QUALITY OF RAW MILK IN DIFFERENT SERIES OF MILK DELIVERIES AT MILK - DISPENSERS

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Abstract: *The purpose of this research was to find out if raw milk in milk-dispensers comply qualitative standards for consumers. We analyzed fifty samples of raw milk for CNM (common number of microorganisms) and ten samples for SCC (somatic cell count) at delivery to and removal from milk-dispensers. We finished the chemical and microbiological analysis of samples in the laboratory for dairy farming at the Biotechnical Faculty in Domzale. Samples were analyzed fresh and never older than 48 hours. Temperature of milk and surroundings was measured with thermometer used for foodstuffs. Analyses of samples indicated that average value of raw milk in all series of deliveries was in the 1st quality class. Cooled sample taken at home contained 5700 CNM/ml of raw milk; this differentiated from milk-dispenser 1 for 85900 CNM/ml and from milk dispenser 2 for 45700 CNM/ml. After direct sale the milk in milk-dispenser 2 had 57300 CNM/ml and milk-dispenser 1 had 62329 CNM/ml. Comparing both samples (taken on delivery and from the milk that remained), there were no large variations in the value of CNM/ml in fresh milk. The content of SCC was on the average 294100/ml milk. In the first series of delivery the average temperatures never exceeded 4.1°C in milk-dispenser 1 and 5.2°C in milk-dispenser 2. In other series of deliveries the average temperature did not exceed 3.9°C in milk-dispenser 1 and 3.6°C in milk-dispenser 2. It can be concluded that statistically location has significant impact on CNM/ml and on milk temperature.*

Key words: *milk – dispenser, raw milk, quality of milk, Fossomatic, Bactoscan*

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1. Introduction

The term milk refers to the milk produced with regular milking and milking out with nothing added to it and nothing removed from it. Due to its high nutritive value it is indispensable food for the cows' descendants in the first days and weeks of life (Kelly and Larsen, 2010). When speaking about the milk and milk product composition, most often the so-called "principal" ingredients are meant, i.e., ingredients largest in quantity. It is neglected that milk has high nutritive value and also functional effects, particularly, because of variety of its composition offering, in addition to proteins (3.3%), fats (3.8%) and lactose (4.7%) also a wide range of minerals, vitamins and other substances with functional properties. It is due to simultaneous presence of all ingredients that the digestibility is better and exploitability of ingredients higher (Phelan et al., 2009). The milk is the most important source of income of cattle-breeders. Until recently the milk production was associated only with the sale of milk to dairies. Stoppages in the sale caused by the drop of the buying power have compelled some farms to start direct sale of milk at milk-dispensers (Janzekovic et al., 2009). According to the information of the Health Inspectorate of the Republic Slovenia in spring 2010 there were in Slovenia 37 registered holders of right to sell raw milk through 96 milk-dispensers. Direct sale is legally defined in the Rules on registration of businesses in the area of foodstuffs of animal origin and in the Decree on implementation of parts of certain EU rules concerning foodstuffs, animal hygiene and official supervision of foodstuffs (Zgonec et al., 2010). Increasing number of people decide on using raw non-pasteurized milk. Strengthened nutritive properties, taste and benefits for health are the reasons for increased interest in the use of raw milk (Oliver et al., 2009). On the selected farm we studied the factors affecting quality of milk sold directly at two milk-dispensers to the final buyer.

The aim of this research was to find out whether the raw milk in milk-dispensers and the milk from the fixed cooling cistern at the farm comply with the standards of quality and microbiological adequacy of milk for the consumer. It was assumed that the milk in all series of transport was cooled to 4°C and that the milk temperature did not rise to more than 7°C.

2. Materials and Methods

2.1 Milk-dispenser

It is an advantage of the automatic milk-dispenser that the raw milk is directly sold to the final buyer. Raw milk is cooled to 4°C and kept in the device not longer than 24 hours. The milk-dispenser comprises: air-conditioned and insulated box with milk cistern (200 l) and mixer (Fig. 1), bottle selling device, cylindrical pouring out chamber with rotary door, pouring out tube and lighting fixture, measuring system for highly precise pouring out of milk, washing system for pouring out system and chamber, GSM alarm module, device for payment by coins and by euro key (cashless payment transactions), graphic LCD display with instructions, transport truck.

Mixer for milk is mounted on the lid of the container for the storage of milk and milk is intended for mixing. The mixer is switched on automatically every 30 minutes and stirred for 5 minutes.

Fig. 1. Mixer for milk

GSM module (Fig. 2) send SMS messages to inform the Manager of the situation on milk-dispenser. Informed in the event that the condition of the milk are 30, 20 and 10 litters. Milk temperature exceeds the permissible if there is any defects in the bar table or on any of the causes of machine stops working.

Milk-dispenser is equipped with a controller ETRA locus ETKM v7.0 (Fig. 3), which is responsible for proper functioning of the entire system. Additional equipment: insect repelling air curtain, billing, designing of labels and logotypes, touch color monitor, audible instructions (NMC milk-dispensers, 2012).

Fig. 2. GSM alarm module

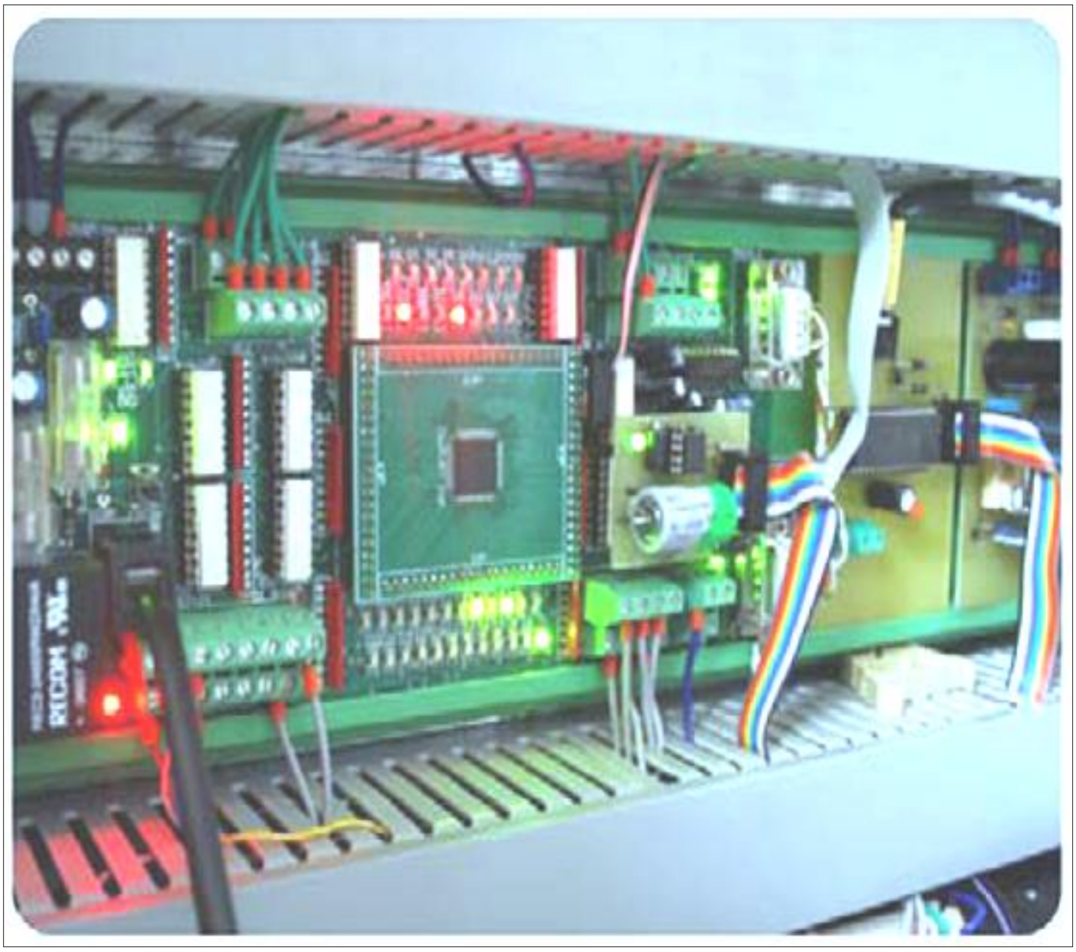

Fig. 3. Process controller

2.2 Milk sampling

The first samples of milk for the analysis on CNM and SCC were taken on the farm from 1600 l fixed cooling cistern. It contained only the milk of the evening milking performed from 17.00 to 18.15 h p.m. The milk temperature was read on the fixed cistern monitor first on completion of milking and for the second time when the milk had been cooled and was ready for transport to milk-dispensers. Thus, also the milk cooling time was obtained. When the raw milk had been cooled to proper temperature 4 - 6°C, it was poured into two smaller cisterns intended for milk change by new fresh milk at the milk-dispenser. Then the two cisterns with cooled milk were loaded into a van and the raw milk was delivered to milk-dispensers at different locations. First, the cistern was delivered and replaced at milk-dispenser 1 and then at the milk-dispenser 2.

For the second time the raw milk sample was taken for CNM from the cistern of the milk-dispenser 1, when the milk was delivered to the milk-dispenser location by measuring the milk temperature in the cistern. The third raw milk sample was obtained from the milk-dispenser 2 cistern on delivery. The fourth and fifth sample were taken from milk remainders in each milk-dispenser`s cistern before replacement by fresh milk. The next day, the samples cooled to maximum 4°C were delivered to the laboratory for dairy farming at the Biotechnical Faculty of Ljubljana having the verification deed of the Slovene verification authority (LP 062) for the compliance with the requirements of the standard ISO 17025. Ten samples taken from fixed cooling cistern were analyzed for SCC by the instrument Fossomatic and fifty samples of all series of deliveries were analyzed for CNM by the instrument Bactoscan. The maker of both instruments is Foss Electronic.

2.3 Determination of microbiological quality of raw milk by Bactoscan

As far as the microbiological quality is concerned two categories are distinguished: CNM and the presence or absence of pathogenic microorganisms. The CNM reflects the general hygiene in milk production, storing and transport and efficacy of cooling, while the presence of microorganisms harmful to health reflects hygiene and health condition of animals and persons working with milk. Low total number of microorganisms in raw milk is a sign of good manufacture dairy practice (Rogelj, 2003).

Bactoscan 8000 is an instrument for automatic detection of microbiological quality of raw milk and is intended for remunerating the milk according to quality. The method is based on counting the individual bacterial cells in the milk sample. The required time of analysis is 5 minutes (standard method of counting took 48 to 72 hours). The standard method of determining the total number of microorganisms in milk, which is an indirect method, is the method of counting colonies on plates (standard plate count) and/or the method of determining the colony forming bacterial cells. Direct microbiological methods include direct microscopic counting of bacteria according to Breed and the DEFT technique. By the DEFT method the bacteria are isolated from milk by filtering and concentrated on the membrane surface, colored with fluorescent ink and counted by epifluorescent microscope. Also the instrument Bactoscan of the Danish maker Foss Electronic operates on the principle of epifluorescent microscopy.

The principle of functioning of the instrument Bactoscan is continuous epifluorescent microscopy. The instrument measures the light bounded from the surface on the object colored with fluorescent ink, i.e., colored bacterium. Usually, the raw milk samples are of bacterial quality of less than 10000 microorganisms/ml of milk to 3000000 and more microorganisms/ml of milk. The instrument Bactoscan 8000 operates after heating the raw milk to 40°C; the apparatus pipettes 2.5 ml of milk sample into the mixing space. The milk is mixed with 7.5 ml of solution causing disintegration of casein micelles and somatic cells and fragmentation of groups of bacteria. The sample is transferred into the calibrated centrifuge of high speed, where bacteria are isolated from other milk ingredients. Proteolytic enzyme alkalase is dosaged. Through the filtering chamber certain bacteria are filtered into the incubation unit, where the mixture is incubated for 3 minutes at 40°C. The proteolytic enzyme disintegrates the particles of somatic cells and the casein particles. The solution of acridine orange dye (1 ml) is added. Counting starts. The result is the number of pulses and/or bacteria/microlitre of milk. From the points in the conversion table the instrument automatically counts the number of colony forming cells/microlitre of milk. The number of bacteria/ml of milk is obtained if multiplying by 1000 (Bajt et al., 1998).

2.4 Determination of raw milk somatic cells by Fossomatic

The number of somatic cells changes from day to day. The milk of morning milking contains less somatic cells than the milk of evening milking. This is partly due to shorter interval between two milkings and smaller milk production. Monthly results indicate that the evening milking has a higher number of cells in milk. This is governed by all factors enumerated hitherto including: food, operation of milking machines, barn outfit (Blowley and Edmondson, 1995). Coounting of somatic cells is a method of discovering mastitis (lacteal gland inflammation) and is one of basic parameters of evaluation of milk quality for remuneration (Janzekovic et al., 2005).

The principle of the instrument functioning is the fluoro-optic-electronic counting of somatic cells. After radiation with xenon arc lamp the somatic cell cores colored with fluorescent ink emit the light passing through microscope to the photodiode of the detection system. The light signals are converted into electronic signals counted by the instrument automatically. More up-to-date instruments of the Fossomatic type operate on the principle of flowing cells. The range of measurements of raw milk samples is from 10000 cells/ml of milk. The result on the screen is the number of somatic cells in thousands per milliliter (Bajt et al., 1998).

2.5 Statistical analysis

The data acquired were entered into the program Microsoft Office Excel 2007 and statistically processed by SPSS Statistics Base 17.0. The correlation between two linear variables was determined by the Pearson’s correlation coefficient. Arithmetic means of the data were tested by the Tukey HSD test with 5% risk. Statistically significant differences were marked with letters. The values marked by the same letter do not statistically differ ($p = 0.05$).

3. Results with discussion

3.1 Calculated statistical parameters

Table 1 shows the basic statistical parameters of raw milk samples at locations of sampling on the farm and at milk-dispenser 1 and 2. As known, the samples taken on the farm are the representative samples which were monitored and it was found out how the CNM/ml of raw milk changes according to different series of deliveries to milk-dispensers and back. The basic statistical parameters related to the samples for researches of the milk quality were determined also for the measured air and milk temperatures. The fresh milked milk was collected in the fixed cistern at the end of milking at 18.19°C in the space. The milk was cooled on the average for 1.38 h for the milk temperature to be adequate for delivery to milk-dispensers.

Parameters	Value ($\bar{x}$ ± sd)	
On farm before delivery		
CNM /ml	5700 ± 6254	
SCC /ml	294100 ± 109822	
T-M (°C)	3.3 ± 1.0	
T-A (°C)	21.7 ± 4.6	
At delivery to dispenser		
	Dispenser 1 ($\bar{x}$ ± sd)	Dispenser 2 ($\bar{x}$ ± sd)
CNM /ml	9600 ± 80211	51400 ± 41204
T-M (°C)	4.1 ± 0.7	5.2 ± 0.6
T-A (°C)	20.8 ± 4.2	19.7 ± 4.5
In rest of the milk at removal		
CNM /ml	62320 ± 47963	57300 ± 51798
T-M (°C)	3.9 ± 0.8	3.6 ± 0.3
T-A (°C)	22.0 ± 4.6	20.1 ± 4.9

T-M – temperature of milk; T-A – temperature of the air; $\bar{x}$ - mean value; sd – standard deviation

Tab. 1. Basic statistical data for three handling places of raw milk ($\bar{x}$ ± sd)

The mean value of SCC/ml of raw milk was 294100 SC/ml. The average value of CNM/ml of raw milk delivered to milk dispensers was different in all series. The original representative sample taken on the farm before delivery had an average value of 5700 CNM/ml of raw milk and differentiates from milk-dispenser 2 samples for 45700 CNM/ml and from milk-dispenser 1 samples for 85900 CNM/ml of raw milk. By the results of analyses of raw milk (Table 1) delivered back to the farm after direct sale it was indicate that the milk-dispenser 2 had the value 57300 CNM/ml of milk and the milk-dispenser 1 the value 62329 CNM/ml. At the milk-dispenser 2 there are no large deviations in the value of CNM/ml of raw milk between the two milk samples on delivery and in the milk remainder. This can be explained by average values of milk temperatures at the time, when it was transported fresh to the milk dispenser 2 (5.2°C). The average air temperature around the milk-dispenser 2 on delivery was lower (19.7°C) than the air temperature on removal of milk (20.1°C). On the milk-dispenser 1 the average value of CNM/ml of raw milk on delivery dropped from 91600 to 62320 CNM/ml in relation to the milk remainder.

Parameters	On farm before delivery	Dispenser 1	Dispenser 2	Sig.
CNM /ml	5700.0^{a}	91600.0^{b}	51400.0^{ab}	0.04
T-M (°C)	3.3^{a}	4.1^{ab}	5.2^{b}	0.00
T-A (°C)	21.7	20.8	19.7	0.62

*a,b – middle, marked with different letters in column are significantly different at 95% probability

Tab. 2. Comparison of average values of the delivery of milk

According to Tukey HSD (Table 2) test the location of milk dispensers statistically significantly differs from the content of CNM/ml of milk-dispenser 1. By way of simplification it can be claimed that on milk-dispenser 1 the CNM/ml is higher because of influences from the environment, since it is located on sunny side in the vicinity of regional highway. As the delivery of milk to milk-dispenser 2 took a longer time, it was found that statistically significant differences existed between the milk temperature on the farm before delivery and the milk temperature of milk-dispenser 2. The milk temperature before milk delivery must be suitably cooled because during transport the milk in the cistern is not cooled.

Dispenser 1	Delivery (*CNM*/ml)	Rest (*CNM*/ml)	T-D (°C)	T-R (°C)	T-R-F (°C)	T-A-D (°C)	T-A-R (°C)
Delivery (*CNM*/ml)	1	-0.519	-0.21	0.057	0.059	0.208	0.361
Rest (*CNM*/ml)		1	-0.141	0.445	0.091	-0.076	0.104
T-D (°C)			1	0.151	0.168	0.458	-0.135
T-R (°C)				1	0.692*	0.479	0.365
T-R-F (°C)					1	0.682*	0.527
T-A-D (°C)						1	0.704*
T-A-R (°C)							1

* $p \leq 0.05$ – statistically significante corelation
T-D – Temperature of milk at delivery to dispenser; T-R – Temperature of rest of the milk in dispenser; T-R-F – Temperature of rest of the milk at farm; T-A-D – Temperature of air at delivery of milk in dispenser; T-A-R – Temperature of air at removal of milk from dispenser

Tab. 3. Linear correlations between parameters of raw milk delivered in dispenser 1

The table 3 shows that with increased temperature in the milk remainder the temperature in the raw milk remainder on the farm increased, since the correlation between them is positive and meanly strong. From the calculated data covered in the calculation of correlations it was found out that the air temperature on delivery on the milk-dispenser 1 statistically significantly affected the temperature in the milk remainder on the farm. It was found that the lower the content of CNM/ml of milk on delivery the smaller the content of CNM/ml in the milk remainder on sale.

Table 4 indicates that the air temperatures on delivery and the air temperatures on the milk remainder change in milk-dispenser 2 are statistically significantly related. Those calculations showed that with increased air temperature on delivery the milk temperature increased, but it did not exceed 4°C. Between measurements strong statistically significant differences ($p \geq 0.01$) exist for the two variables of milk temperature on delivery and air temperature on delivery, since the ambient air temperature affects the milk temperature, as the milk is not cooled during delivery in cistern. As the cooled milk was delivered after the evening milking, the temperatures were not of considerable influence, since the raw milk preserved its quality and low temperatures during whole delivery.

Dispenser 2	Delivery (*CNM*/ml)	Rest (*CNM*/ml)	T-D (°C)	T-R (°C)	T-R-F (°C)	T-A-D (°C)	T-A-R (°C)
Delivery (*CNM*/ml)	1	-0.416	-0.118	0.280	0.188	-0.068	0.066
Rest (*CNM*/ml)		1	0.043	0.156	0.611	0.346	0.331
T-D (°C)			1	-0.188	0.008	0.811**	0.463
T-R (°C)				1	0.610	-0.199	-0.198
T-R-F (°C)					1	0.272	0.299
T-A-D (°C)						1	0.670*
T-A-R (°C)							1

* $p \leq 0.05$ – statistically significante corelation
** $p \leq 0.01$ – statistically significante correlation
T-D – Temperature of milk at delivery to dispenser; T-R – Temperature of rest of the milk in dispenser; T-R-F – Temperature of rest of the milk at farm; T-A-D – Temperature of air at delivery of milk in dispenser; T-A-R – Temperature of air at removal of milk from dispenser
Tab 4. Linear correlations between parameters of raw milk delivered in dispenser 2

4. Conclusions

Buying habits of consumers will change in the future. It is well known that the sale of raw milk through milk-dispensers is based on local level and on a foodstuff of known origin, therefore buyers trust it more. In the final retail price of raw (pasteurized) milk sold in markets the cost of raw milk production is 25% of the price, the cost of milk processing in dairy industry is 25% of the price and the trading cost is 50% of the price. It is a fact that input costs (food, breeding costs, outfit, depreciation, energy sources etc.) in milk production are rather high and aggravate the farmers' economic position. Therefore, farmers try to find new alternatives to improve their economic position (Zanini and Leone, 2006).

In the research it was found for the raw milk delivered to the two milk-dispensers that the average value dropped from 91600 CNM/ml of milk after 48 hours in milk dispenser 1 to 62320 CNM/ml, which is probably a consequence of good maintenance of desired temperature in the cooling device, since on delivery higher milk temperature was measured (4.1°C) than in the remainder (3.9°C). Reduced CNM/ml of milk is attributable to sensitivity of bacteria of mesophilic class. For milk-dispenser 2 it was found that the average value was 51420 CNM/ml and 57300 CNM/ml in the milk remainder. The milk temperature on milk-dispenser 2 was on the average higher than the milk temperature on delivery on milk-dispenser 1 for 1.1°C, since the milk was first delivered to milk-dispenser 1. Milk temperatures on delivery and air temperature on delivery of milk–dispenser 2 are strongly statistically significantly related ($p \leq 0.01$). If the air temperature in the vicinity of milk-dispenser 1 increases, also the milk temperature on delivery increases. The milk quality for sale is not affected only by initial handling, but also by milk-dispenser location, since it was proved that the contents of CNM/ml of raw milk statistically significantly differ between the farm location and the milk-dispenser 1.

It can be concluded that milk production on the concerned farm is fit for sale of row milk by milk-dispenser. The milk was hygienically suitable in all series of deliveries and cooling was convent, since it did not exceed 7°C. The requirements for milk concerning production, quality and trading were considered and coordinated with European rules and regulations.

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