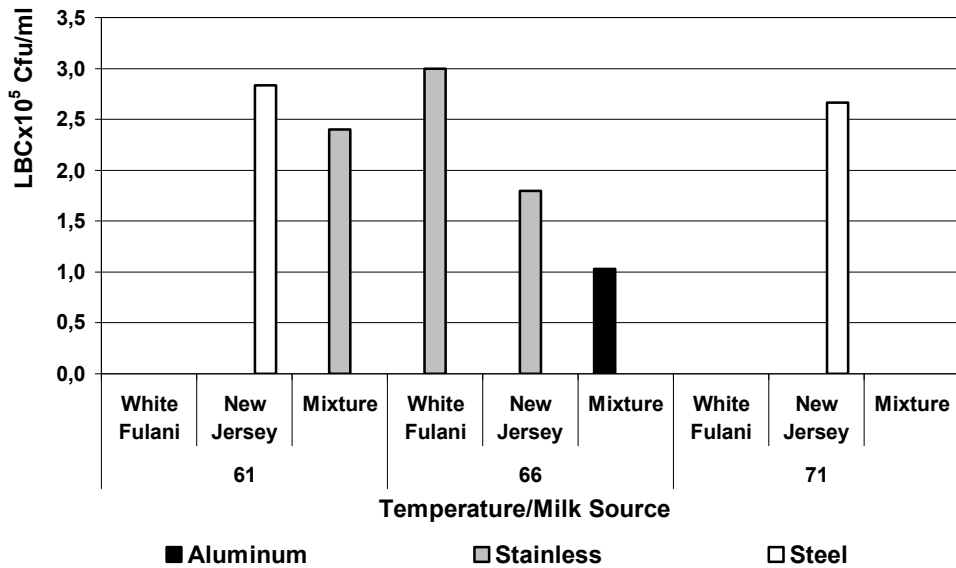


Figure 3. Chart showing the graphical illustration of the LB count in applied temperature and milk source

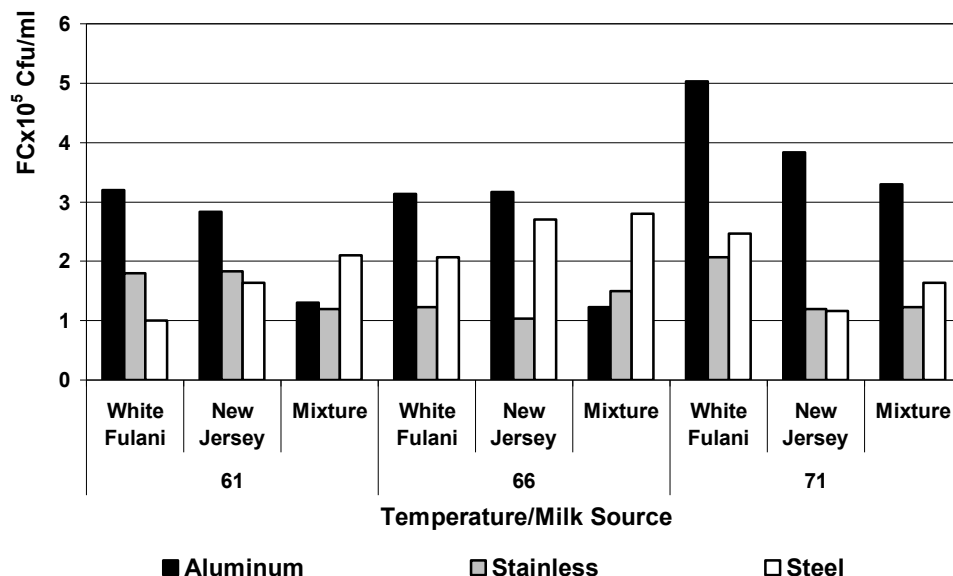


Figure 4. Chart showing the graphical illustration of the fungal count in applied temperature and milk source

It could be observed that at 61°C, aluminium has the highest fungi count (5.55%) of the total fraction for the White Fulani breed then followed by stainless steel (3.12%) and galvanized steel (1.73%), then same trend in the New Jersey breed also followed with aluminium (4.98%), stainless steel (3.18%) and galvanized steel (2.83%). This was reduced in the breed mixture where galvanized steel (3.64%) has the highest fungi count, then aluminium (2.25%) and stainless steel (2.08%) at the same temperature. Also, at 66°C aluminium material showed the highest FC both in the local (5.49%) and the foreign breed (5.43%) of the total fraction, which is then followed by galvanized steel (3.58%, 4.68% and 4.85%) for the White Fulani, New Jersey and the breed mixture respectively, leaving stainless steel with the least count of (2.14%, 1.79% and 2.6%) for the local breed, foreign breed and breed mixture respectively. Finally, at 71°C, aluminium has the highest count (8.72%, 6.64% and 5.72) for the White Fulani, New Jersey and the breed mixture respectively. For stainless steel, the percentage count were (3.58%, 2.08% and 2.13%) for the White Fulani, New Jersey and the breed mixture respectively, and for the galvanized steel the percentage count of the whole fractions are; 4.28%, 2.02% and 2.83% for the White Fulani, New Jersey and the breed mixture respectively. In this study, stainless steel showed the lowest microbial growth probably due to its thermal properties or density. It could be the same reason why it is preferred by farmers for milk storage as reported by [11].

Conclusions

It can be concluded that within the scope of this research, in order to get a low bacterial counts, the temperature of 71°C should be used for pasteurizing using a stainless

steel for 15second indicating high temperature short time pasteurization. Also, in order to get a low fungi counts, the temperature 61°C should be used for pasteurizing using a stainless steel for 30minutes. It can also be concluded that the milk sourced from the New Jersey breed (foreign breed) will cause little health risk compared to the locally sourced white Fulani breed.

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