Macro- and micromineral composition of milk from purebred Holsteins and four generations of three-breed rotational crossbred cows from Viking Red, Montbéliarde and Holstein sires

Sudeb Saha\textsuperscript{a}, Martina Piazza\textsuperscript{b}, Giovanni Bittante\textsuperscript{b} and Luigi Gallo\textsuperscript{b}

\textsuperscript{a}Department of Dairy Science, Faculty of Veterinary, Animal and Biomedical Sciences, Sylhet Agricultural University, Sylhet, Bangladesh; \textsuperscript{b}Dipartimento di Agronomia Animali Alimenti Risorse Naturali e Ambiente (DAFNAE), University of Padova, Legnaro, Padova, Italy

\textbf{ABSTRACT}

This study compared the detailed mineral profiles of milk from purebred Holstein (HO) and four generations (F1 to F4) of crossbred cows (CR) derived from a 3-breed rotational crossbreeding system involving Viking Red (VR) and Montbéliarde (MO) sires. Purebred and CR were kept and fed together in the same herd. Individual milk samples were collected once per cow from 120 multiparous cows (40 HO and 20 for each generation of CR from F1 to F4). The milk samples were analysed for macrominerals (Na, Mg, P, S, K, Ca), essential (Cr, Mn, Fe, Cu, Zn, Mo), and environmental microminerals (Li, B, Ba) using inductively coupled plasma-optical emission spectrometry. The coefficients of variation ranged from 11 to 28\% for macrominerals and from 17 to 40\% for microminerals. The mineral composition of milk from purebred HO and CR were mostly comparable. Conversely, it differed in different breed combinations of CR: VR-sired cows had the greatest macromineral contents, MO-sired cows the lowest, while HO-sired CR was intermediate. The milk from MO-sired crossbreds had lower contents of some microminerals (Mo, Zn, and Ba), while the milk from HO-sired crossbreds had greater contents (Fe and Mo). We conclude that the mineral profile of milk of CR derived from different combinations of VR, MO and HO breeds was comparable to that of milk from HO cows kept in the same herd, and that the variations in the macro- and micromineral profiles were greater among CR than between purebreds and crossbreds.

\textbf{INTRODUCTION}

Although the mineral content of milk is generally lower than 10 g/L (Gaucheron 2005), the mineral profile is characterised by many elements present in several different chemical configurations, such as inorganic ions and salts, and constituents of organic molecules (Cashman 2011a). As a result, milk and milk products are important sources of minerals for human nutrition (Cashman 2006; Zamberlin et al. 2012). Aside from this role, minerals are implicated in the structure and stability of casein micelles (Gaucheron 2005). They also influence the renneting ability of milk, thus playing a role in cheese manufacturing (Gustavsson et al. 2014; Malacarne et al. 2014), and can be used in the diagnosis of specific diseases in dairy cows, such as mastitis (Hamann and Krömker 1997; Summer et al. 2009).

The mineral content of milk depends on several environmental factors, such as diet and feeding practices, and it varies across and throughout lactations (Gaignon et al. 2018; Denholm et al. 2019; Stocco et al. 2019). Genetic factors also affect the variation of...
several minerals, both within and across breeds. Significant heritability estimates have been reported for some macro- and microminerals (van Hulzen et al. 2009; Buitenhuizen et al. 2015; Denholm et al. 2019). Stocco et al. (2019) reported that breed was a major source of variation for most essential minerals in milk. Comparative effects on the mineral profiles of milk have been investigated in some specialised and dual-purpose breeds (Hermansen et al. 2005; Barlow et al. 2006; Buitenhuizen et al. 2015; Stocco et al. 2019), yet the effect of crossbreeding on the mineral content of milk has so far not been dealt with. Crossbreeding is of increasing interest due to the declining fertility, health and longevity of modern specialised dairy cows (Malchiodi et al. 2014a; Hazel et al. 2017) and is now extending to many countries (Hazel et al. 2017; Clasen et al. 2019). A 3-breed rotational crossbreeding system, in particular, involving Montbéliarde (MO), Viking Red (VR) and Holstein (HO) breeds has raised interest in the dairy sector (Shonka-Martin et al. 2019). This study aimed to compare the detailed mineral profiles of milk produced by purebred HO and four generations of crossbred cows (CR) derived from a 3-breed rotational crossbreeding system using VR, MO, and HO sires.

Methods and materials

This study is part of a wider project evaluating 3-breed rotational crossbreeding (Saha et al. 2020). It was carried out on a dairy herd located in northern Italy, managed according the rules of protected denomination of origin Parmigiano Reggiano cheese. The cows were fed a total mixed ration based on dry roughage, mainly alfalfa and meadow hay, and concentrates. This farm was managed under the Procross 3-breed rotational crossbreeding program, which is jointly marketed by Coopex Montbéliarde (Roulans, France) and Viking Genetics (Randers, Denmark). A total of 120 cows (40 purebred Holstein and 80 CR) were randomly selected from a group of multiparous cows at lactation stages between 100 and 300 DIM (average parity 2.8 ± 0.9, average lactation stage 165 ± 49 DIM). The following sire-breeding sequence was used for cross-breeding the cows (20 cows for each genetic combination): VR semen on HO cows to produce F1 (VR × HO); MO semen on F1 cows to produce F2 (MO × (VR × HO)); and HO semen on F2 cows to produce F3 ((HO × (MO × (VR × HO)))). F3 cows were inseminated using again VR semen to obtain F4 cows (VR × (HO × (MO × (VR × HO)))). Purebred HO and CR were raised and milked together, and were fed the same diets.

Individual milk samples (2.0 L/cow) were collected once per cow during the evening milking in six different sampling sessions (20 cows per session), in each of which purebreds and CR of all breed combinations were sampled. After collection, milk samples (without preservative) were refrigerated (4°C) and analysed within 24 h of collection. Test day milk yield was recorded for each cow at the day of the sampling. Milk samples were analysed for somatic cell count (SCC, Fossmatic Minor, Electric A/S, Hillerød, Denmark) and the values log transformed to somatic cell score (SCS). Protein and fat contents were measured with a Milkoscan FT2 infra-red analyser (Foss Electric A/S, Hillerød, Denmark) and the values log transformed to somatic cell score (SCS). Protein and fat contents were measured with a Milkoscan FT2 infra-red analyser (Foss Electric A/S, Hillerød, Denmark) and the values log transformed to somatic cell score (SCS). Protein and fat contents were measured with a Milkoscan FT2 infra-red analyser (Foss Electric A/S, Hillerød, Denmark) and the values log transformed to somatic cell score (SCS). Protein and fat contents were measured with a Milkoscan FT2 infra-red analyser (Foss Electric A/S, Hillerød, Denmark) and the values log transformed to somatic cell score (SCS). Protein and fat contents were measured with a Milkoscan FT2 infra-red analyser (Foss Electric A/S, Hillerød, Denmark) and the values log transformed to somatic cell score (SCS).
material BCR–063R “Skim milk powder” (Institute for Reference Materials and Measurements, Geel, Belgium). The measured and the certified values were in excellent agreement for all the minerals measured.

Before analysis, all data were classified for parity (PAR, 2nd parity and >2nd parity, 53 and 67 cows, respectively), days in milk (DIM, class 1: <150d; class 2: 151 to 210 d; class 3: >210 d, 50, 46 and 24 cows, respectively) and breed combinations (purebred HO, F1, F2, F3 and F4 CR). Data on the contents of 6 macrominerals (Na, Mg, P, S, K, Ca), 6 essential microminerals (Cr, Mn, Fe, Cu, Zn, Mo) and 3 environmental microminerals (Li, B, Ba) were analysed using a mixed model procedure in SAS 9.4 (SAS Institute, 2013), which included the random effects of sampling date and the fixed effects of PAR, DIM and breed combination.

Orthogonal contrasts (p<.05) were used to investigate the effects of crossbreeding (purebred HO vs. CR) and the effects of the breed of the terminal sire/generation in the CR: VR sire: (F1 + F4) vs. (F2 + F3); MO sire: F2 vs. (F1 + F3 + F4); and HO sire: F3 vs. (F1 + F2 + F4).

Results and discussion

On average, the cows yielded 32.0 kg/d of milk containing 4.30% fat and 3.95% protein (Table 1), with a nearly 10% greater milk yield and nearly 5% lower protein content in HO compared to CR cows (data not in table). A total of 32 minerals were measured, but 17 were below the limit of detection in some or all of the milk samples and were not included in the analysis.

Average macromineral concentrations ranged from 96 mg/kg for Mg to 1477 mg/kg for K, with coefficients of variation from 11 to 14% for all the macrominerals except Na, where it was 28%. The average contents of the different macrominerals in milk and their variations found in the present study are generally in good agreement with the values obtained using the same or similar methods by Cashman (2011a), Stocco et al. (2019) and Denholm et al. (2019). Average essential micromineral concentrations ranged from 3 μg/kg for Cr to 3876 μg/kg for Zn, with coefficients of variation from 20 to 40%. The means of the essential micromineral contents of milk are also in agreement with the values reported by Cashman (2011b), with the exception of Mn, which was lower in our study. For most of the essential trace elements, the variability in the contents in this study (average coefficient of variation: 25%) was nearly half (on average 45%) that reported by Stocco et al. (2019); however, they sampled milk from cows kept in 27 multi-breed herds. The average contents of the environmental microminerals ranged from 5 (Li) to nearly 400 μg/kg (B), and their variability was comparable to that of the essential microelements.

Least squares means for the mineral contents of milk across breed combinations are reported in Table 2. The breed combination significantly affected the concentrations of all macrominerals and 6 of the 9 microminerals. Also Stocco et al. (2019), when comparing milk from different purebred cows, found that breed affected the content of all macrominerals and 7 of the 9 microminerals.

The differences between the purebred HO and the CR were never significant, with the exception of Mn and Ba (Table 2). On the other hand, large differences were observed within CR according to their sire/breed/generation. Namely, milk from crossbred daughters of VR sires (F1 cows and F4 cows) had greater (from 3.7 to 9.5%) P, S, K and Ca contents, and a 10% lower content of Na compared with the crossbred daughters of MO and HO sires. In addition, the milk from MO-sired cows (F2) had lower (–4.7 to −7.5%) Mg, P, S, K and Ca contents, and a 19% greater content of Na compared with the other CR, as well as lower levels of some essential microelements (Cr, Fe, Zn, and Mo, from −8 to −12%) and one environmental microelement (Ba, −11%). Lastly, the mineral content of milk from HO-sired CR (F3) did not differ from that of the average of the other 2 sire lines, except for the greater content of Fe and Mo in the former.

### Table 1. Descriptive statistics of yield, composition and mineral concentration of milk (n = 120).

| Trait                        | Mean  | SD   | Min  | Max  |
|------------------------------|-------|------|------|------|
| Milk yield, kg/d             | 32.00 | 8.10 | 10.00| 48.00|
| Milk composition:            |       |      |      |      |
| Fat, %                       | 4.30  | 1.12 | 2.09 | 7.63 |
| Protein, %                   | 3.95  | 0.36 | 3.22 | 5.08 |
| SCS*                         | 2.83  | 1.61 | −0.64| 6.73 |
| Macro-minerals, mg/kg        |       |      |      |      |
| Na                           | 401   | 114  | 210  | 907  |
| Mg                           | 96    | 13   | 66   | 126  |
| P                            | 960   | 119  | 618  | 1296 |
| S                            | 351   | 39   | 256  | 464  |
| K                            | 1477  | 206  | 995  | 2092 |
| Ca                           | 1224  | 130  | 912  | 1575 |
| Essential micro-minerals, μg/kg | | | | |
| Cr                           | 3     | 1    | 2    | 5    |
| Mn                           | 19    | 5    | 10   | 35   |
| Fe                           | 285   | 64   | 158  | 522  |
| Cu                           | 81    | 33   | 28   | 190  |
| Zn                           | 3876  | 775  | 1805 | 5676 |
| Mo                           | 52    | 10   | 33   | 84   |
| Environmental micro-minerals, μg/kg | | | | |
| Li                           | 5     | 2    | 2    | 10   |
| B                            | 393   | 68   | 264  | 565  |
| Ba                           | 48    | 11   | 28   | 84   |

*SCS = 3 + log2 (SCC/100,000).
Very little is to be found in the literature regarding the detailed mineral profiles of milk from different breeds, and none on the different crossbreed combinations, particularly when the search is restricted to data obtained using certified primary laboratory analytical methods. When compared with other breeds, Holstein Friesian milk has generally been found to have a lower mineral content. This has been reported by Barlowska et al. (2006), who compared local Polish breeds and HO for 8 macro- and microminerals, and by Hermansen et al. (2005) and Buitenhuis et al. (2015), who compared Jersey and HO for several macro- and microminerals. Similarly, Gaucheron (2005) reported that the milk from Normandy cows had a higher mineral content than the milk from HO. Stocco et al. (2019) analysed 15 macro- and microelements in milk from 6 different breeds and they reported that milk samples from HO cows had the lowest amounts of almost all the essential minerals. Glantz et al. (2009) found no differences in the Ca, P, K, Mg and Zn contents of milk from herds rearing HO and Swedish Red in summer, but in winter the Swedish Red milk had lower Ca and P contents than the HO milk. In the present study, milk samples from purebred HO and CR were comparable for all macrominerals and the majority of microminerals analysed. Purebred HO and 2- and 3-breed crosses from the HO, MO, and VR breeds have been generally reported to differ in milk volume (higher in HO), and in fat, protein and casein concentrations (higher in CR) (Malchiodi et al. 2014b; Shonka-Martin et al. 2019; Saha et al. 2020), and this trend has been confirmed also in this study (data not provided). Therefore, it seems that differences in milk yield and milk nutrients contents reported between the different breed combinations are not linked to differences in the concentrations of the minerals in milk. We are not aware of any previous research comparing the mineral profiles of purebred and CR, and we are therefore unable to corroborate our findings with the literature. We found that the mineral profiles of milk from the CR were not homogeneous, but rather varied significantly across the different genetic lines: the milk samples from daughters of VR sires generally had greater levels of macrominerals, while that from daughters of MO sires had lower levels of macrominerals and several essential microminerals. The minerals in milk are important not only as sources of bio-available nutrients for human nutrition, but also because along with protein fractions, protein genetic variants and acidity they help define the technological properties of milk during cheese-making (Bittante et al. 2012). Scandinavian breeds are known for having higher frequencies of milk protein alleles (especially A and E alleles of the CSN3 gene codifying for k-casein), which have unfavourable effects on milk coagulation and curd firming (Poulsen et al. 2013). The greater contents of some favourable macrominerals in the milk from VR-sired CR found here could in some way compensate for the higher frequencies of some unfavourable genetic variants, whereas the opposite situation is true for MO-sired CR. The proportions of different protein fractions, and particularly k-casein, also follow a similar pattern (Maurmayr et al. 2018). This could explain the modest differences in

| Trait                      | HO | F1 VR× | F2 MO× | F3 HO× | F4 VR× | SEM |
|----------------------------|----|--------|--------|--------|--------|-----|
| **Macro-minerals, mg/kg**  |    |        |        |        |        |     |
| Na                        | 395| 363    | 469    | 400    | 418    | 26  |
| Mg                        | 97 | 97     | 91     | 98     | 99     | 3   |
| P                         | 969| 981    | 900    | 923    | 1015   | 32  |
| S                         | 348| 366    | 343    | 344    | 370    | 10  |
| K                         | 1447| 1532  | 1388   | 1420   | 1512   | 70  |
| Ca                        | 1228| 1283  | 1167   | 1197   | 1247   | 70  |
| **Essential micro-minerals, µg/kg** | |        |        |        |        |
| Cr                        | 3  | 3      | 3      | 3      | 3      | 0.3 |
| Mn                        | 18 | 19     | 20     | 21     | 21     | 1   |
| Fe                        | 280| 277    | 272    | 316    | 300    | 17  |
| Cu                        | 86 | 64     | 72     | 86     | 85     | 10  |
| Zn                        | 4005| 3915  | 3514   | 4030   | 4049   | 194 |
| Mo                        | 53 | 51     | 47     | 56     | 54     | 3   |
| **Environmental micro-minerals, µg/kg** | |        |        |        |
| Li                        | 5  | 5      | 5      | 4      | 0.4    |     |
| B                         | 391| 388    | 389    | 395    | 388    | 24  |
| Ba                        | 51 | 52     | 43     | 47     | 46     | 2   |

Contrasts (p-Value)

| HO vs. F1 + F2 + F3 + F4 | VR sire (F1 + F4) vs. (F2 + F3) | MO sire F2 vs. (F1 + F3 + F4) | HO sire F3 vs. (F1 + F2 + F4) |
|--------------------------|---------------------------------|-------------------------------|-------------------------------|
| HO vs. F1 + F2 + F3 + F4 | >0.05                           | <0.01                         | <0.01                         |
| VR sire (F1 + F4) vs. (F2 + F3) | >0.01                           | <0.10                         | <0.04                         |
| MO sire F2 vs. (F1 + F3 + F4) | >0.01                           | <0.05                         | <0.07                         |
| HO sire F3 vs. (F1 + F2 + F4) | >0.01                           | <0.01                         | <0.01                         |

\[ F1 = VR \times HO; F2 = MO \times (VR \times HO); F3 = HO \times (MO \times VR \times HO); F4 = VR \times \{HO \times (MO \times VR \times HO)\}. \]
milk technological properties between the two types of CR, and also their advantage over the purebred HO cows (Malchiodi et al. 2014b; Saha et al. 2020).

Conclusions
This study furthers our knowledge of the effects of crossbreeding on milk composition by analysing traits not previously investigated. The results reported here show that the mineral profiles of milk from CR obtained from different combinations of VR, MO and HO breeds within a 3-breed rotational crossbreeding program are greatly affected by the breed combination, and this is particularly apparent when comparing VR- with MO-sired cows. However, the average mineral profile of milk produced by the different crossbred types/generations was comparable to that of the purebred HO cows kept in the same herd.

Acknowledgements
Gratitude is expressed to Gian Luca Cavani and Carmelo Monteleone (Albalat, Cortile di Carpi, MO, Italy), for their cooperation and support, to Claudio Mariani (Genesi Project S.r.l., Castelnovo Sotto, Reggio Emilia, Italy), and to the technical staff of the DAFNAE Department for their assistance in data collection and chemical analysis.

Ethical approval
All authors declare that this study follows the principles of the Declaration of Helsinki.

Disclosure statement
None of the authors has a financial or personal relationship with other people or organisations that could inappropriately influence this publication. No potential conflict of interest was reported by the author(s).

Funding
This work was supported by University of Padova under [grant BIRD 188213/18], Genesi Project S.r.l. (Castelnovo Sotto, Reggio Emilia, Italy) and Procross Aps (Randers, Denmark).

References
Barłowska J, Litwińczuk Z, Krol J, Kędzierska-Matyešek M. 2006. Fatty acid profile and minerals content in milk from cows of various breeds over spring-summer feeding period. Pol J Food Nutr Sci. 56(15):13–16.
Bittente G, Penasa M, Cecchinato A. 2012. Invited review: genetics and modelling of milk coagulation properties. J Dairy Sci. 95(12):6843–6870.
Buitenhuis B, Poulsen NA, Larsen LB, Sehested J. 2015. Estimation of genetic parameters and detection of quantitative trait loci for minerals in Danish Holstein and Danish Jersey milk. BMC Genet. 16:52.
Cashman KD. 2006. Milk minerals (including trace elements) and bone health. Int Dairy J. 16(11):1389–1398.
Cashman KD. 2011a. Macromolecules, nutritional significance. In: Fuquay JW, editor. Encyclopedia of Dairy Sciences. 11th ed. Amsterdam, The Netherlands: Elsevier Ltd.; p. 925–932.
Cashman KD. 2011b. Trace elements, nutritional significance. In: Fuquay JW, editor. Encyclopedia of Dairy Sciences. 11th ed. Amsterdam, The Netherlands: Elsevier Ltd.; p. 933–940.
Clasen JB, Fogh A, Kargo M. 2019. Differences between performance of F1 crossbreds and Holsteins at different production levels. J Dairy Sci. 102(1):436–441.
Denholm SJ, Sneddon AA, McNelly TN, Bashir S, Mitchell MC, Wall E. 2019. Phenotypic and genetic analysis of milk and serum element concentrations in dairy cows. J Dairy Sci. 102(12):11180–11192.
Gaignon P, Gelé M, Hurtaud C, Boudon A. 2018. Characterization of the nongenetic causes of variation in the calcium content of bovine milk on French farms. J Dairy Sci. 101(5):4554–4569.
Gaucheron F. 2005. The minerals of milk. Reprod Nutr Dev. 45(4):473–483.
Glantz M, Lindmark-Månsson H, Stålhammar H, Bårström LO, Fröjelin M, Knutsson A, Teluk C, Paulsson M. 2009. Effects of animal selection on milk composition and processability. J Dairy Sci. 92(9):4489–4604.
Gustavsson F, Glantz M, Buitenhuis AJ, Lindmark-Månsson H, Stålhammar H, André A, Paulsson M. 2014. Factors influencing chymosin-induced gelation of milk from individual dairy cows: Major effects of casein micelle size and calcium. Int Dairy J. 39(1):201–208.
Hamann J, Krömker V. 1997. Potential of specific milk composition variables for cow health management. Livest. Prod. Sci. 48(3):201–208.
Hazel AR, Heins BJ, Hansen LB. 2017. Production and calving traits of Montbéliarde × Holstein and Viking Red × Holstein cows compared with pure Holstein cows during first lactation in 8 commercial dairy herds. J Dairy Sci. 100(5):4139–4149.
Hermansen JE, Badsberg JH, Kristensen T, Gundersen V. 2005. Major and trace elements in organically or conventionally produced milk. J Dairy Res. 72(3):362–368.
ISO-IDF (International Organization for Standardization and International Dairy Federation). 2010. Milk—determination of fat content. International Standard ISO 1211 and IDF 1: 2010. Geneva, Switzerland: ISO; Brussels, Belgium: IDF.
ISO-IDF (International Organization for Standardization and International Dairy Federation). 2014. Milk and milk
products—determination of nitrogen content—Part 1: Kjeldahl principle and crude protein calculation. International Standard ISO 8968-1 and IDF 1:2014. Geneva, Switzerland: ISO; Brussels, Belgium: IDF.

Malacarne M, Franceschi P, Formaggioni P, Sandri S, Mariani P, Summer A. 2014. Influence of micellar calcium and phosphorus on rennet coagulation properties of cows milk. J Dairy Res. 81(2):129–136.

Malchiodi F, Cecchinato A, Bittante G. 2014a. Fertility traits of purebred Holsteins and 2- and 3-breed crossbred heifers and cows obtained from Swedish Red, Montbéliarde, and Brown Swiss sires. J Dairy Sci. 97(12):7916–7926.

Malchiodi F, Cecchinato A, Penasa M, Cipolat-Gotet C, Bittante G. 2014b. Milk quality, coagulation properties, and curd firmness modeling of purebred Holsteins and first- and second- generation crossbred cows from Swedish Red, Montéliearde, and Brown Swiss bulls. J Dairy Sci. 97(7):4530–4541.

Maurnay A, Pegolo S, Malchiodi F, Bittante G, Cecchinato A. 2018. Milk protein composition in purebred Holsteins and first/second-generation crossbred cows from Swedish Red, Montbeliarde and Brown Swiss bulls. Animal. 12(10):2214–2217.

Poulsen NA, Bertelsen HP, Jensen HB, Gustavsson F, Glantz M, Lindmark Månsson H, Andrén A, Paulsson M, Bendixen C, Buitenhuis AJ, et al. 2013. The occurrence of noncoagulating milk and the association of bovine milk coagulation properties with genetic variants of the caseins in 3 Scandinavian dairy breeds. J Dairy Sci. 96(8):4830–4842.

Saha S, Amalfitano N, Bittante G, Gallo L. 2020. Milk coagulation traits and cheese yields of purebred Holsteins and 4 generations of 3-breed rotational crossbred cows from Viking Red, Montbéliarde, and Holstein bulls. J Dairy Sci. 103(4):3349–3362.

Shonka-Martin BN, Hazel AR, Heins BJ, Hansen LB. 2019. Three-breed rotational crossbreds of Montbéliarde, Viking Red, and Holstein compared with Holstein cows for dry matter intake, body traits, and production. J Dairy Sci. 102(1):871–882.

Stocco G, Summer A, Malacarne M, Cecchinato A, Bittante G. 2019. Detailed macro- and micromineral profile of milk: effects of herd productivity, parity, and stage of lactation of cows of 6 dairy and dual-purpose breeds. J Dairy Sci. 102(11):9727–9739.

Summer A, Franceschi P, Malacarne M, Formaggioni P, Tosi F, Tedeschi G, Mariani P. 2009. Influence of somatic cell count on mineral content and salt equilibria of milk. Ital J Anim Sci. 8(sup2):435–437.

van Hulzen KJE, Sprong RC, van der Meer R, van Arendonk JA. 2009. Genetic and nongenetic variation in concentration of selenium, calcium, potassium, zinc, magnesium, and phosphorus in milk of Dutch Holstein-Friesian cows. J Dairy Sci. 92(11):5754–5759.

Zamberlin Š, Antunac N, Havranek J, Samaržija D. 2012. Mineral elements in milk and dairy products. Mljekarstvo. 62:111–125.