Acta Alimentaria, Vol. 45 (3), pp. 347–353 (2016)
DOI: 10.1556/AAlim.2015.0016

PHYSICOCHEMICAL QUALITY OF DIRECTLY SOLD RAW MILK IN HUNGARY

A. Jancsó[a], G. Császár[b] and L. Varga[a]*

[a]Institute of Food Science, Faculty of Agricultural and Food Sciences, University of West Hungary, H-9200 Mosonmagyaróvár, Lucsony u. 15–17. Hungary
[b]Hungarian Dairy Research Institute, H-9200 Mosonmagyaróvár, Lucsony u. 24. Hungary

(Received: 20 October 2014; accepted: 19 November 2014)

The importance of short food supply chains is increasing in the food sector, and direct selling is a promising alternative to commercial chains in dairy trade. Several channels and practices of direct raw milk sales exist in Hungary. Because short food supply chains in the Hungarian dairy sector have not yet been investigated in detail, we have little or no knowledge on the composition of directly sold raw milk. For this reason, a 9-month study was undertaken from June 2013 through February 2014, wherein directly sold raw bovine milk samples were tested for fat, protein, lactose, and solids-not-fat contents and for freezing point. A total of 21 direct sellers located in Budapest, Hungary were sampled twice a month. The results were compared to the official Hungarian raw milk quality data referring to the same period. The direct milk vendors involved in this study were found to sell raw milk with reduced levels of lactose and solids-not-fat and elevated freezing points, compared to the national raw milk data. The findings of this research underline the need for stricter regulations and control with respect to direct raw milk sales in the country.

Keywords: direct selling, raw milk, chemical composition, freezing point

Nowadays, the theory and practice of the so-called short food supply chains are gaining ground in Europe and North America. In this concept, the foods involved are traceable to a farmer. The number of intermediaries between farmer and consumer should preferably be zero (Kneafsey et al., 2013). Further dimensions of the short food supply chains are defined by Renting and co-workers (2003), who divide them into three categories, such as face-to-face, proximate, and extended short food supply chains, depending on the extent of direct relations between producers and consumers in time and space. To understand developments in food markets, we need a “sociology of the market” (Marsden & Arce, 1995), which aims to unravel the patterns of social interaction between various actors in the agri-food chain and analyses how supply chains are constructed as arrangements of interlocking projects of these actors (Van der Ploeg & Frouws, 1999).

In 1984, a novel quality-based raw milk control and payment system was introduced in Hungary (Unger, 2001). Since then all farmers within the scope of the raw milk testing regulation have been required to submit samples for comprehensive quality tests on a regular basis. The major physicochemical and microbiological–hygienic parameters of raw milk, hereinafter referred to as collected raw milk (CRM), have been recorded and analysed systematically over the last 3 decades, however, considerably less information is available on the quality of directly sold raw milk (DSRM). CRM is predominantly received by dairy plants, whereas small farmers mostly sell their raw milk directly to the public. The legislatively prescribed minimum sampling frequency, the specific quality parameters to be examined, and

* To whom correspondence should be addressed.
Phone: +36-96-566 652; fax: +36-96-566 653; e-mail: VargaL@mtk.nyme.hu

the relevant thresholds for DSRM (Ministry of Agriculture and Rural Development, 2010) are easier to be complied with, compared to the corresponding regulations for CRM. The objectives of this research were to monitor the major physicochemical properties of raw milk purchased from direct sellers and to compare the test results with those of the Hungarian quality-based raw milk payment system for the same period. To our knowledge, this is the first scientific study evaluating the physicochemical quality of directly sold raw milk in Hungary.

1. Materials and methods

1.1. Sampling

For Hungarian authorities and milk producers within the scope of the quality-based raw milk payment system, regulations no. 852/2004/EC, 853/2004/EC, 854/2004/EC (EC, 2004a,b,c), and joint decree no. 16/2008. (II. 15.) FVM-SZMM (Ministry of Agriculture and Rural Development & Ministry of Social and Labour Affairs, 2008) specify the requirements for sampling and analysis of CRM. Based on these legal provisions and the findings of earlier scientific studies (Pelsue Jr., 1973; Biggs et al., 1984; Tremonte et al., 2014), DSRM samples were purchased at a total of 21 locations in Budapest, Hungary twice a month over a 9-month period ranging from June 2013 through February 2014. The sampling locations included farmers' markets, milk vending machines, and various forms of farmers' local milk delivery schemes.

At certain locations only 1-l and 1.5-l pre-bottled samples could be purchased in PET bottles. Apart from these cases, sterile 0.5-l glasses with threaded plastic caps were used for sampling purposes. Because refrigeration at 0–2 °C is a suitable method of preserving the relevant quality of raw milk up to 48 h of storage (Unger, 2001), our samples were kept cooled at temperatures lower than 4 °C, thus simulating the real routine of raw milk purchase and home storage.

1.2. Physicochemical analyses

The samples were delivered to the Raw Milk Testing Laboratories of the Hungarian Dairy Research Institute at Mosonmagyaróvár and Budapest (Hungary). The analyses were mostly performed within 24 h from the time of sampling, but this time span never exceeded 36 h. Each test method applied in the laboratories was accredited by the Hungarian Accreditation Board (Budapest, Hungary). Fat, protein, lactose, and solids-not-fat (SNF) contents and freezing point results are discussed in this study. Compositional parameters were determined by a MilkoScan™ milk analyser (Foss Electric, Hillerød, Denmark) as described by the relevant International Standard (IDF, 2000), whereas freezing point measurements were done by an Advanced® 4D3 Cryoscope (Advanced Instruments, Norwood, MA, USA) in accordance with an ISO-IDF International Standard (ISO-IDF, 2009).

1.3. Statistical evaluation

For each parameter quantified, individual test results were grouped into ranges, shown in Table 1, according to the categories used in the official Hungarian raw milk quality database (Hungarian Dairy Research Institute, 2014) so that comparability could be achieved. Data from both sources were then averaged to yield means and standard deviation for the period examined. No statistical tests were applied to eliminate possible outliers. Because it is impossible to gain accurate and quantitatively weighted data in the direct selling sector, the unweighted data of the present study (n=360) were compared to the official national weighted raw milk data of the same period (n=22 949).

2. Results and discussion

2.1. Fat content

The data in Table 1 show that over one third of DSRM and approximately 60% of CRM samples had fat contents in the range of 3.51–4.00%. In turn, both extremely low (≤2.75%) and high (≥4.76%) fat levels were more frequently observed in DSRM than in CRM, with occurrence percentages of 9.5% and 0.5% (low), and 8.9% and 1.3% (high), respectively, resulting in identical mean fat concentrations (3.8%) in the two groups of raw milk (Table 2). From these results it appears likely that batches of DSRM were not thoroughly agitated prior to sale. GOODRIDGE and co-workers (2004) emphasize the importance of adequate agitation of bulk milk to ensure homogeneity, and warn about the consequences of both insufficient and excessive intensities that may result in inhomogeneity in the former case and churning in the latter.

2.2. Protein content

A slightly skewed normal distribution was observed for protein content of raw milks (Table 1). In the EU, raw milk belongs to drinking milks, and Council Regulation no. 1234/2007/EC (EC, 2007) declares that drinking milk shall contain a minimum of 2.9% (w/w) of protein for milk containing 3.5% (w/w) of fat, or an equivalent concentration in the case of milk having a different fat content. More than 6% of the DSRM and only 0.3% of the CRM samples tested had a protein content not exceeding 2.8%. Similarly, the percentage of DSRM containing ≤3.2% of protein, 42.8%, was considerably higher than the corresponding value of 24.2% for CRM. It should be noted, however, that the majority of samples had protein contents ranging from 3.11% to 3.40% in both groups. It is also worth mentioning that no substantial differences were found between the percentages measured for DSRM and CRM in each of four ranges of protein content exceeding 3.50% (Table 1). Table 2 shows that the mean protein concentrations determined for DRSM and CRM were identical (3.3%). This is in agreement with the general observation that bovine milk typically contains 3.2–3.5% of protein, which may, however, largely vary depending on the breed, lactation stage, and nutritional and health status of the cow (JENNESS, 1986; FOX, 2011; CLAEYS et al., 2014).

2.3. Lactose content

As shown in Table 1, approximately half (i.e., 49.0%) of the DSRM samples tested contained less than or equal to 4.60% of lactose, whereas the corresponding proportion for CRM was as low as 5.6%. In turn, the vast majority (i.e., 92.4%) of CRM samples had lactose contents ranging between 4.61% and 4.90%. The percentage of samples containing at least 4.91% of lactose was between 1% and 2% in both groups of raw milk. Lactose, the principal determinant of osmotic pressure in milk, is known to be the least variable milk component, with a mean concentration of about 4.8% in bovine milk (CSAPÓ & CSAPÓNÉ KISS, 2009; FOX, 2011). The decreased lactose levels observed in DSRM samples (Table 2) were most likely indicative of compromised udder health, e.g., mastitis (LACZAY, 2008; AULDIST, 2011; GEARY et al., 2013).

Table 1. Frequency distribution of fat, protein, lactose, and solids-not-fat contents and freezing point values of directly sold raw milk and collected raw milk samples taken in Hungary from June 2013 through February 2014

Fat			Protein			Lactose			Solids-not-fat			Freezing point		
Content* (%, w/w)	Distribution (%)		Content* (%, w/w)	Distribution (%)		Content* (%, w/w)	Distribution (%)		Content* (%, w/w)	Distribution (%)		Range* (°C)	Distribution (%)	
	DSRM	CRM		DSRM	CRM		DSRM	CRM		DSRM	CRM		DSRM	CRM
≤2.75	9.5	0.5	≤2.80	6.1	0.3	≤4.60	49.0	5.6	≤8.40	25.5	3.0	≥(–0.500)	11.7	0.2
2.76–3.00	3.6	0.9	2.81–3.00	5.0	2.5	4.61–4.70	27.0	29.1	8.41–8.60	24.4	14.8	(–0.501)–(–0.510)	2.5	0.6
3.01–3.25	6.4	4.0	3.01–3.10	11.7	5.8	4.71–4.80	14.0	48.3	8.61–8.80	29.2	39.0	(–0.511)–(–0.515)	3.1	1.9
3.26–3.50	13.6	13.8	3.11–3.20	20.0	15.6	4.81–4.90	8.9	15.0	8.81–9.00	13.9	30.8	(–0.516)–(–0.520)	7.0	6.0
3.51–3.75	18.9	30.6	3.21–3.30	17.5	23.8	4.91–5.00	1.1	1.8	9.01–9.20	6.1	9.3	(–0.521)–(–0.525)	22.6	47.6
3.76–4.00	16.4	29.2	3.31–3.40	15.3	22.7	≥ 5.01	0.0	0.2	9.21–9.40	0.6	2.3	(–0.526)–(–0.530)	33.1	34.3
4.01–4.25	10.8	14.0	3.41–3.50	8.3	14.0	Total	100.0	100.0	≥9.41	0.3	0.8	(–0.531)–(–0.535)	10.6	7.0
4.26–4.50	8.3	4.1	3.51–3.60	7.5	7.2				Total	100.0	100.0	(–0.536)–(–0.540)	4.7	1.3
4.51–4.75	3.6	1.6	3.61–3.70	4.7	4.0							≤(–0.541)	4.7	1.1
≥4.76	8.9	1.3	3.71–3.80	1.7	1.8							Total	100.0	100.0
Total	100.0	100.0	≥3.81	2.2	2.3									
			Total	100.0	100.0									

* These ranges are identical with those used in the official Hungarian raw milk quality database (HUNGARIAN DAIRY RESEARCH INSTITUTE, 2014); DSRM: directly sold raw milk (n = 360, own experimental data); CRM: collected raw milk [n = 22 949, data from the official Hungarian raw milk quality database (HUNGARIAN DAIRY RESEARCH INSTITUTE, 2014)]

Table 2. Gross chemical composition and freezing point of directly sold and collected raw milk in Hungary (June 2013–February 2014)

Parameter tested	Directly sold raw milk (n=360)	Collected raw milk (n=22 949)
Fat (%, w/w)	3.8±1.4	3.8±0.4
Protein (%, w/w)	3.3±0.3	3.3±0.2
Lactose (%, w/w)	4.5±0.5	4.7±0.1
Solids-not-fat (%, w/w)	8.5±0.6	8.8±0.2
Freezing point (°C)	–0.517±0.036	–0.524±0.007

All values are arithmetic means ± standard deviation

2.4. Solids-not-fat content

The price paid by the processor to the producer for raw milk is supposed to accurately reflect the quantity and value of products that can be manufactured from it and, for this reason, SNF content is an important element of many raw milk pricing systems (EMMONS et al., 1990). In the direct selling sector, however, no such systematic quality control and pricing schemes exist. Half of the DSRM samples tested from June 2013 through February 2014 contained less than or equal to 8.60% of SNF, whereas the large majority (i.e., 82.2%) of CRM samples had SNF concentrations reaching or exceeding 8.61%, according to the official national raw milk data referring to the same period (Table 1). The proportion of samples containing at least 9.21% of SNF was negligible in both groups. All things considered, the mean SNF content of DSRM samples (85.0 g kg^{-1}) was 3.4% lower than that of CRM samples (88.0 g kg^{-1}) (Table 2).

2.5. Freezing point

The freezing point of raw milk is relatively constant, with breed, lactation stage, and season influencing it to a slight degree only. Although somewhat larger variations may be expected if cows are underfed or do not have free access to drinking water (BHANDARI & SINGH, 2011), the freezing point test is widely used to detect the adulteration of milk by the addition of water. A freezing point of –0.520 °C and below is generally accepted in Hungary as the standard for unadulterated raw milk. The majority of samples in this study had freezing points in the range of –0.521 °C to –0.530 °C in both groups of raw milk (Table 1). Extremely high freezing points, i.e., –0.500 °C and above, were much more common in DSRM (11.7%) than CRM (0.2%) samples. Besides the possible adulteration of DSRM with water, another plausible explanation for this observation is the high percentage of low-lactose DSRM samples (Table 1), because lactose, together with chloride, accounts for 65–75% of the freezing point depression of milk (BYLUND, 1995; BHANDARI & SINGH, 2011). Batches of DSRM were also much more likely to contain low-freezing-point samples than were those of CRM. The high percentage of extreme values (i.e., ≥–0.500 °C or ≤–0.536 °C) in DSRM samples resulted in an increased standard deviation in this group compared to CRM, even though a difference of only 0.007 °C (–0.517 °C vs. –0.524 °C) was observed in mean values (Table 2).

3. Conclusions

The Hungarian direct milk vendors involved in this 9-month study were found to sell raw bovine milk with reduced levels of lactose and SNF and elevated freezing points, compared to the official national raw milk data referring to the same period. The results presented here underline the need for stricter regulations and control with respect to direct raw milk sales in the country. Further investigations are needed to monitor the microbiological and hygienic quality of DSRM, thereby determining the potential health risk posed by this product.

References

Auldist, M. (2011): Milk quality and udder health: effect on processing characteristics. -in: Fuquay, J.W., Fox, P.F. & McSweeney, P.L.H. (Eds) *Encyclopedia of dairy sciences, Vol. 3*. Academic Press, London, UK, pp. 902–907.

Bhandari, V. & Singh, H. (2011): Analytical methods: physical methods. -in: Fuquay, J.W., Fox, P.F. & McSweeney, P.L.H. (Eds) *Encyclopedia of dairy sciences, Vol. 1*. Academic Press, London, UK, pp. 248–255.

Biggs, D.A., Szijarto, L.F. & Van de Voort, F.R. (1984): Fresh milk sampling for centralized milk testing. *J. Dairy Sci.*, *67*, 3085–3092.

Bylund, G. (1995): The chemistry of milk. -in: Bylund, G. (Ed.) *Dairy processing handbook*. Tetra Pak Processing Systems, Lund, Sweden, pp. 13–36.

Claeys, W.L., Verraes, C., Cardoen, S., De Block, J., Huyghebaert, A., Raes, K., Dewettinck, K. & Herman, L. (2014): Consumption of raw or heated milk from different species: an evaluation of the nutritional and potential health benefits. *Food Control*, *42*, 188–201.

Csapó, J. & Csapóné Kiss, Zs. (2009): A tehéntej táplálkozástudományi szempontból legfontosabb összetevői II. Laktóz-, ásványianyag- és vitamintartalom (The most important components of bovine milk from a nutritional point of view II. Lactose, minerals, and vitamin contents). -in: Kukovics, S. (Ed.) *A tej szerepe a humán táplálkozásban (The role of milk in human nutrition)*. Melánia Kiadó, Budapest, Hungary, pp. 167–186.

EC (2004a): Regulation (EC) no. 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. *Off. J. EU*, *L139*, 1–54.

EC (2004b): Regulation (EC) no. 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin. *Off. J. EU*, *L139*, 55–205.

EC (2004c): Regulation (EC) no. 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption. *Off. J. EU*, *L139*, 206–320.

EC (2007): Council Regulation (EC) no. 1234/2007 of 22 October 2007 establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products (Single CMO Regulation). *Off. J. EU*, *L299*, 1–149.

Emmons, D.B., Tulloch, D. & Ernstrom, C.A. (1990): Product-yield pricing system. 1. Technological considerations in multiple-component pricing of milk. *J. Dairy Sci.*, *73*, 1712–1723.

Fox, P.F. (2011): Milk: bovine milk. -in: Fuquay, J.W., Fox, P.F. & McSweeney, P.L.H. (Eds) *Encyclopedia of dairy sciences, Vol. 3*. Academic Press, London, UK, pp. 478–483.

Geary, U., Lopez-Villalobos, N., O'Brien, B., Garrick, D.J. & Shalloo, L. (2013): Meta-analysis to investigate relationships between somatic cell count and raw milk composition, Cheddar cheese processing characteristics and cheese composition. *Irish J. Agr. Food Res.*, *52*, 119–133.

Goodridge, L., Hill, A.R. & Lencki, R.W. (2004): A review of international standards and the scientific literature on farm milk bulk-tank sampling protocols. *J. Dairy Sci.*, *87*, 3099–3104.

Hungarian Dairy Research Institute (2014): Official Hungarian raw milk quality database (updated on a daily basis). Available only at request at http://www.mtki.hu/activities/state-duties (last accessed 28 March 2014).

IDF (2000): *Whole milk – Determination of milk fat, protein and lactose content – Guidance on the operation of mid-infrared instruments*. International Dairy Federation, Brussels, Belgium, International Standard IDF 141C:2000.

ISO-IDF (2009): *Milk – Determination of freezing point – Thermistor cryoscope method (Reference method)*. International Organization for Standardization, Geneva, Switzerland & International Dairy Federation, Brussels, Belgium. International Standard ISO 5764:2009 & IDF 108:2009.

JENNESS, R. (1986): Lactational performance of various mammalian species. *J. Dairy Sci.*, *69*, 869–885.

KNEAFSEY, M., VENN, L., SCHMUTZ, U., BALÁZS, B., TRENCHARD, L., EYDEN-WOOD, T., BOS, E., SUTTON, G. & BLACKETT, M. (2013): Short food supply chains and local food systems in the EU. A state of play of their socio-economic characteristics, Available at http://ftp.jrc.es/EURdoc/JRC80420.pdf (last accessed 20 October 2014).

LACZAY, P. (2008): Tejtermelési higiénia (Hygiene of milk production). in: LACZAY, P. (Ed.) *Élelmiszer-higiénia, élelmiszerlánc-biztonság* (Food hygiene, food chain safety). Mezőgazda Kiadó, Budapest, Hungary, pp. 239–307.

MARSDEN, T.K. & ARCE, A. (1995): Constructing quality: Emerging food networks in the rural transition. *Environ. Plann. A*, *27*, 1261–1279.

MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT (2010): 52/2010. (IV. 30.) sz. FVM rendelet a kistermelői élelmiszer-termelés, -előállítás és –értékesítés feltételeiről (Decree no. 52/2010. (IV. 30.) FVM on the conditions of food production, processing, and sales by small-scale producers). *Magyar Közlöny*, *66*, 14360–14368.

MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT & MINISTRY OF SOCIAL AND LABOUR AFFAIRS (2008): 16/2008. (II. 15.) FVM–SZMM együttes rendelet a nyers tej vizsgálatáról (Joint decree no. 16/2008 (II. 15.) FVM–SZMM on raw milk testing). *Magyar Közlöny, 64*, 969–971.

PELSUE JR., N.H. (1973): Minimum number of fresh milk samples: a test of the theory. *J. Dairy Sci.*, *56*, 968–971.

RENTING, H., MARSDEN, T.K. & BANKS, J. (2003): Understanding alternative food networks: exploring the role of short food supply chains in rural development. *Environ. Plann. A*, *35*, 393–411.

TREMONTE, P., TIPALDI, L., SUCCI, M., PANNELLA, G., FALASCA, L., CAPILONGO, V., COPPOLA, R. & SORRENTINO, E. (2014): Raw milk from vending machines: effects of boiling, microwave treatment, and refrigeration on microbiological quality. *J. Dairy Sci.*, *97*, 3314–3320.

UNGER, A. (2001): A nyers tej minősége, minősítése és ára (Quality, grading, and price of raw milk). -in: SZAKÁLY, S. (Ed.) *Tejgazdaságtan (Dairy science)*. Dinasztia Kiadó, Budapest, Hungary, pp. 115–129.

VAN DER PLOEG, J.D. & FROUWS, J. (1999): On power and weakness, capacity and impotence: rigidity and flexibility in food chains. *Int. Plann. Stud.*, *4*, 333–347.