THESES OF DOCTORAL (PhD) DISSERTATION

ANDRÁS JANCSÓ

MOSONMAGYARÓVÁR

2015

THESES OF DOCTORAL (PhD) DISSERTATION

INSTITUTE OF FOOD SCIENCE
FACULTY OF AGRICULTURE AND FOOD SCIENCES
UNIVERSITY OF WEST HUNGARY

Antal Wittmann Multidisciplinary Doctoral School of Plant, Animal and
Food Sciences
Gábor Pulay Doctoral Program in Food Science

Head of Doctoral School:
Prof. Dr. Miklós NEMÉNYI, CMHAS

Head of Doctoral Program:
Prof. Dr. habil. Jenő SZIGETI, CSc

Dissertation Adviser:
Prof. Dr. habil. László VARGA, PhD

The practice of direct selling and the quality of directly sold raw bovine milk

Written by:
András JANCSÓ

MOSONMAGYARÓVÁR

2015

1. INTRODUCTION

In Hungary all qualitative parameters of collected raw milk samples have been registered and processed. Significantly less information is available on the quality of raw milk, which is partly of small farmer origin and is sold directly to consumers. Furthermore, the effects of different sales channels and practices on raw milk quality have not been investigated in detail as yet. The objectives of this study were:

− the systematic interpretation of *direct selling* and comprehensive overview of the most significant historical events in this field, leading to the present-day direct selling practices in Hungary, and to review the relevant legislative background;

− the demonstration of the direct selling channels, the selling practices and the standard of technical background applied;

− the presentation and evaluation of raw bovine milk quality – sold directly through the most common sales channels – in terms of fat, protein, lactose, and solids-not-fat contents, freezing point, acidity, pH, sample temperature, total plate count, somatic cell count, coliform count and inhibitory substances;

− the overview of the marketing and sales price aspects and the critical points/challenges of direct raw milk sales.

2. MATERIALS AND METHODS

To explain the practice of direct raw milk sales and to demonstrate its qualitative parameters, a 13-month study was undertaken from June 2013 through June 2014. Samples were collected and observations were made at 21 direct selling points. An important selection criterion was that they represented all the typical selling channels and practices in the area investigated.

Due to the basically non-cooperative approach of the raw milk sellers, anonymity was maintained throughout the investigation. Thus, no information about the sample sources (*e.g.* exact area of operation) was published. A total of eight districts in Budapest, Hungary were involved in the sampling procedures.

Only physical preservation was applied in the form of cooling at 4 °C or below. The reason for applying cooling-based preservation alone was that this simulated best the real routine of raw milk purchase and home storage.

For the mathematical–statistical evaluation of the test results, data frequency distribution and outlier tests were applied (Thompson test, $\alpha = 0.05\%$). The tightness of the correlation in the background of the data was evaluated with correlation analysis. Averages were calculated at selling point and overall (complete data set) levels.

3. RESULTS

The tools, methods and opportunities of direct raw milk sales have gone through significant changes during the past few years. The pace of development significantly speeded up in the 20th century, and especially in the past decade, due to technical progress and sales-increase efforts.

Investigation of the relevant Hungarian and European (EU) legislation suggests that it prefers, supports and provides perspective to direct selling as a form of trade, but from a *complex product quality* point of view, it does not provide an absolute guarantee to the consumers' health, and the value-for-money ratio.

In the investigated area raw milk was sold through three main channels: on markets (market halls), via self-service (raw milk vending machines) and various forms of mobile delivery services (milk tankers, farmers' local milk delivery schemes). Different selling practices were identified within the sales channels, where primitive (non-refrigerated), conventional, and—even by Western European standards—modern selling practices were represented. The standard of selling, especially from hygiene and technological discipline aspects, varied widely. Due to the peculiarities of the investigated area, the popularity of traditional sales forms and the current situation of direct selling, market and market hall locations were over-represented in the dissertation as compared to other selling forms.

In both directly sold and collected milks, the majority of fat content test results fell into the range of 3.25-4.00%, with overall mean

values of 3.75 ± 1.25% and 3.74 ± 0.37%, respectively. The differences were particularly pronounced in the extreme ranges (<2.75% and >4.75%), where a significant relative predominance of directly sold samples was observed. Extreme test results suggest insufficient agitation, whereas in the low fat content samples improper selling practice and manipulations (skimming, dilution) could be assumed.

Less variability was recorded in protein concentrations. The protein content results of directly sold and collected milks fell mostly in the range of 3.10-3.40%. The overall mean protein content of directly sold samples (3.24%) was slightly lower than that of collected milks (3.31%). Protein contents not exceeding 2.80% were much more common in directly sold milks than in collected milks. This phenomenon may be explained by dilution (presence of extraneous water), which was also supported by the freezing point depression results.

All test results considered, directly sold raw milk samples contained less lactose than did collected milks, and the differences were negligible only above lactose concentrations of 4.90%. The mean lactose content of collected raw milks (4.75 ± 0.08%) exceeded the lactose content of directly sold milks (4.54 ± 0.43%) over the same period. The reduced lactose concentrations in directly sold milks might mostly be explained by mastitis (56%), addition of water and other manipulations (33%), and fermentation of lactose, *i.e.,* the souring of milk (11%).

The solids-not-fat content results were similar to those of protein and lactose contents, and could be related to those. The range not

exceeding 8.60% was dominated by directly sold raw milks, whereas test results over 8.60% were more common in collected milks. The overall mean of directly sold raw milks (8.52%) was lower than that of collected raw milk samples (8.76%).

Most of the collected milk samples had freezing points in the range of -0.525 °C and -0.520 °C, whereas the freezing points of directly sold milks were typically between -0.530 °C and -0.525 °C. Again, more extremities were recorded in directly sold raw milks. The overall mean and standard deviation of directly sold raw milks (-0.518 ± 0.032 °C) were significantly higher than those of collected raw milk samples (-0.524 ± 0.006 °C). A plausible explanation for the higher freezing point of directly sold raw milk samples could be the leftover stagnant rinsing water in the pipeline system of raw milk selling equipment (*e.g.*, raw milk vending machines), the decreased lactose content, the low concentration of other milk components increasing the freezing point of milk, and dilution/intentional addition of extraneous water.

The majority (72%) of directly sold raw milk samples had acidity values within the range typical of fresh raw milk (6.0-7.2 °SH). The overall mean ± SD was 6.68 ± 1.55 °SH. More than one quarter (28%) of the samples tested indicated some kind of abnormalities, with half of them showing souring. Low titratable acidity results suggested compromised udder health, late lactation or dilution with water, whereas elevated results were indicative of excessive souring.

Over a third (37%) of the test results fell into the pH range characteristic of fresh raw milk (pH 6.5-6.7). The majority of samples

(53%) had pH values between 6.7-6.9, and only 10% of the test results indicated acidification (pH 4.6-6.5). The overall pH mean ± SD was 6.67 ± 0.17, with significant deviations from this being observed only in a few cases.

10-15 °C was the most frequent (28%) interval for sample temperature data, but nearly in equal numbers were they recorded in 8-10 °C and 6-8 °C intervals. The overall sample temperature mean was 9.18 ± 3.27 °C, whereas individual data significantly fluctuated (1.5-20.2 °C). Sample temperature, however, did not have appreciable effect on total plate counts and coliform counts of raw bulk milk. No reliable conclusions could be drawn regarding the hygienic–microbial quality of directly sold raw milk samples based on single temperature measurements.

Almost each selling point failed to meet the raw milk total plate count requirements. Only 14% of directly sold raw milk samples had results below the regulatory threshold of 100,000 cfu/ml. In contrast, 46% of samples contained more than 1,000,000 cfu/ml of microorganisms, indicating serious hygienic problems. The overall mean total plate count was 31,000 cfu/ml in collected milks, whereas more than a 2 log cycles higher mean value was obtained for directly sold raw milks (3,707,656 cfu/ml). In terms of the total plate count–to–coliform count ratio, a good correlation was found between collected and directly sold raw milks.

Individual somatic cell counts (SCC) ranged from a few thousand to several millions (5,300,000 cells/ml), suggesting large and abnormal variations in factors affecting this parameter. Approximately 40% of

SCC results—at both selling point and overall levels—were abnormally high (i.*e.*, >400,000 cells/ml). These data indicate compromised udder health.

Similar to total plate counts, the individual coliform counts largely fluctuated (100-3,000,000 cfu/ml). At selling point level, the differences even exceeded 4 log cycles, which indicated serious hygienic problems and post-secretory contamination of faecal origin. The overall mean of the 506 samples tested (106,937 cfu/ml) also well reflects the magnitude of the problem. The elevated coliform counts could, at least in part, be explained by physical contamination with manure, soil or straw particles, sometimes visible at the bottom of the bottles.

The presence of inhibitory substances was not typical in directly sold raw milks. Although the 0.4% rate of positive samples is worse than the 0.04% proportion of positive samples among collected milks, under the present conditions—in the absence of regular quality control—this can be called satisfactory.

The average sales price of raw milk at different selling points varied between 166.92 HUF/l and 252.31 HUF/l, and the differences in individual prices were even more pronounced (159-267 HUF/l). Price increases were common during the test period. Six sellers (29%), however, had constant prices, and at one selling point (5%) even price reduction was recorded. The effects of dairy market tendencies on directly sold raw milk pricing having been investigated, it was found that at 10 sellers (48%) the prices appreciably and positively correlated to the collected raw milk prices, although the degree of tightness

fluctuated. The same was experienced in relation to the 2.8% fat content drinking milk prices, where positive and tight correlation was found at 11 sellers (52%). It was concluded that these sellers, to some extent, considered the collected milk prices and the drinking milk prices, and they monitored the dairy market tendencies when formulating their pricing strategies. The pricing of neighbouring sellers showed that most of them were influenced by the prices of other sellers (pricing adjustment). Compositional, microbiological and value-for-money analyses revealed that some selling points at the opposite ends of the quality rank sold their milk at the same price level, and sometimes worse quality milk even cost more. The quality ranks of certain selling points and their average selling prices showed weak (or no) correlation.

The application of marketing tools was not typical in the practice of direct raw milk sales. Only a few sellers were observed to recognize the opportunities of the integrated marketing tools and their application at the strategic level.

Out of the critical points, human factor and work organization were deemed highly challenging. Their proper management assumes the hiring of professionally competent, skilled and humanly acceptable employees, reducing fluctuation and the rationalization of working order. As for operation, maintenance and service, it is desirable that an unbroken cold chain, proper cooling temperatures and elimination of critical points (*e.g.*, dripping fillers) be ensured. All equipment used in raw milk sales are supposed to have a completely cooled flow system.

The importance of proper cleaning and maintenance is stressed not only with respect to raw milk selling machinery, but also in terms of

milking and raw milk handling. When raw milk vending machines are installed in public places, the existing phenomenon of abusive and destructive behaviour should be considered. Surface minimization is to be achieved in raw milk handling, thus avoiding the unnecessary operations that increase microbial risks. Packaging- and labelling-related problems were mostly observed in producer-bottled raw milks. The packaging material provided by producers or sellers was most commonly empty mineral water bottles, giving rise to hygienic concerns. The legally required labelling elements were completely missing from these packaging materials.

4.   CONCLUSIONS

The changes that have gone through in the tools, methods and opportunities of direct raw milk selling well demonstrate the process, whereby achievements of technical progress and new sales trends infiltrate to nearly all areas of food production and marketing. By implementing advanced tools and practices, it is possible to increase the quantity and efficacy of sales and improve food safety.

The theoretical opportunity of selling high-quality raw milk was given at each sales channel, but selling was realized under fluctuating hygienic and technological circumstances. This had an immense effect on the homogeneity and physicochemical and microbiological–hygienic parameters of raw milk.

The results obtained highlight the need for stricter and more precise legislation, an organized and regular quality control in the dairy sector, which focuses on direct selling itself instead of specific producer groups. It is problematic that based on the present legislation the price consequence cannot be guaranteed, and no quality improvement can be achieved without financial interest.

All things considered, the quality of directly sold raw milk samples was found to be inferior to that of collected raw milk samples tested during the same period. It is likely that improper milking, raw milk handling and selling practices adversely affected the physicochemical and microbiological–hygienic quality of raw milk. Further investigations are needed to reveal any other effects of the

selling form on the quality and microbial composition of directly sold raw milk.

The changes in raw milk sales prices, the correlations with collected and drinking milk prices suggest up-to-date information on the market, follow-up on market prices and supply–demand relations. Correlations between the prices applied by raw milk sellers operating in the same area (*e.g.*, on the same market) indicate price adjustment strategies. The results of value-for-money analyses reveal un-coordinated circumstances and a rather imaginary pricing strategy. This phenomenon could be diminished by the introduction of a rewarding–sanctioning pricing system already applied for collected milks and by the application of price-consequence.

One of the biggest challenges facing direct sellers is to familiarize themselves, to some extent, with the marketing approach. They should also recognize the benefits of its application and the drawbacks of its negligence. The proper choice of marketing tools that best fit the size, form, opportunities, image and character of the company should be made with cost optimization and continuous follow-up. It is of strategic importance that communication be based on real product quality and benefits, marketing tools be applied consciously, in an organized way. Strengthening consumer awareness and trust are also among the important goals to achieve. One of its basic conditions is positive consumer feedback, based on good impressions and, most importantly, good product quality.

The proper approach alone could considerably improve critical points and challenges such as human factor, work organization,

operation, maintenance, service, raw milk handling, selling practice, quality aspects, packaging and labelling.

Physicochemical, microbial–hygienic and management education of the personnel involved in raw milk production and selling, the consistent observation of basic technological and hygienic prescriptions, the application of proper hygienic approach and practice could considerably improve the complex quality and increase the quantity of directly sold raw milk.

5. NEW SCIENTIFIC FINDINGS

1. The comparable physicochemical characteristics and microbiological–hygienic properties (*i.e.*, fat, protein, lactose and solids-non-fat contents, freezing point, total plate count, somatic cell count, inhibitory substances) of directly sold raw milk have been found to be significantly inferior to those of collected raw milk samples over the same period. This was the consequence of improper milking and raw milk handling practices and hygienic failures/shortcomings in these operations. The results of non-comparable parameters (acidity, pH, coliform count) also support this finding.

2. The current legislation in force in this field and the control practice of competent authorities do not guarantee the protection of consumers' financial interests and their health. No quality control system, based on the analysis of samples taken on the spot of selling, exists in direct selling of raw milk, and price-consequence is not enforceable.

3. Currently, there is no correlation between the essential compositional (*i.e.*, fat and protein contents) and microbiological–hygienic (*i.e.*, total plate count, somatic cell count, coliform count) quality and the sales price of directly sold raw milk. Over the investigated period, the price of directly sold raw milk has shown a good correlation with the price of collected milk and that of commercial drinking milk.

6. SCIENTIFIC PUBLICATIONS ON THE TOPIC OF THE DISSERTATION

Peer-Reviewed Papers

Jancsó, A., Császár, G., Varga, L.: Physicochemical quality of directly sold raw milk in Hungary. *Acta Alimentaria* (in press). DOI: 10.1556/AAlim.2015.0016.

Jancsó, A., Császár, G., Varga, L. (2014): A fogyasztóknak közvetlenül értékesített termelői nyers tehéntej egyes fizikai–kémiai és mikrobiológiai–higiéniai jellemzőinek vizsgálata (Determination of some physicochemical and microbiological–hygienic properties of directly sold raw bovine milk). *Tejgazdaság (Hungarian Dairy Journal)* 74 (1-2), 19–33.

Jancsó, A., Császár, G., Varga, L. (2013): Kontrollminták kifejlesztése tejipari laboratóriumokban alkalmazott fagyáspont-, szomatikus sejtszám- és mikrobaszám-vizsgálatok pontosságának ellenőrzéséhez (Development of control samples for checking the accuracy of freezing point, somatic cell count and microbial count determinations in dairy laboratories). *Tejgazdaság (Hungarian Dairy Journal)* 73 (1-2), 15–21.

Jancsó, A., Császár, G., Varga, L. (2010): Kalibrációs minták kifejlesztése nyers tej és tejtermékek beltartalmi jellemzőinek mérésére alkalmas automata műszerekhez (Development of calibration samples for automated instruments designed to determine the chemical composition of raw milk and dairy foods). *Tejgazdaság (Hungarian Dairy Journal)* 70 (1-2), 9–13.

Papers Published in Conference Proceedings

Jancsó, A., Császár, G., Varga, L. (2006): Kalibrációs minták kifejlesztése nyers tej és tejtermékek beltartalmi jellemzőinek mérésére alkalmas automata műszerekhez (Development of calibration samples for automated instruments designed to determine the chemical composition of raw milk and milk products). *XXXI. Óvári Tudományos Nap "Élelmiszer-alapanyag előállítás – quo vadis?"*. Az előadások és poszterek teljes terjedelemben megjelent anyagai. Nyugat-magyarországi Egyetem, Mezőgazdaság- és Élelmiszer-tudományi Kar, Mosonmagyaróvár, Compact Disc, 7 pp. [ISSN: 0237-9902]

Jancsó, A., Császár, G. (2004): Termék- és vizsgálatspecifikus körvizsgálati rendszer kidolgozása tejipari vizsgálólaboratóriumok számára (Development of a product- and test-specific proficiency testing system for dairy laboratories). *XXX. Óvári Tudományos Napok "Agrártermelés – harmóniában a természettel"*. Az előadások és poszterek teljes terjedelemben megjelent anyagai. Nyugat-magyarországi Egyetem, Mezőgazdaság- és Élelmiszer-tudományi Kar, Mosonmagyaróvár, Compact Disc, 6 pp. [ISSN: 0237-9902]