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Nutritional status of the foals related to the age and to mares' feeding

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Summary

Two studies were carried out to investigate on the nutritional status of newborn foals also related to some mare milk characteristics. In the first study 5 foals born from Franch Montagnes x Bardigiana mares were muzzled and artificially reared in order to get more information on foals' nutritional status during the first weeks after birth. Mares' milk characteristics were also investigated. In a second study, the effects of fish oil supplementation, source of ω3-PUFA, to five mares' diet on some plasma metabolites and on growth rate of the foals were evaluated according to a switch back design.
Although the high variability between foals, remarkable changes in the blood chemistry and in some metabolic profiles were observed in artificially reared or suckling foals during the first weeks of extrauterine life.

keywords: mare, milk, foal, plasma metabolites

Nährstoffversorgungslage des Fohlens in Abhängigkeit von Alter und Ernährung der Stute

Es wurden zwei Untersuchungen durchgeführt, um den Ernährungszustand von Fohlen im Zusammenhang mit einigen Eigenschaften der Muttermilch zu bewerten. Während der ersten Untersuchung wurden fünf mit einem Maulkorb versehene Fohlen künstlich ernährt, um den Nahrungsbedarf des Fohlen von der Geburt bis zum Alter von einem Monat zu bestimmen.
Auch die Eigenschaften der Stutenmilch wurden untersucht.
Während der zweiten Studie wurden die Auswirkungen eines Fischölzusatzes (ω3-PUFA Quelle) in der Diät von fünf Stuten anhand von einigen Plasmametaboliten und der Wachstumsrate der Fohlen beurteilt (cross over design). Trotz der hohen Variabilität unter den Fohlen konnten bedeutende Unterschiede im Blutstatus und in einigen Metabolitenprofilen von künstlich ernährten oder säugenden Fohlen während der ersten Lebenswochen beurteilt werden.

Schlüsselwörter: Stute, Milch, Fohlen, Plasmametaboliten

Introduction

In order to estimate nutrient requirement of suckling foal is essential the knowledge of the nutritional status of the foal and of the milk yield and composition of the mare. However data on plasma parameters of the foal during the first weeks after birth are limited and usually extrapolated from those of the adult horse although growth rate during weaning is extremely high and the physiological status of the young animal undergoes changes continuously. Yet reports on milk production and characteristics show limited and contradictory results so that it may be suspected that mare milk could not meet the requirement of the developing foal.
Aim of this paper was to investigate on the baseline nutritional status of the foals also by studying some milk characteristics especially related to the foal during the first weeks after birth.
Mare's milk is generally characterised by a high content of lactose and a low content of fat, that shows an interesting fatty acid composition with high proportion of polyunsaturated fatty acids.

In most mammals ω3-polyunsaturated fatty acids (ω3-PUFA) play a central role in the maintenance of epidermal integrity as major components of structural lipids of membrane cells and in many physiologic and pathologic processes as regulators of cell function (*Sardesai* 1992). Therefore they are considered to be essential for growth, immune response and reproduction.
Considering that mare nutrition may influence the fatty acids composition of the milk (*Doreau* 1991), aim of the second study was to evaluate the effects of cod liver oil (source of ω3-PUFA) supplementation in the mare diet on some plasma metabolites of the foal also related to some milk characteristics

Material and methods

Study 1

Eight multiparous French Montagnes x Bardigiana mares, aged 5 to 18 years, never milked before and only winter

Tab. 1: Chemical analysis and list of ingredients of milk replacer used in study 1 (% as fed)

Chemische Zusammensetzung und Komponenten des Milchaustauschers in Versuch 1

Nutrients	%
Dry matter	95.0
Crude protein	22.0
Extract ether	13.0
Crude fiber	0.1
Ash	7.0
Ca	1.0
P	0.65
Na	0.5

List of ingredients: Milk skimmed dehydrated (spray), dextrose, fats and oils, milk whey protein dehydrated, alfalfa meal dehydrated, milk whey, wheat, lysine (16 g/kg), vitamins and minerals premix.

stabled, were individually penned since 1 month before foaling. As soon as foals were born, they were muzzled, artificially reared as directed (Item n. 1811®, Salvana Int. GmbH, Elmshorn, Germany). Milk replacer chemical analysis is reported in table 1. Foals were maintained with their dams throughout the study and immunglobulins were injected i.v. on a regular basis.

Blood samples from foals were collected in heparinised vacutainers by jugular venipuncture at 10:00 on d 0, 7, 15, 21, 30, 45 and 60 relative to foaling. Blood samples were centrifuged after collection, and plasma samples were stored at -20°C until the analysis. Plasma levels of glucose, total protein, cholesterol (Boehringer Mannhein GmbH, Germany) and NEFA (Poli Industria Chimica, Italy) were determined by commercial kits.

During the lactation, mares were daily fed 15 kg fresh herbage, 10 kg meadow hay and 4.5 kg concentrate (CP= 16.7 % DM, Elite Horses by Mangimi Frassi, Cremona, Italy) twice a day (08:00 and 18:00). Mares were hand milked every two hours (12 milkings/d): milk yield was daily recorded and sampled twice a week in order to evaluate dry matter, protein, lipid and lactose milk content, according to official methods (FIL-IDF). Milk samples obtained from 4 mares were collected twice a week from week 6 to 14 of lactation and were also analysed for fatty acid composition by gas-chromatography (*Gargano* and *Toppino* 1981). After sampling, residues of milk were offered to the foals.

Study 2

The experiment was carried out on 4 Haflinger mares and their foals during the first 120 d of lactation. Experimental model was a crossover design: two mares were daily fed 13 kg meadow hay and 3 kg concentrate

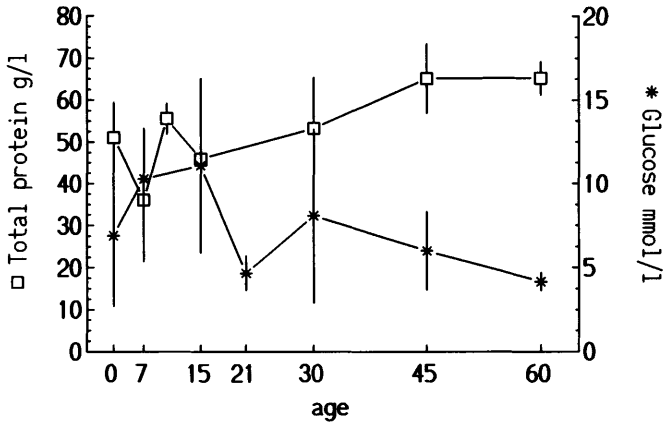

Fig. 1: Course of total protein (g/l) and glucose (mmol/l) in the plasma of foals during the experimental period (study 1).

Verlauf des Gehaltes an Gesamtprotein (g/l) und Glucose (mmol/l) im Plasma der Fohlen während Versuch 1

Fig. 2: Course of total cholesterol (mmol/l) and NEFA (mmol/l) during the experimental period (study 1).

Verlauf des Gehaltes an Gesamtcholesterol (mmol/l) und freien Fettsäuren (mmol/l) im Plasma der Fohlen während Versuch 1

(16 % CP, Cavalli, C.A.P. Novara, Italy – Control diet). The other two mares were fed the same diet supplemented with 150 g cod liver oil (Fish oil diet) so that the energy content of the diets were 125.6 MJ DE/d and 131.2 MJ DE/d for control and fish oil diets respectively. Each experimental period lasted 8 weeks: weeks 1 to 4 were used to adapt the animals to the treatment. Mares were hand milked at 10h00, 14h00 and 18h00 twice a week and foals were muzzled two hours before milking.

On the same time of milk collection blood samples from foals were withdrawn and analysed for glucose, cholesterol and total protein concentration. Body weight and linear body measurements (*Frape* 1986) were recorded at the same time.

Milk samples were collected and analysed for fat content and fatty acid composition by using the procedures described in study 1. Reported results are expressed as means ± standard deviation.

Results and discussion

Study 1

Blood parameters trends are shown in figure 1 and 2. Plasma glucose concentration of the foals (fig. 1) generally increased up to 11.1 ± 5.2 mM (x ± s.d.) during the first two weeks after birth and subsequently decreased to a plateau value (6.00 mM). These results are in agreement with those observed by other authors (*Glade* 1991; *Smyth* et al. 1993). During the experimental phase, total protein levels (fig. 1) remained relatively constant ranging around 60 g/l according to other authors (*Kitchen* and *Rossdale* 1975; *Ubaldi* et al. 1982), except for the first week when the total protein level decreased in plasma to 36.1 g/l, probably due to the metabolic adaptation to the artificial milk. Total plasma protein of the foals remained lower than those observed in mares during the same experiment (*Dell'Orto* et al. 1994): this difference could be explained by the fact that foals are not able to synthesise high levels of serum protein before 6 weeks of age (*Morgan* 1973) and that high levels of albumins are needed for the growth (*Greppi* and *Serrantoni* 1993). Plasma cholesterol concentration (fig. 2) decreased from 0 d (4.02 ± 1.18 mM) to 21 d (2.72 ± 0.91 mM). These values are relatively constant up to 60 d of age. NEFA values (fig. 2) showed a wide variability among subjects, especially in newborns. A negative relationship between plasma cholesterol and plasma NEFA was also observed (r= –0.98; P= 0.024).

Tab. 2: Individual mean values of fatty acids composition of milk fat (g/100g) observed at maximum and minimum level and their coefficients of variation (%) (study 1)

Mittelwerte und Variationskoeffizienten (%) für die Fettsäurenzusammensetzung des Milchfettes (g/100g) für die höchsten und niedrigsten Werte (Versuch 1)

	Max		Min	
- < C16	34.8	(4.1 %)	27.4	(8.4 %)
- C 16: 0 ÷ C 18: 0	26.8	(6.8 %)	24.6	(2.9 %)
- C 16: 1 ÷ C 18: 1	30.2	(13.0 %)	25.5	(8.1 %)
- C 18: 2	7.8	(18.5 %)	5.6	(25.4 %)
- C 18: 3	10.2	(21.3 %)	5.5	(26.6 %)

Milk yield showed high variability and on 4th week of lactation it ranged between 3 and 5 kg/d. Observed yield values are lower than those reported by others (*Doreau* 1991; *Oftedal* et al. 1983) probably due to different methodological approaches; in the present study, mares were not injected exogenous oxytocin in order to avoid any effect on milk composition.

Milk fat content varied between 0.6 % and 2.4 %, while higher values were found on protein content (min. 1.9 %, max. 3.4 %). A higher stability was found for total solids and lactose in milk.

Tab. 3: Glucose, Cholesterol and Total Protein plasma concentration of the foals (x ± s.d.) (study 2)

Glucose, Cholesterol und Gesamtprotein bei den Fohlen (x ± s) (Versuch 2)

	Fish oil	Control
Glucose, mmol/l	6.39 ± 0.20	6.32 ± 0.26
Cholesterol, mmol/l	3.22 ± 0.04	3.18 ± 0.05
Total protein, g/l	69.46 ± 0.52	69.21 ± 0.67

Tab. 4: Effect of fish oil administration on fat and its fatty acid composition of mare' milk (study 2)

Wirkung einer Fischölzulage auf Gesamtfett und Fettsäurenzusammensetzung der Stutenmilch (Versuch 2)

	Fish oil	Control	P (for difference)
Fat (%)	0.72 ± 0.04	0.90 ± 0.04	0.006
Fatty acid composition (g/100g)			
- C 4	0.20 ± 0.03	0.19 ± 0.03	ns
- C 6	0.32 ± 0.027	0.21 ± 0.031	0.018
- C 8	2.71 ± 0.085	2.36 ± 0.096	0.02
- C 10	6.93 ± 0.16	5.65 ± 0.19	0.0001
- C 12	7.67 ± 0.20	6.79 ± 0.23	0.014
- C 14	8.65 ± 0.17	7.55 ± 0.19	0.0003
- C 16	21.27 ± 0.46	21.55 ± 0.53	ns
- C 16: 1	6.80 ± 0.14	7.21 ± 0.16	ns
- C 18	1.81 ± 0.06	1.66 ± 0.07	ns
- C 18: 1 ω 9	20.02 ± 0.41	21.14 ± 0.46	ns
- C 18: 2 ω 6	10.67 ± 0.19	11.32 ± 0.22	0.049
- C 18: 3 ω 3	8.33 ± 0.25	9.79 ± 0.28	0.0011
- others	4.02 ± 0.19	4.03 ± 0.04	ns

Legend: ns= not significant

Mean values and coefficient of variation of fatty acid composition, observed at maximum and minimum level during the experimental phase are summarised in table 2. According to *Doreau* and *Boulot* (1989) mare milk shows a relatively higher content of fatty acids with less than 16 carbons (min 27.4 %, max. 35 %) and a high content in linolenic acid (min 5.5 %, max. 10.2 %) and linoleic acid (min. 5.6 %, max. 7.8 %), but the amount of unsaturated long chain fatty acids in milk seem to be related to the amount consumed.

Study 2

Glucose, cholesterol and total protein plasma mean concentration of the foals were not significantly affected by the dietary treatment of the dams, as reported in table 3. Plasma glucose levels confirm the values reported in stu-

dy 1, after the first week of age. Plasma cholesterol pattern was as well in the range of values as observed in the previous study. Compared to others' results, these levels are similar to those reported for adult horses (*Greppi* and *Serrantoni* 1993). Observed plasma levels of total protein confirm what previously hypothesised about their increase throughout the growth of the foal.
Mares' dietary treatment did not affect foals' body weight and linear body measurements: because of the experimental design, growth rates of the foals were influenced by the treatment during both period 1 or 2.
It is interesting to notice that fish oil supplementation of mares' diet significantly affected fat content of the milk, as table 4 shows; fatty acids composition was also affected by the treatment. Short and medium chain fatty acids (C<16) concentration increased while linolenic acid concentration decreased. Although these results seem to be in contrast with other data, as already reported in study 1, they are confirmed by the results of a subsequent trial, where higher levels of fish oil administration to the mares (450 g/d/mare) caused a similar response in fatty acids composition. However the adoption of a more sensitive method of analysis showed the increasing effect of fish oil only on PUFA, i.e. on fatty acids with carbon chains longer than 18 (*Salimei* et al. 1995).

Conclusions

Although the high variability among subjects, remarkable changes in the blood chemistry and in some metabolic profiles were observed in artificially reared or suckling foals during the first weeks of extrauterine life. However, after the first weeks of life investigated blood constituents tended to be more stable and more comparable to the adults, suggesting a development of the nutritional status of the foal. Fish oil administration modified the fat content and the fatty acids composition of the milk, but it did not affect plasma levels glucose, cholesterol and total protein of the foals.

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