Milk composition and milk yield in mares

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Introduction

The mare’s milk is essential to the foal during its first time of life, and it is therefore important for us to know what characterizes it. In case a foal would lose its mother, it is crucial that the foal receives a milk replacer suitable for its needs.

The mares’ udder consists of two smaller caudal glands and two larger cranial glands, but sometimes six glands can occur. No milk can pass from one gland to another. The pairs of glands and udder half are separated by the medial suspensory ligament along the intermammary groove. Each quarter consists of one gland cistern and one teat cistern. Since the horse has two teats and four quarters, each teat has two orifices where two quarters exits (Davis Morel, 2008).

Mares’ milk is also an important foodstuff to the human population (Montanari et al., 1996) and it has also been considered if mares’ milk can replace cows’ milk in infants and children that has IgE-mediated milk allergy (Businco et al., 2000). The aim of this review is to investigate the milk yield and composition of mares’ milk and to describe causes for variation in milk yield and composition.

Literature review

Milk yield

Colostrum is produced the 1-3 first days post partum (Doreau et al., 1992) and after 2.5-3 months the peak in milk yield is reached and thereafter milk yield decreases (Bouwman & Van der Schee, 1978; Gibbs et al., 1982; Santos & Silvestre 2008). The average milk production for a lactating mare is 2-3.5 % of the horse’s bodyweight per day (Gibbs et al., 1982; Jansson et al., 2004; Santos & Silvestre, 2008), which means that a mare weighing 500kg produces 10-18kg milk in average per day. There are differences in milk production between individuals, where small horses in general produce more milk (3-3.5 %) per kg body weight (Jansson et al., 2004).

It has been shown that it is possible to affect the milk yield in mares through the mare’s diet (Gibbs et al., 1982; Doreau et al., 1992). A diet with a low hay:concentrate ratio results in a higher milk production than a diet with a high hay:concentrate ratio (Doreau et al., 1992). Also, the protein source in the diet does matter. When comparing soy bean meal and soy bean meal with urea as protein sources, the soybean meal alone results in a higher milk production than with addition of urea (Gibbs et al., 1982). Another factor that may affect the milk yield is the milking technique. Caroprese et al. (2007) compared milk yield from hand milked horses with machine milked horses, and showed a higher milk yield and a shorter milking time when the mares were machine milked than hand milked.

Dry Matter

The dry matter (DM) content is about 25 % in colostrum (Ullrey et al., 1966; Csapó et al., 1995). Salimei et al. (2002) measured a DM content of colostrum of 20.3 %, which differs a bit from the results by Ullrey et al. (1966) and Csapó et al. (1995). The lower DM content received by Salimei et al. (2002) may be due to the different breeds and different amounts of feed among the studies. However one of the four breeds used by Csapó et al. (1995) was also used by Salimei et al. (2002). Mature milk has a DM content of around 10-12 % which decreases throughout the lactation (Ullrey et al., 1966; Gibbs et al., 1982; Schryver et al., 1986b; Salimei et al., 2002).
The fat content in the milk of mares is relatively low with an average of around 1-1.5 % (Gibbs et al., 1982; NRC, 1989; Csapó et al., 1995; Malacarne et al., 2002). Lower and higher average values are also received (Bouwman & Van der Schee, 1978; Santos and Silvestre, 2008), where the lowest values are obtained from diets rich in concentrate. Low values can also be obtained due to incomplete milk removal because of a higher concentration of fat in the end of milking (Doreau & Boulot, 1989). The fat content also varies during the lactation period, with an overall decrease in fat content from colostrum to the end of lactation (Bouwman & Van der Schee, 1977; Gibbs et al., 1982; Doreau & Boulot, 1989; NRC, 1989). It has also been shown that machine milked mares’ gives milk more rich in fat compared to hand milked mares, which is probably because of a more complete emptying of the udder (Caroprese et al., 2007). Another factor that affects the fat content in mares’ milk is obesity of the mare at parturition, where a thin mare produces milk that contains less fat than an obese mare (Doureau & Boulot, 1989). A factor that only affects the fat content in the colostrum is the number of parturitions the mare has gone through. The more foals, the higher fat content in colostrum (Pikul et al., 2008).

It has already been mentioned that a diet rich in concentrate will lower the fat content in milk (Doreau & Boulot, 1989). A diet with oil and fiber will give a higher content of fat in milk than a diet rich in starch and sugar (Hoffman et al., 1998). However, it is shown that an addition of urea to a concentrate based on soybean meal as a source of protein did not affect the fat content in milk (Gibbs et al., 1982), indicating that the protein source does not affect the fat content in milk.

The mare’s milk fat contains a relatively high concentration of free fatty acids and phospholipids (Doreau & Boulot, 1989) and about 80 % is triacylglycerides (Malacarne et al., 2002). Milk fat from mares has a high amount of unsaturated fatty acids where approximately half of the fatty acids are unsaturated (Malacarne et al., 2002; Pikul et al., 2008; Pikul & Wójtowski, 2008). Also 20-25 % of the milk fat consists of less than 16 carbon atoms (Doreau & Boulot, 1989), and the content of linoleic and linolenic acids is high (Doreau & Boulot, 1989; Doreau et al., 1992; Malacarne et al., 2002). The high concentration of linoleic and linolenic acid is due to the lack of biohydrogenation of long chain fatty acids in the gut of horses, leading to a high influence of diet on the amount of long chain fatty acids in milk (Doreau & Boulot, 1989). The amount of these two acids can be changed through the diet, where a high hay:concentrate ratio results in a lower concentration of linoleic acid and a higher concentration of linolenic acid (Doreau et al., 1992).

The protein in mares’ milk decreases over the lactation period (Bouwman & Van der Schee, 1978; Oftedal et al., 1983) and the protein fraction of the milk is in average about 2 % (Gibbs et al., 1982; Doreau & Boulot, 1989; Csapó-Kiss et al., 1995; Santos & Silvestre, 2008). The highest decrease in protein occurs during the Colostral period (Ullrey et al., 1966; Bouwman & Van der Schee, 1978; Salimei et al., 2002), but a study by Cięśla et al. (2009) showed higher protein content after the Colostral period with no significant change during the Colostral period. Independent if protein is expressed as nitrogen or amino acids, the content decreases during the beginning of the lactation period (Doreau et al., 1992; Csapó-Kiss et al., 1995).

The protein in mares’ milk consists of non protein nitrogen (NPN), whey protein and casein. The fraction of NPN is about 10 % (Doreau & Boulot, 1989) and is 40 % higher in Colostrum.
than in mature milk (Csapó-Kiss et al., 1995). Up to 50 % of the NPN fraction consists of urea (Doreau & Boulot, 1989; Salimei et al., 2002). The fraction of whey protein is about 40 % of the total protein in mares’ milk (Csapó-Kiss et al., 1995; Malacarne et al., 2002), while the casein fraction is about 50 % (Doreau & Boulot, 1989; Csapó-Kiss et al., 1995; Malacarne et al., 2002). Pre-albumin is a protein included in whey proteins and is only present in the colostrum (Cieśla et al., 2009). Another whey protein are the immunoglobulins (Malacarne et al., 2002) which have a high concentration in the beginning of the colostral period but decreases both during the colostral period and during the whole lactation period (Csapó-Kiss et al., 1995; Cieśla et al., 2009). The α-globulins and albumins, which also are whey proteins (Davies Morel, 2008), increases from the colostral period to the mature milk (Cieśla et al., 2009).

It has been shown by Doreau et al. (1992) that a diet rich in concentrate results in lower content of nitrogen in milk even if the diet has a higher crude protein level than the control diet based on forage. However, another study made by Gibbs et al. (1982) resulted in no change of protein content in milk when urea was added to the concentrate diet based on soybean meal. Like the fat content, the protein content is also influenced by number of parturitions. If the mare has passed more than two parturitions, the protein content in milk is lower than after one or two parturitions (Gibbs et al., 1982).

**Carbohydrate**

The carbohydrates in mares’ milk consist mostly of lactose with only a very small amount of glucose and galactose (Doreau & Boulot, 1989). The average amount of lactose in milk is about 6 % (Malacarne et al., 2002; Santos & Silvestre, 2008). In the beginning of the lactation period there is a low amount of lactose in milk, about 3.4 % (Salimei et al., 2002), which increases during the lactation period (Ullrey et al., 1966; Doreau et al., 1992; Mariani et al., 2001; Salimei et al., 2002). In a study by Doreau et al. (1992) it was shown that lactose content in milk is higher when the horses are fed a diet rich in concentrate, than when fed a diet rich in forage.

**Ash**

Ash content is determined by reducing the organic material from a sample, which means that the mineral content is a part of the ash content (McDonald et al., 2002). The content of ash in mares’ milk is highest during early lactation and decreases towards the end (table 1), which thereby also is the case for several minerals (table 2). The different values obtained in the colostral period were taken in different times. Csapó-Kiss et al. (1995) measured a mean value between days 0-2 and Ullrey et al. (1966) took a milk sample immediately after parturition. Even when the same analyzing method were used, as in the studies of Ullrey et al. (1966) and Schryver et al. (1986a), there were differences in the results (table 1). These differences could be explained by the use of different breeds, housing systems or diets in several of the studies.
Table 1. Ash (%) content in mares’ colostrum and milk

<table>
<thead>
<tr>
<th>Breed</th>
<th>Ash %</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter and Arabian</td>
<td>0.72</td>
<td>Ullrey et al., 1966</td>
</tr>
<tr>
<td>Draft Breeds¹</td>
<td>0.59</td>
<td>Csapó-Kiss et al., 1995</td>
</tr>
<tr>
<td>Haflinger</td>
<td>N.S</td>
<td>Summer et al., 2004</td>
</tr>
<tr>
<td>Thoroughbred horses</td>
<td>0.58</td>
<td>Schryver et al., 1986b</td>
</tr>
<tr>
<td>Thoroughbred horses</td>
<td>0.58</td>
<td>Schryver et al., 1986a</td>
</tr>
<tr>
<td>Dutch warmblooded</td>
<td>N.S</td>
<td>Oftedal et al., 1983</td>
</tr>
<tr>
<td>saddlehorses</td>
<td>N.S</td>
<td>Bouwman &amp; Van der Schee, 1978</td>
</tr>
</tbody>
</table>


The mineral content in table 2 may vary depending on diet. Doreau et al. (1992) received milk containing more calcium and phosphorus from a diet rich in forage than on a diet rich in concentrate. The diets had no effects on concentrations of sodium, potassium and magnesium (Doreau et al., 1992). The variation in mineral content (table 2) may also be explained by the different times where the content was measured in the studies (Ullrey et al., 1974; Ullrey et al., 1966; Csapó-Kiss et al., 1995). There is also a variation when the different minerals reaches their peak, for calcium the peak is about a week after parturition and thereafter the concentration decreases. In comparison, phosphorus reaches its peak within a couple of days and then the concentration decreases (Bouwman & Van der Schee, 1978; Doreau et al., 1992). However, the contents of magnesium, potassium and sodium decrease directly after parturition (Ullrey et al., 1966).

Table 2. Mineral content in mares’ milk (μg/g) during colostrum and mature milk week 16

<table>
<thead>
<tr>
<th></th>
<th>Colostrum</th>
<th>Mature milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>748-847²</td>
<td>614-700²⁴</td>
</tr>
<tr>
<td>P</td>
<td>389-742²¹</td>
<td>216-540²⁴</td>
</tr>
<tr>
<td>Mg</td>
<td>140-473²</td>
<td>43²⁴</td>
</tr>
<tr>
<td>K</td>
<td>928-1143²</td>
<td>341-370³³</td>
</tr>
<tr>
<td>Na</td>
<td>320-524²</td>
<td>115-161²²</td>
</tr>
<tr>
<td>Zn</td>
<td>2.95-6.40³</td>
<td>1.80-2.40³</td>
</tr>
<tr>
<td>Fe</td>
<td>1.00-1.31¹</td>
<td>0.49³</td>
</tr>
<tr>
<td>Cu</td>
<td>0.61-0.99³</td>
<td>0.20-0.28³³</td>
</tr>
</tbody>
</table>


Vitamin

The content of vitamin A, alfa-tocopherol and beta-carotene was highest during parturition and the contents decreased within two days. The concentration of beta-carotene was 64.7 times higher in the colostrum than in mature milk and for vitamin A and vitamin E the contents were 2.8 and 5.7 times lower in mature milk than in colostrum (Schweigert & Gottwald, 1999). The content of vitamins in colostrum and mature milk is shown in table 3.
Table 3. Vitamin content (mg/kg) in mare’s milk

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Colostrum</th>
<th>8-45 days post partum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>0.88</td>
<td>0.34</td>
</tr>
<tr>
<td>Vitamin D₃</td>
<td>0.0054</td>
<td>0.0032</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>1.342</td>
<td>1.128</td>
</tr>
<tr>
<td>Vitamin K₃</td>
<td>0.043</td>
<td>0.029</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>23.8</td>
<td>17.2</td>
</tr>
</tbody>
</table>

Table 3 adapted from Csapó et al. (1995).

Conclusions

The milk yield in horses is in average 2-3.5 % of the horses’ body weight and the main components of milk are fat 1-1.5 %, protein 2 %, lactose 6 %, ash 0.37-0.49 % and different vitamins and minerals. There may also be some other trace minerals in mare’s milk not discussed in this work. The mature milk has an average DM of about 10-12 %. It seems to be possible to affect yield and composition of milk mainly through the diet. Other parameters that may affect the variation in the results between the different studies are number of animals, incomplete milking, milking intervals, handling of the suckling foal, sampling procedure and housing systems. Different breeds did not seem to cause any major differences in milk composition or yield. Almost no studies found, compares the milk composition and yield between different breeds. The vitamin content, mineral content and the carbohydrates in mares’ milk are not well studied, why there is a need of studying these elements in mares’ milk to be able to conclude their importance.
Literature


