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Traditional Livestock System and Improvement of Cow's Hygienic Milk Quality Sold in N'Djamena, Chad

Bechir M[1,2]*, Makhlouf H[2], Kimassoum D[3] and Tidjani A[1]

[1]University of N'Djamena, Faculty of Sciences of Human Health, B.P. 1027 N'Djamena, Chad

[2]Sahelian Alliance of Applied Researches for Sustainable Development, B.P. 2449 N'Djamena, Chad

[3]Ministry of Public Health, B.P. 548. N'Ndjamena Tchad, Chad

***Corresponding author:** Mahamat Bechir, University of N'Djamena, Faculty of Sciences of Human Health, B.P. 1027 N'Djamena, Chad

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Abstract

Unlike most Sahelian towns, the production and selling of milk in N'Djamena is generally made in a traditional way and causes a serious hygiene and public health problem. This survey aims to improve the hygienic quality of milk by reducing contamination at critical points in the milk production chain. The approach is based on using suitable, cleaning and disinfection equipment's of milking, collection and storage.

The results showed contamination had significantly decreased by comparing the situation before and after interventions. The average of total mesophilic flora felt from 3106 to 104, total coliforms from 6.8103 to 3.9101; thermotolerant coliforms from 2101 to 0.6101 and Staphylococcus from 1.07102 to 1.5101. The pH increased from 6.55 to 6.6 and the dornic acidity from 20 to 21.

The investment cost is 15 FCFA/day in the village with 146 liters of milk sold at 275 FCFA per unit. It is 12 FCFA/day per dairy unit for 324.6 liters sold at 533.33 FCFA per unit. The model for improving the hygienic quality of milk sold in N'Djamena improved the physico-chemical qualities of milk and significantly reduced the rate of microbial contamination.

The general hygiene improvement and especially personal hygiene quality was weak because it is very difficult to change traditional behavior, but the boil milk action contributed to reduce the initial contamination.

Keywords: Milk; Hygiene; Quality; N'Djamena Chad

Introduction

Over the past three decades, global milk production has grown by more than 59 percent, from 530 million tons in 1988 to 843 million tons in 2018 [1]. In Africa, milk production is growing more slowly than in other countries, just 70 million tons in Africa [2].

In Sub-Saharan Africa, milk production was 2% of the world and 77% of whole African production. In Chad, pastoralist country, milk production was estimated at 430 000 tons/year, 71% of which comes from cows. Around N'Djamena it was about 36 000 tons/year [3].

World milk consumption was estimated at 113 Kg MEq/p/year in 2017. In Chad, it was 28 Kg MEq/p/year and at N'Djamena, it was 76 Kg MEq/p/year, much higher than most Sahelian capitals (37 in Dakar and 34 in Bamako) [4]. This disparity is linked to cultural reasons and dietary behavior.

Despite this important production, milk production and selling in Africa in general and particularly in Chad was in traditional issue, without any health and price controls. Quality studies carried out in this sector showed high microbial contamination comparing to international standards [5-7]. This poor quality poses a real problem of conservation and public health. Hamza points out that milk and dairy products were the most important responsible involved in collective food contamination [8]. (TIAC), they could be responsible also for most zoonoses disease such as tuberculosis and brucellosis [9].

Improving milk hygiene and quality is possible with an adaptation model developed in Bamako by Bonfoh [10]. This model based on using a suitable milking and adapted equipment with good cleaning and disinfection.

The objective of this study aims to improve milk hygiene quality by reducing contamination on the critical points in the production chain in N'Djamena. Specifically it aims to:

- Identifying critical points and contamination factors.
- Adapting and applying the model for improving hygiene and quality.
- Assessing the effect of model on milk quality and dairy economy.

Methodology

It was a longitudinal, descriptive and analytical study. Two cohorts during three months of milk a were followed

Study sites

The Study carried out around N'Djamena, Chad. Data were collected at the « Total dairy » and in two farm villages, Arriguyig, 42 km at the north of N'Djamena and Warsi, 30 km at the South of N'Djamena. These farms supply the « Total dairy » in N'Drammen (Figure 1).

Sampling

The "Total dairy" identified among ten others because it was the

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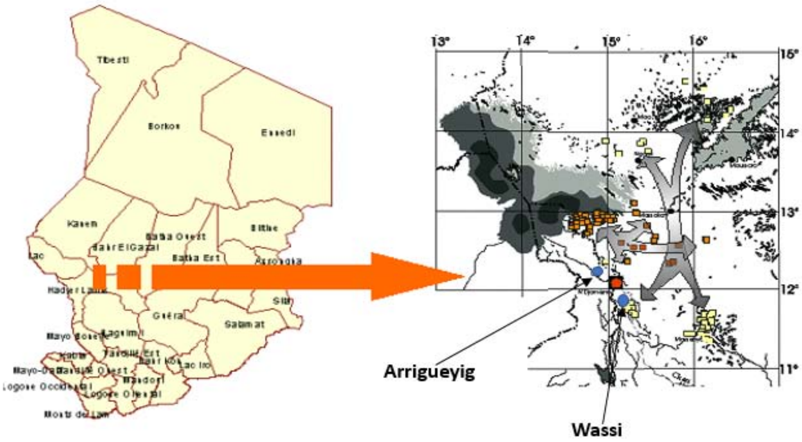

Figure 1: Study site, Arrigueyig and Wassi villages around N'Djamena.

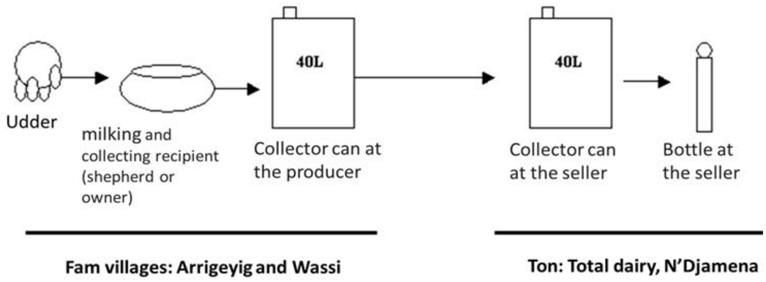

Figure 2: 5 sampling critical points.

most important traditional dairy in the city of N'Djamena, in terms of quantity it provided 200-300 liters of milk per day. Two of the six milk suppliers chose on the basis of their regularity and availability, as well as the intermediaries who work in the milk chain.

The sampling points chosen are the most important contamination nodes. Five control points shown in Figure 2 are retained on the production, distribution and sales chain (Figure 2).

The 5 sampling critical points were:

- Milk sampling at the udder.
- Milk sampling at the collecting recipient in farm.
- Milk sampling at the can in farm.
- Milk sampling at the can in dairy.
- Milk sampling at the bottle in dairy.

Physicochemical analysis

- Temperature.
- Milk density at 20°C.
- Alcool test.
- Resazurine Test.
- Titration Acidity.

Microbiological analysis

- Total Aerobic mesophilic flora on agar count plate.
- Total thermotolerant coliform on Mac conkey (crystal lactose agar).
- Staphylococcus on Chapman (hyper salt agar with mannitol and red phenol).

The result expressed at the flowing formula and the count value was transformed into a logarithm before analysis

$$N = \frac{\sum C}{V\left(n1 + 0,1n2\right)d}$$

N: number of UFC/ml;

ΣC: sum of counted colonies in the box;

V: volume of inoculum used in the box;

n1: number of box at the 1th dilution;

n2: number of box at the 2nd dilution;

d: rate of dilution at the 1th box.

Statistical analysis

Data was collected and subsequently entered and analysed in Excel and SAS software. Cost evaluation equipment and consumable noted from all stakeholder. The depreciation price of equipment was respectively calculated according to formula proposed by Bonfoh [11].

Hygiene cost evaluation calculated by these formula

Before intervention

$HC^2_0 = EC^3_0 + CC^4_0$

With intervention

$HC_1 = EC_1 + CC_1$

Improved cost

$IC^5 = HC_1 - HC_0$

Investment cost

$$\alpha^6 = \left[(IE+WC)_f - (IE+WC)_i\right] \times \frac{1}{L_x}$$

^{2}HC = Hygiene Cost;

^{3}EC = Equipment Cost;

^{1}CC = Consumtion Cost;

^{5}IC = Improovement Cost;

α^6 = daily intervention cost;

IE = Investment on equipments;

WC = Working Captal;

L_x = Livingtime (day);

i = Before intervention;

f = After intervention;

Results

Sampling and milk treatment process

Total of 200 samples was collected, 100 before intervention and 100 after intervention (Table 1).

Critical point at the production and transformation process

Milk production at the villages: Livestock system was pastoral and traditional based on seasonal variation. In the wet season, the most part of livestock moves to less humid and sandy areas at the North. Dairy remain at the villages and were closed in a dark hut the day. This is to avoid the fly bites particularly tabanides fly (*Tabanus* sp.), Similis flies (*Similium* sp.) and other harmful insects which are rife in the rainy season. This is to avoid the bites of tabanides flies (*Tabanus* sp.), Similis (*Similium* sp.). Cows are taken to pasture during the night and do not return until the morning before sunrise. In the dry, the hut is abandoned in favor of the enclosure. When pasture becomes scarce and poor, the animals were supplemented with straw, hay and peanut or cottonseed cake.

Traditional milking: Milking takes place in the enclosure where the animals spend the night in the dry season and in front of the large animal hut in the rainy season. The place is not very clean with dung. The milking men are generally men, rarely old women. Calabash or cup of iron or aluminum were used for milking. Milking is done early in the morning at 5:48 ± 19 min at the coolest time of the day 20 °C ± 1.1 (Oct.-Nov.) And takes place in five stages: i) the calf separated from its mother is released to suckle; ii) after about a minute, it is removed and attached to its mother's right foreleg; iii) the mother's two hind legs are equally restrained; iv) the milking man crouches under the animal in a near-sitting position, places the milking container between his knees and begins milking with both hands; v) at the end, the milking man stops milking, releases the calf and detaches the two hind legs of the cow, the calf immediately returns to continue suckling.

The average of milk milked per animal is 1.43 liters ± 0.13 (Oct-Nov).

Milk collection: The milk was collected at 7 h 32 mn ± 13 mn, the average of ambient temperature was 25.3 °C ± 1.4 and the temperature of hot milk in can was 65.6 °C ± 11.8 (Max 85.6, Min 47.4). The can used for milk collection was placed at the woman responsible of milk collection. All the women come to measure their milk, using a "Koro" (iron cup measuring 2 liters) before putting it in the can. These primary collectors were 9 in Arrigueyig village and 12 in Wassi village. The utensils used for this purpose are also used for household activities. The Can used here come from recuperation of Oil can of industries. Their capacity is usually 40 liters, but heat and pressure have distorted and expanded them and able to contain up to 46-50 liters. The cans in general used for more than one years old and more often pierced and sealed with plastics and screws.

Transport: Cans' milk were transported on motorcycle (3 cans) or with public transport pick-up cars. The distances between the villages; Arrigueyig and Wassi is respectively 42 and 30 km.

Dairy: The milk arrived in the dairy at 10:41 am ± 46mn with a temperature of 46.2 °C ± 2.4 and the ambient temperature is 33.2 °C ± 1. The dairy is located approximately at 100 m from the soled point. It includes a large hangar used for washing bottles and packaging milk, a warehouse with three reservoir filled with ice water that hold the milk bottles when they were full.

The storage room receives empty bottles, bags of sugar and other useful items.

Used bottles were the recuperation of bottles of mineral water. They were collected by housekeepers in hotels, restaurant or other space and then sold to intermediaries who then resell them to the

Table 1: Milk control points.

Sampling point	Contrôle				Amélioration hygiène			
	n	Breeder collector	frequency	Total	n	Breeder collector	frequency	Total
Udder milk	5	2	3	20	5	2	3	20
Milk from collecting recipient	5	2	3	20	5	2	3	20
Milk from can at the producer	5	2	3	20	5	2	3	20
Milk from can at the seller	5	2	3	20	5	2	3	20
Milk from bottle at the seller	5	2	3	20	5	2	3	20
				100				100

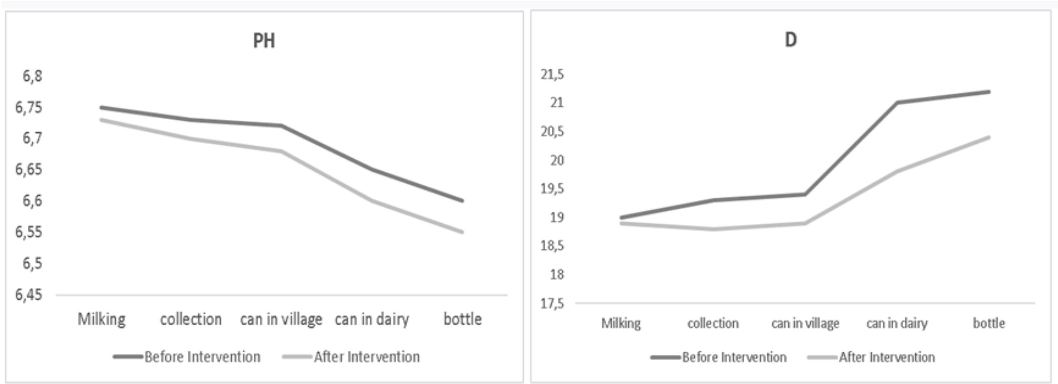

Figure 3: Variation of pH and dornic acidity before and after the intervention.

Table 2: Alcool and resazurin tests.

Alcool				Resazurin							
Before %		After %		Before %				After %			
Negative	Positive	Negative	Positive	Excel	Good	Accep.	Bad	Excel	Good	Accep.	Bad
66.66	33.33	92.89	7.14	0	30.95	69.05	0	0	100	0	0

dairy. It was cleaned in a large basin with water, mixed with powder soap. Il was rinsed and stored before receiving milk.

When the milk arrived, it transferred into a large basin and then sweetened (3 kg of sugar in 40 liters or can) and mixed by plastic cup. After mixed, the bottles were filled by the same cup. The bottles of sweetened milk were finally plunged into an ice container. At the end, the bottles were transported in a cool box to the point sale.

Transformation du lait

Variation of pH and dornic acidity before and after the intervention: When the averages of the pH increase, those of the dornic acidity decrease at the various control points before and after the intervention (Figure 3).

Variance analysis (Proc Corr) carried out between the sequences and the control points showed a very significant variation between the results obtained before and after intervention with $p < 0.01$ for the pH and the Dornic acidity (SAS PROC GENMOD).

Variation of alcohol and resazurin tests at the point of sale before and after the intervention: We obtained the results shown in Table 2, with the alcohol test at 68 °C and the resazurin test. The alcohol and resazurin tests are therefore very close (Table 2).

The correlation analysis (Proc Mixed) carried out on SAS with a Peterson correlation coefficient N = 84 showed a variation of the two parameters (alcohol and resazurin) between the sequences on the one hand and the control points on the other hand., with $p < 0.001$ in all cases.

Density

The sample density averages range from 1.030 at the milking to 1.028 at the dairy with a maximum of 1.034 at the milking and a minimum of 1.025 at the dairy.

Effect of the intervention on the microbiological quality of the milk

The total aerobic mesophilic flora of milk: The average of the total aerobic mesophilic flora was presented after logarithmic data conversion (Figure 4).

The analysis of variance (Proc Corr) performed between the sequences and the control points showed a very significant variation in the results obtained before and after the intervention with $P < 0.01$ for UFC (SAS PROC GENMOD (Table 3).

L'analyse de variance (Proc Corr) effectuée sur SAS entre les séquences et les points de contrôle a montré une variation significative sur les résultats obtenus avant et après l'intervention avec $p<0,05$ pour toutes les variables présentées dans le tableau X (SAS PROC GENMOD).

Subclinical mastitis

Milk hygiene quality improvement did not influence this parameter but this analysis showed the udder's health. The results

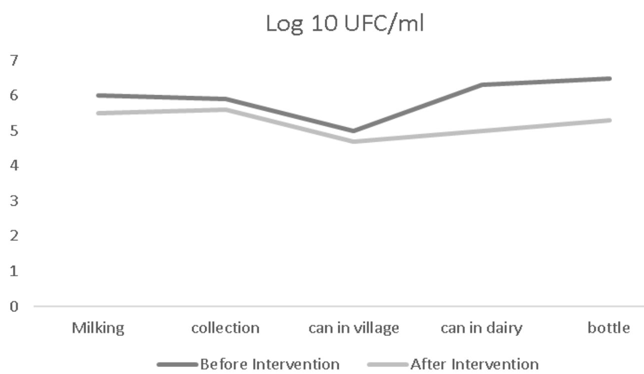

Figure 4: Variation of logarithmic means of UFC at different. Checkpoints before and after the intervention.

Table 3: Microbiological analysis.

	UFC	Yeast and fungi	Total Coliforms	Thermotolerant Coliforms	Staphylococcus
Before	$310^6 \pm 10^6$	$6.810^3 \pm 16.10^3$	$1.310^3 \pm 28.10^3$	$210^1 \pm 17.10^1$	$1.0710^2 \pm 10^2$
After	$10^4 \pm 5.10^4$	$3.910^1 \pm 54.10^1$	$5.910^1 \pm 61.10^1$	$0.610^1 \pm 10^1$	$1.510^1 \pm 10^1$

Table 4: Subclinical mastitis prevalences.

Villages	n	Positifs	
		Number	%
Arrigueyig	63	14	22.2
Wassi	41	10	24.4
Total	104	24	23.1

Table 5: Equipment and consumables cost recorded at the villages and at the dairy.

	Before Intervention		After Intervention		Daily Intervention Cost
	EC_0 (FCFA)	CC_0 (FCFA)	EC_1 (FCFA)	CC_1 (FCFA)	
Villages	44 500	462	52 000	3 717	717
Dairy	87 100	1 250	89 600	5 314	547

shown below related to all dairy cows from the two villages, Arrigueyig and Wassi (Table 4).

The variance analysis (Proc Corr) carried out on SAS showed a significant variation of microbiological contamination before and after the intervention with $p < 0.05$ for all the variables presented in Table X (SAS PROC GENMOD).

Cost of quality hygiene

The equipment and consumables cost recorded at the villages and at the dairy are shown in (Table 5).

The dairy turnover in the villages, was 39 325 FCFA with 143 liters sold at 275 FCFA per unit.

The intervention cost (with the formula presented in the method) was 15 FCFA/day.

At the dairy, the turnover was 174 000 FCFA with 324.6 liters sold at 533.3 FCFA per unit.

The intervention cost was 12 FCFA/day.

Discussion

The study model

The frequency of sampling and the number of cohort appear to be reduced. Bonfoh et al., [11]. Shows that the variation in quality assessment indicators in the production chain is very low and the data can easily be analyzed statistically with a small sample size. The multiplication of samples depends also on the logistic and income (high cost of field and laboratory work).

Improving milk quality by replacing obsolete equipment by an adequate model of cleaning and disinfection is also very expensive. It would be interesting if this type of intervention would be associated with a milk-improving program.

Advantages and disadvantages of the identified practices

The application of heating carried out in the villages is a very good practice and corresponds to high pasteurization. This heating reduces significantly the initial contamination and to destroy pathogenic germs. This is an advantage compared to what was observed in Bamako in Mali [10].

The practices of hands washings, washing of materials as well as the cleaning of cans make were weakly respected. While, these practices reduce the risk of contamination of the milk as had been demonstrated in the analyzes of milk and products dairy in Ethiopia [12].

Thus, presumed pathogenic Staphylococci, total and thermotolerant coliforms and yeasts and molds, 4.104 CFU/ml in Bamako [10] are found in very low quantities in the studies by Millogo et al., [8]. in Burkina Faso.

However, recontamination after heating by the primary collectors, transporter and handlers at the dairy is very important. This phase represents a real critical point in the appearance of risks (deterioration, toxi-infection). reported by Vias in Niamey.

The physicochemical parameters also revealed the poor quality of the milk as well as the existence of subclinical mastitis in the dairy herd. Donik et al., [13]. Point out that mastitis and decreases in pH are the main causes of milk instability. The observed prevalence of subclinical mastitis: 23% is lower than that of Bamako, 34% [10] and Niamey, 43% we think that our results are below reality because according to Schweizer, the Shalm test is done with the first spurts of milk whereas in our case as in Mali and Niger the suckling of the calf which causes the descent of the milk in traditional breeding also eliminates the first drafts. The density measurement also made it possible to observe the wetting of the milk. Heated and skimmed milk should have a higher density than normal (1.030 - 1.033) because evaporation and skimming increase the density. We recorded an average density of 1.028 with a minimum of 1.025 at the dairy. There is therefore a wetting in addition to the skimming performed. Pissang [14] also noted the practice of wetting in this sector with a density of 1.025. This phenomenon exists almost everywhere in the Sahel, Diatta records densities of between 1.027 - 1.030 among GIEs in Senegal, Bonfoh [10] notes that 22% of milk is wet in Bamako. The other physicochemical indicators obtained are also very close to those obtained in traditional dairies. Diatta also obtained the following values in Senegal pH: 6-7; °D: 16-21.

The equipment used: milking calabashes, painted iron cup, cans and collection bottle, does not lead to good milk hygiene [8].

In addition, the plastic container used for transport which receives fairly hot milk (65.5°C) can be a danger to public health. Multon and Bureau have shown that heat promotes the migration of monomers (ethylene, propylene, styrene, vinyl chloride) through the mass of polymers. Among these monomers, the carcinogenic effect of vinyl chloride is well known and described by cited by Multon and Bureau.

The time taken between the milking and the point of sale is quite long (5 hours on average). The distance between the villages and the dairy does not appear to be the main cause of the delay. It is in part due to the collector passing through other remote villages before returning to collect his container of milk.

The prolonged transport time at room temperature and environmental conditions could be the cause of the proliferation of microorganisms in milk [15,16].

Efficiency of model

Among the five critical points, three particularly caught our attention:

The moment of the milk measurement and the filling of the container by the primary collectors, the quality of the container used and the packaging at the dairy.

The application at these levels of hygiene measures by the washing and disinfection technique as well as the separation of the dairy from the healthy sector from the contaminated sector, have made it possible to significantly reduce the rates of microbial contamination and the cost, to improve the physicochemical quality of the milk at the point of sale. Statistical analysis with correlation and comparison tests of variables measured before and after the intervention showed that the variations obtained before and after the intervention are significant $p < 0.05$.

However, the averages of microbial contamination obtained after the intervention are still above international standards for pasteurized milk on D1 and correspond to those of pasteurized milk on D4 [7]. Because the adoption of the improvement method at the individual level, among primary collectors in villages and among dairy workers requires regular monitoring and a change of habits that cannot be achieved in a short time. It is also necessary to define local standards relative to African conditions as advocated by Dutortre [17]

The reduction of other indicators such as coliforms, staphylococci, yeasts and molds was significant and we noted a clear improvement between the samples taken before and after intervention, but the observed rates remain above those of pasteurized milk [7]. These results resemble the results of analyzes of cow's milk analyzed by Gazu et al., [18].

High temperature during the journey and the duration of transport can also promote the multiplication of germs.

The cost of hygiene obtained was very modest compared to the turnover achieved per day in the dairy and in the villages, but other costs are necessary to change the recovery and handling equipment used by suitable one.

The intervention made it possible to adjust and properly orient the expenses related to hygiene by replacing the equipment (calabash milking and iron cup by aluminum cups, drilled cans, sieves) and by introducing water bleach in the villages and improving its use in the dairy.

Economic analyzes have shown the existence of expenses related to hygiene in the two villages and to the dairy, but these are insufficient and poorly applied.

The intervention costs were very low 14.8 FCFA/day in the villages and 12.3 in the dairy. These costs are lower than those obtained by Bonfoh [10] in Bamako 39 FCFA/d over the entire chain. This difference is due to the importance of the investment made in Bamako (replacement of plastic cans with stainless cans with wide mouths). The work of Sib et al., [19] showed that the income generated by the sale of milk was much higher than among others.

Motivation of actors

The training of actors was participatory and revealed well-known concepts such as food spoilage by handling and the importance of heating food for proper preservation. For example, they know that the rest of the meals eaten the day before can be stored once they have been heated, otherwise they will spoil. This passage demonstrated the involvement of the human hand in food spoilage, and the introduction of sodium hypochlorite for disinfecting hands and utensils was much more understandable in both villages.

Despite this obvious motivation, it was difficult for the intermediary actors (milking men, primary collectors, etc.) to follow the recommendations because traditional behavior cannot be changed in short term. Awareness raising and training must be continuous with retraining to have reliable long-term results.

Conclusion

The improving milk hygienic quality model in N'Djamena showed an appreciable result. It was able to improve the physicochemical qualities and significantly reduced the microbial contamination.

The improvement in the level of general hygiene and especially personal hygiene is weak because it is very difficult to change traditional behavior, but the heating applied to the milk, reduce initial contamination.

The introduction of sodium hypochlorite in the villages and its good use for the disinfection of equipment in general and the transport container in particular, had significantly reduced the rate of contamination and improved the quality of milk at the point of sale.

Three points of recontamination persist. This concerns the time of filling the can, which is done by women in the villages, the hygienic quality of the can and the packaging of the milk in the dairy which is also done with bare hands. The costs of the intervention were very affordable given the turnover achieved per day and argue for the adoption of the model.

Apart from the danger due to germs, the plastic transport container not designed for food products, and which receives hot milk, also presents a potential danger to public health.

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