

## VITAMIN A AND CAROTENE METABOLISM IN COWS AND THEIR CALVES FED FROM BUCKETS

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### Abstract

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The vitamin A and carotene metabolism has been studied in 40 cows and their calves up to the age of three months under conditions of intensive production during winter season. The vitamin A level in blood plasma of pre-partum cows was found to be lower than that of post-partum cows. The vitamin A concentration in the first colostrum was 10 times higher than the concentration found in cow blood plasma. The carotene level in colostrum was lower than that in blood plasma of cows.

Before the first colostrum intake the average vitamin A concentration in blood plasma of calves was very low and did not exceed 10 µg/100 ml. After the colostrum ingestion the plasma vitamin A level raised, the hypovitaminosis A was, however, found in 75 % of followed calves and in high number of calves continued up to the age of 3 weeks. In the following period the occurrence of hypovitaminosis in calves was reduced which was brought about by the addition of vitamin in milk substitute. The significant rise in plasma vitamin A levels occurred during the first weeks of calf life after vitamin A had been supplemented into the first colostrum. The carotene levels in blood plasma of calves up to the age of 8 weeks were very low and their increase appeared after the hay ingestion.

Under conditions of large-scale animal production the animals are concentrated in a small area and therefore the hypovitaminoses are accompanied by a potential danger of a disease affecting first of all the alimentary and respiratory tracts. It follows from our results that the addition of vitamin A to calves in first days of their lives, especially in winter season, is of a great importance.

*Cow, calf, blood plasma, colostrum, vitamin A, carotene, metabolism.*

Under normal conditions cattle do not ingest natural vitamin A but produce it from provitamins contained mostly in green food. Beta-carotene, converted mostly in the mucosa of small intestine to vitamin A, appears to be the most efficient provitamin. Calves are born with low levels and stores of vitamin A and carotene which indicates that the permeability of syndesmo-chorial placenta for these substances is considerably limited (Dann 1932).

Colostrum appears to be the only source of vitamin A and carotene in early postnatal period of calf life (Moore 1957; Steinbach, Meyer 1967; Steinbach et al. 1970; Branstetter et al. 1973; Tomlinson et al. 1976). The concentration of vitamin A and carotene in colostrum is influenced by the diet, season, breed and by individual differences. Steinbach and Meyer (1967) found in the first colostrum in winter season 1170 international units of vitamin A/100 ml, in summer season 1890 I. U./100 ml. Similar values were reported by Branstetter et al. (1973),

although Sutton et al. (1947) obtained lower vitamin A concentrations. A significant rise in vitamin A level in colostrum appeared after several weeks of administration of 70 000 I. U. of vitamin A (per day and cow) (Steinbach et al. 1970).

During the last weeks of pregnancy a decrease in vitamin A levels in blood plasma is very pronounced, this being probably due to the utilization of vitamin by dam organism in order to ensure an abundant intake of this substance of vital importance to a calf.

Vitamin A is necessary for animals to provide for normal growth, reproduction, normal function of epithelia, mucosae and for good health condition. Hypovitaminosis A may manifest itself by impaired growth, hyperkeratotic changes on skin and mucosae, by conjunctivitis, xerophthalmia, night blindness, diarrhea, by disturbances in bone growth and by function disorders of sexual organs, abortions, lower vitality and resistance of young animals towards respiratory and other infections (Moore 1957; Dvořák 1959; 1960; Příbyl 1963; Spratling et al. 1965; Mitchel 1967; Rosenberger 1970; Mingazov 1974; Jagoš et al. 1975). The increased susceptibility to diseases of alimentary and respiratory tract at hypovitaminosis follows from epithelization disorders and undoubtedly also from a limited activity of specific and non-specific defense mechanisms.

The determination of hypovitaminosis A on the basis of clinical signs is very complicated and for this reason the measurement of vitamin A, and possibly carotene concentrations in blood plasma, liver, colostrum and milk is well justified. Under normal conditions the vitamin A levels in blood plasma average about 30  $\mu\text{g}/100\text{ ml}$  in most animal species. Generally, plasma vitamin A concentrations below 10  $\mu\text{g}/100\text{ ml}$  are regarded as being very low, 10–19  $\mu\text{g}/100\text{ ml}$  as low and the range of 20–50  $\mu\text{g}/100\text{ ml}$  as reasonable (Sebrell, Harris 1967). In normal calves after colostrum nutrition the vitamin A concentration in liver is 10–50  $\mu\text{g}/\text{g}$  of tissue, in blood plasma over 25  $\mu\text{g}/100\text{ ml}$  (Rosenberger 1970). According to Repp and Watkins (1958) the vitamin A concentration does not drop below 25  $\mu\text{g}/100\text{ ml}$  in blood plasma, assuming that its reserve is sufficiently high.

Our worker Dvořák (1959) has studied vitamin A levels in calves in relation to maternal organism. In calves with restricted colostrum intake during first 15 days the vitamin A concentration in plasma decreased below 40 I. U./100 ml and at the same time 75 % of calves was taken ill. Decreased vitamin A levels in blood plasma were found in all calves suffering from bronchopneumonia and in more than 50 % of calves with dyspepsia (Dvořák 1960). In the case of beef cattle the weight gains were proved to be on a good level as long as the vitamin A concentration in blood plasma did not drop below 25  $\mu\text{g}/100\text{ ml}$  (Kohlmeier and Burroughs 1970). The vitamin A concentration decreasing under 15  $\mu\text{g}/100\text{ ml}$  in calf blood plasma, the lowered feed intake was observed (Abrams et al. 1969).

### Materials and Methods

The study was carried out in winter season (January–April 1977) on 40 late-pregnant cows and their 42 calves of Czech Spotted breed in large-capacity cow-house accommodating 600 heads. The clinical examination and blood sampling was carried out 2–5 weeks before the expected delivery and 2–4 weeks post partum on cows and from birth up to the age of 3 months on their calves. Apart from this, urine and average colostrum samples of the first milking were collected from cows. The nutrition (laboratory analysis of feed ration), zoohygienic conditions, the system of bucket feeding of calves, the level of care were followed. In the case of calves with diarrhoea the bacteriological examination of smears was carried out at the Research Institute of Veterinary Medicine in Brno.

Immediately after birth and navel stump treatment the calves were moved into individual cages and at the age of 14–18 days transferred to another calf-house, where they were placed also in cages till one month of age. Starting from the first colostrum ration the calves were fed from buckets twice a day. Daily colostrum ration was 4–5 litres and from the sixth day the calves were changed to a milk substitute Laktosan A. On the 8th day calves were given 6–7 litres of Laktosan per head and day. The addition of a mixture TK-1 (concentrate) started from the 11th day and that of meadow hay from three weeks.

By clinical examination of late pregnant cows no significant changes were found whereas in most calves short-term diarrhoea at the age of 3–7 days was observed. In diarrhoea course no rise in body temperature was noted and in no case pathogenic serotype *E. coli* was found in bacteriological smears.

To diarrhoeic calves rehydrating solution in the amount of 6–8 liters was administered orally during 25 hours, exceptionally during 48 hours.

The average calf body mass before the colostrum intake was 42.2 kg and ranged from 36 to 56 kg. Twins were not included in this range since their lowest mass reached 27 kg per one. The average daily gain up to three months of age was 0.52 kg/head.

A half of newborn calves was given vitamin preparation Combinal A + D<sub>2</sub> supplemented to the first colostrum ration.

Calf blood samples were collected from v. jugularis prior to colostrum ingestion (1–4 hours) and than after the colostrum ingestion after 1, 3, 7, 14, 21, 42, 56 and 84 days.

The vitamin A content in cattle blood plasma was determined on spectral Perkin-Elmer 204 fluorometer according to Thompson et al. (1971, 1973) using Van Stewenick, De Goeija (1973) information modified by Bouda and Jagoš (1979). The vitamin A content in colostrum was also determined spectrofluorometrically according to Senyk et al. (1975). The carotene level in blood plasma and colostrum was determined photometrically according to Knobloch (1956).

Obtained results were evaluated on a Hewlet-Packard computer, 9810 A Model. To test the difference significance of two selective means the Student's *t*-test was used. The method of simple split analysis and Duncan's test were used to evaluate the difference between the separate samplings.

## Results

The vitamin and carotene levels in blood plasma of 40 cows and their colostrum are given in Table 1. In pre-partum cows the vitamin A content was found to be significantly lower ( $P < 0,01$ ) than in post partum cows. On the other hand, carotene was lowered in post partum cows. The colostrum from the first milking contained in average 10times higher amount of vitamin A in comparison with cow plasma.

The dynamics of mean plasma concentrations of vitamin A in calves in depen-

Table 1  
The vitamin A and carotene mean concentrations in blood plasma in prepartum and postpartum cows and in their colostrum

Material	Followed index	Prepartum cows	Postpartum cows	P
Blood plasma	vit. A ( $\mu\text{g}/100 \text{ ml}$ )	43.4 $\pm$ 5.7	48.2 $\pm$ 8.0	++
	carot. ( $\mu\text{g}/100 \text{ ml}$ )	371.0 $\pm$ 78.0	278.0 $\pm$ 77.0	++
Colostrum	vit. A ( $\mu\text{g}/100 \text{ ml}$ )		440.0 $\pm$ 334.0	
	carot. ( $\mu\text{g}/100 \text{ ml}$ )		124.8 $\pm$ 73.0	

$P < 0.01 = ++$

Table 2  
The mean levels of vitamin A ( $\mu\text{g}/100 \text{ ml}$ ) in blood plasma of 40 cows and their 42 calves

Animal	Age (days)	Combinal A + D <sub>2</sub> added		Combinal A + D <sub>2</sub> not added		P	
		$\bar{x}$	s	$\bar{x}$	s		
Calves (T)	Before colostrum intake	9.2	2.5	8.0	2.7	—	
	T	29.4	10.8	15.5	4.2	++	
	T	23.3	6.2	17.4	5.4	++	
	T	5–7	21.1	5.1	16.6	5.3	++
	T	14	19.3	2.8	15.9	3.9	++
	T	21	19.4	3.2	19.3	3.7	—
	T	42	25.1	3.7	23.7	3.3	—
	T	56	28.7	8.7	26.1	9.9	—
	T	84	30.8	7.1	31.4	7.1	—
	Cows	Prepartum	—	—	43.3	5.7	—

$P < 0.01 = ++$

$P > 0.05 = -$

dence on age is given in Table 2. It is evident from the tables that the lowest values under  $10 \mu\text{g}/100 \text{ ml}$  were found in calves before the colostrum intake but after the colostrum ingestion a significant rise was observed.

A marked increase in plasma vitamin A content in calves occurred after the addition of 15 ml of Combinal A + D<sub>2</sub> into the first colostrum ration. Vitamin A concentrations doubled after 24 hrs when compared with a control group. Statistically significant differences outlasted 14 days after the addition of Combinal A + D<sub>2</sub>. The vitamin A levels decreased under  $20 \mu\text{g}/100 \text{ ml}$  in 75 % of calves aged 3 days and in 85 % of calves aged 7 days. After the 20th day of age the vitamin A increase was observed in both groups caused by vitamin A content in Laktosan. The carotene concentration in calf plasma increased markedly by the age of 8 weeks, i. e. when calves received hay in greater extent.

### Discussion

The study of vitamin A and carotene metabolism represents only a partial component of experiments, the main objective being to elucidate the complexity of relations between a mother and her progeny in conditions of large scale production technology. The main task of this work was to study the vitamin A and carotene levels in blood plasma and colostrum of calves and their mothers and to utilize the obtained results in diagnostics and prophylaxis of most frequent calf diseases. So far no importance has been ascribed to metabolic disorders even though it is known that the factors, influencing metabolism, could often be important in etiology and pathogenesis of infectious diseases. From the aforementioned it follows that the work concerns even the problems of infectious diseases since the impaired metabolism could be a predisposing factor favourizing the growth of conditionally pathogenic germs, predominantly in gastrointestinal and respiratory tract.

The diagnostics of metabolic disorders in young animals in early postnatal period is rendered difficult due to a series of functional and morphologic changes that are, moreover, complicated in calves by a gradual development of forestomachs. The young animal's metabolism is influenced not only in the postnatal period; the manifestation of vital functions in first days of life is predisposed by mother metabolism from the prenatal period. From this reason our attention was firstly focused to the cow metabolism and to a system of preventive diagnostics, the part of which is formed by the so-called metabolic test.

Recently, several attempts have been made to apply the metabolic test to calves, too. Our observation shows that the metabolic test cannot be used for calves in the same extent as in cows. The choice of clinico-biochemical data for the diagnostics of metabolic disorders has to be carefully considered. It is necessary to take into account the development of immunobiological processes, the homeostasis lability and the change dynamics in dependence of age.

When evaluating nutrition of late-pregnant cows a slight excess of digestible nitrogen matter and shortage of starch units was found in cow Jud ration. Zoo-hygienic conditions and prophylactorium capacity were found to be insufficient. Often and delayed colostrum feeding was one of the main defects, having quite a considerable effect on calf diarrhoea.

The vitamin A concentrations in blood plasma were found to be on a fair level although the carotene concentrations in plasma were lower which can be attributed to the parenteral application of vitamin A to cows six weeks prepartum.

Significantly lower values of vitamin A observed in prepartum cows, in comparison with postpartum cows, have been in accordance with literature data (Thompson and Mc Gillivray 1957; Gažo, Landau 1959; Samochin et al. 1975; Dvořák et al. 1978). The vitamin A decreases in plasma of prepartum cows are, according to Thompson (1975) probably caused by a vitamin A transfer to colostrum and not by hormonal changes as generally stated.

If we compare the vitamin A concentration in colostrum and blood plasma the significance of colostrum for the calf is more evident. The vitamin A concentrations in colostrum, as found by us, are in accordance with the results of Steinbach and Meyer (1967). Different results were observed in carotene levels which were found to be three times higher in cow blood plasma than in colostrum; however, according to literature data carotene is not transferred to vitamin A in the calf intestinal mucosa during the first weeks of their lives.

It follows from the observation of the vitamin A concentration in blood plasma of adult cattle and calves that calves are born with a very low level of vitamin A which is a result of a restricted transplacental transport from dam to foetus. The observed low concentration of vitamin A (about 10  $\mu\text{g}/100\text{ ml}$ ) in calf blood plasma before the colostrum intake is in agreement not only with our findings as far as calf foetuses are concerned (Jagoš et al. 1979) but also with data of other authors (Dvořák 1959). After 24 hours after the first colostrum ingestion a significant rise of vitamin A in calf plasma appeared, the vitamin A levels in control calves (without the vitamin A — Combinal A + D<sub>2</sub> addition) do not, however, reach normal values even after finished colostrum nutrition.

It is evident from the results that in 75 % of calves the plasma levels of vitamin A were reduced both at the age of 3 days and later. Only after the 20th day of age an increase in mean vitamin A levels appeared. This was ensured by vitamin A content in Laktosan. It cannot, however, be unequivocally stated that when administering Laktosan the hypovitaminoses in calves were not observed as found by Surynek et al. (1976). When determining the vitamin A content in milk substitute Laktosan the significant decrease, in comparison with a standard, of vitamin A was observed. In our experiment the reduced vitamin A values were found in 20 % of calves aged 8 weeks. It seems likely that the used method (Surynek et al. 1976) is not specific for vitamin A determination in plasma. This could explain the observed differences. Different amounts of vitamin A used in milk substitutes cannot also be excluded.

A marked rise in plasma vitamin A content in the first 14 days of calf life appeared when vitamins (15 ml of Combinal A + D<sub>2</sub>) were added to the first colostrum ration. It follows from our observation that colostrum is the only source of vitamin A in early postnatal period of calves and furthermore, it was demonstrated by us that in winter season even colostrum alone is not sufficient to provide vitamin A levels and that it is necessary to supply vitamin A in the first days of calf lives, the first colostrum ration being most suitable. Our observation is further supported by findings of Steinbach and Meyer (1967) who found the vitamin A content in colostrum being lower by 42 % in winter than in summer.

Under conditions of large-scale rearing technology when animals are concentrated in small areas a potential danger of stress factors and diseases appears to affect first of all the alimentary and respiratory tract and to increase substantially organism demands on vitamins. A newly born calf has very low vitamin A stores and therefore its deficit or impaired availability result in an increased susceptibility to diseases not only as a consequence of epithelizing disturbances in pylorus,

intestine and in respiratory tract but according to Elze et al. (1973) also lead to activity limitation of specific and nonspecific defense mechanisms.

The determination of hypovitaminosis on the basis of clinical signs is not easy. We suppose that the vitamin A level in blood plasma and its content in liver is a good indicator when determining hypovitaminosis A in calves. In the case of adult animals the vitamin A determination in liver is not always sufficient (Thompson 1975) and complementary examination of blood plasma, and possibly of milk, is advisable. When vitamin A is not supplemented to animals the carotene determination in plasma is valuable.

### **Metabolismus vitamínu A a karotenů u krav a jejich telat, napájených z nádob**

Metabolismus vitamínu A a karotenu byl studován v zimním období u 40 krav a jejich telat do stáří 3 měsíců v podmínkách velkovýrobních technologií. U krav před porodem byla hladina vitamínu A v krevní plazmě nižší než po porodu. Koncentrace vitamínu A v prvním kolostru byla  $10 \times$  vyšší než v krevní plazmě krav. Hladina karotenů byla v kolostru nižší než v krevní plazmě krav.

Před příjmem kolostra byla průměrná hladina vitamínu A v krevní plazmě telat velmi nízká a nepřesahovala  $10 \mu\text{g}/100 \text{ ml}$ . Po příjmu kolostra došlo ke zvýšení plazmatických hladin vitamínu A, přesto však hypovitaminóza A byla zjištěna u 75 % sledovaných telat a přetrvávala u vysokého počtu telat do stáří 3 týdnů. V dalším období došlo ke snížení výskytu hypovitaminózy u telat, což bylo způsobeno přidáním vitamínem v mléčné náhražce. K významnému zvýšení plazmatických hladin vitamínu A došlo v prvních týdnech života telat po přidání vitamínu A do prvního podaného kolostra. Hladiny karotenů v krevní plazmě telat do stáří 8 týdnů byly velmi nízké a k jejich zvýšení došlo po příjmu sena.

V podmínkách velkovýrobních technologií jsou zvířata koncentrována na malém prostoru, a proto i při hypovitaminózách vzniká potenciální nebezpečí onemocnění, postihujících především trávicí a respirační ústrojí. Z našich výsledků vyplývá evidentní význam přidávání vitamínu A telatům v prvních dnech jejich života, zejména v zimním období.

### **Метаболизм витамина А и каротинов коров и их телят, поенных из сосудов**

Метаболизм витамина А и каротина в зимний период изучался в кровяной плазме и молозиве 40 коров и в кровяной плазме их телят в возрасте до 3 месяцев в условиях промышленных технологий. У коров перед отелом уровень витамина А был ниже периода после отела. Концентрация витамина А в первом молозиве была 10 раз ниже кровяной плазмы коров. Уровень каротинов в молозиве был ниже кровяной плазмы коров.

До приема молозива средний уровень витамина А в кровяной плазме телят был очень низким — ниже  $\text{мкг}/100 \text{ мл}$ . После приема молозива наблюдалось повышение уровня витамина А, однако гиповитаминоз А был выявлен в случае 75 % исследуемых телят и имел место в большом количестве телят в возрасте до 3 недель. В последующий период произошло понижение наличия гиповитаминоза у телят, причина которого заключалась в добавлении витамина в молочном заменителе. Существенное повышение плазматического уровня витамина А произошло в первые недели жизни телят после добавления витамина А в первое подаваемое молозиво. Уровня каротинов в кровя-

ной плазме телят в возрасте 8 недель были весьма низкими. Их повышение произошло после приема сена.

В условиях производственных технологий животные находятся на небольшом пространстве и в особенности при наличии гиповитаминоза существует возможная опасность заболевания, в первую очередь, пищеварительного и дыхательного трактов. Из полученных нами результатов вытекает существенное значение добавки витамина А телятам в первые дни их жизни, в особенности и в зимний период.

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