Effect of Parenteral Administration of Vitamin A in Dairy Cattle During Dry Period, on Vitamin A Status of Neonatal Calves

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Abstract

The present study has been conducted to evaluate the effect of intramuscular administration of vitamin A during dry period in pregnant dairy cows which have already received it in their daily ration on vitamin A status of neonatal calves. Single intramuscular injection of 2000000 IU vitamin A was carried in 10 dairy cows at 7 months of pregnancy (group 1) and in another 10 dairy cows at 8 months of pregnancy (group 2). Ten pregnant dairy cows received saline injection as placebo and were selected as the control group. Blood samples were collected from dairy cows at 7 and 8 months of pregnancy as well as their newborn calves' pre and after colostrum intake. Vitamin A concentration of calves of two treatment groups before and after receiving of colostrum were significantly higher than that in control group (P< 0.05). Daily supplementation of vitamin A in late pregnancy in dairy cows may not compensate for the calves need for vitamin A and single injection of this vitamin A during dry period either in 7 or 8 month of pregnancy can significantly increase level of vitamin A in their neonatal calves.

Keywords: Vitamin A, Dairy cow, Far off, Close up, Calf

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Introduction

Vitamin A is the general term for a variety of substances including retinol, retinal, retinoic acid, retinyl esters as well as provitamin A carotenoids such as β-carotene. Retinol and its derivatives are only found in animal tissues whereas β-carotene is principally found in plants (Olson, 1984; Blomhoff, 1994). Vitamin A is a fat soluble nutrient which is involved in numerous essential life processes. It has an important role in vision, reproduction, immunity, cell differentiation and growth and development (Basu and Dickerson, 1996; Napoli, 1999; Noziere *et al*. 2006).

More specifically, it is of utmost importance to allow successful gestation and proper offspring development (Clagett-Dame and DeLuca, 2002).Vitamin A is also essential for the development and good functioning of the immune system (Semba, 1998). Among ruminants, only bovines accumulate high concentrations of carotenoids, mainly β-carotene, possibly due to lower Vitamin A synthesis efficiencies in enterocytes (Noziere *et al*. 2006). Vitamin A deficiency may induce fetal resorption, stillbirth and malformation (Bates, 1983; Basu and Dickerson, 1996; Clagett-Dame and DeLuca, 2002). Cattle do not ingest vitamin A naturally but produce it from provitamins available mostly in green food. β - carotene, converted mostly in the mucosa of small intestine to vitamin A, appears to be the most efficient provitamin (Bouda *et al*. 1980).

Primary vitamin A deficiency is of major economic importance in groups of young animals on pasture or fed diets deficient in the vitamin or its precursor. It especially occurs in beef cattle and sheep on dry range pasture during periods of drought. Secondary vitamin A deficiency may occur in case of chronic diseases of liver or intestine, presence of highly chlorinated naphthalene in diet, low phosphate diets, high environmental temperature, increased amount of nitrate in the feed, and continued ingestion of mineral oil (Radostits *et al*. 2007).

A maternal deficiency of vitamin A can result in herd outbreaks of congenital hypovitaminosis- A in calves (van der Lugt *et al*. 1989; Mason *et al*. 2003). In one such occurrence, out of 240 heifers fed a vitamin- A deficient ration, 89 calves were born dead, 47 were born alive but blind and weak that died within 1- 3 days after birth (Mason *et al*. 2003). Calf health depends on any factors related to management and nutrition, and the importance of consumption of an adequate amount of high quality colostrums on acquisition of passive immunity is widely recognized (Quigley and Drewry, 1998). Colostrum is a source of immune components and nutrients for the neonates and contains greater concentrations of protein, fat, vitamins and minerals than does milk. Because some vitamins do not cross the placental barrier, colostrum is the primary source of these nutrients for the calf after birth (Kume and Tanabe, 1993; Quigley and Drewry, 1998).Vitamin A and β-carotene provide a protective effect against various diseases and enhance many facets of the immune system (Chew, 1987). Lotthammer (1979) reported that calves of carotene-deficient cows had a higher incidence of diarrhea and mortality in the first week of life. Chronic deprivation of vitamin A results in an anemia with some accompanying Fe deficiency (Mejia *et al*. 1979).

The addition of vitamin A supplements to diet may not always be sufficient to prevent deficiency. Carotene and vitamin A are readily oxidized, particularly in the presence of unsaturated fatty acids. Heat, light, and mineral mixes are known to increase the rate of destruction of vitamin A supplement in commercial rations. In one study, 47- 92% of the vitamin A in several mineral supplements was destroyed after 1 week of exposure to the trace minerals, high relative humidity, sunlight and warm temperature (Divers *et al*. 1986).

As indicated earlier in this paper, addition of vitamin A supplements to diet may not always be sufficient to prevent deficiency in cows and their newborn calves and destruction of carotene and vitamin A in commercial rations is a very common occurrence; therefore, the present study has been conducted to evaluate the effect of parenteral administration of vitamin A in pregnant dairy cows, which received this vitamin as supplement in their daily diet, at two different times before parturition on serum β- carotene and vitamin A concentration of their newborn calves.

Material and Methods

To determine the effect of parenteral administration of vitamin A in late pregnancy in dairy cows on serum vitamin A concentration of new born calves, a total of 30 Holstein- Friesian dairy cows in advanced pregnancy with an average body weight of 550± 30 kg and three to six parity were randomly selected from an industrial dairy farm. Selected pregnant dairy cows were randomly allocated to three main groups: group 1, group 2 and the control group. Animals of the first group (group 1) were administered with vitamin A intramuscularly at 210 days of pregnancy, as soon as they were transferred to far off stall. Dairy cows in the second group (group 2) received single injection of vitamin A when moved to close up, almost a month prior to expected calving date. Animals in control group received normal saline injection as placebo at 7th and 8th month of pregnancy and did not receive any vitamin injection during pregnancy. The total amount of vitamin A, which has been injected to animals in groups 1 and 2, consisted of 2,000,000 IU vitamin A as palmitate per dose. These animals received their daily diet as total mixed ration (TMR), the composition of concentrate and supplemented vitamins of feed materials shown in tables 1 and 2. Jugular blood samples were taken from dairy cows two times before parturition; the first collection was carried out at 7 month of pregnancy in the far off stall and the second one occurred at 8 months of pregnancy when they entered the close up stall.

Calves born from experimental dairy cows were weighed at birth, separated from the dams and housed in individual pens. Each calf received fresh colostrum from their dam equal to 6- 10 percent of their live body weight in the first 6 hours of life and again 2 kg after 12 hours of birth. During the next two days, each calf was nourished with dam's colostrum and milk. Blood samples (15 ml) were collected via jugular puncture into nonheparinized evacuated tubes from newborn calves at two times: prior to the colostrum feeding and two days after birth. The concentration of vitamin A and β- carotene in sera of dairy cows and new- born calves was measured according to Swanson *et al*. (2000).

Mean values of vitamin A and β- carotene were analyzed by using Student's t-test, and a value of $P<$ 0.05 was considered to be significant.

Results

The mean values of neonatal calves' body weight at birth in experimental groups are presented in table 3. Statistical analysis did not show any significant difference between mean body weights of newborn calves in three groups ($P>$ 0.05). Table 4 shows the mean values of vitamin A and β- carotene concentrations in experimental cattle of three groups in the last two months of pregnancy. Serum vitamin A and β- carotene concentrations of dairy cows of control groups, during 7 and 8 month of pregnancy, were not significantly different as compared with cows in injected groups (group 1 and 2) ($P>$ 0.05). The mean values of serum vitamin A and β- carotene for dairy cows in group 1, during the last two months of pregnancy, were also not significantly different as compared with cows in group 2. Table 5 shows the mean serum concentration of vitamin A in newborn calves of the three mentioned groups prior and 2 days after colostrum feeding. The serum vitamin A concentration of calves in control group prior to colostrum feeding (35.5± 14.5 µg/dl) was significantly lower than those in calves of group 1 (90.6± 30.1 µg/dl) and group 2 (93.1± 39.2 µg/dl) ($P<$ 0.05). The corresponding average vitamin A values two days after birth were 62.5± 22.0 µg/dl for calves of control group, 120.3± 32.8 µg/dl for calves of group 1 and 118.3± 42.2 µg/dl for calves of group 2. Statistical analysis for mean values showed a significant increase in vitamin A concentration in sera of calves of treatment groups two days after birth as compared with that of control groups ($P<$ 0.05). Serum vitamin A concentration of calves in group 1 before receiving colostrum and two days after birth, was not significantly different with serum vitamin A concentration of calves in group 2 during the mentioned times. The β- carotene levels in sera of calves in the present study are shown in table 6. Statistical analysis did not show any significant difference between serum β- carotene concentrations of calves in three different groups.

Table 1.The composition of concentrate in last two months of pregnancy.

Composition	percent
Barley	30%
Corn	20%
Barley bran	11.2%
Soya meal	18%
Rape seed meal	14%
Fish powder meal	1%
Propylene glycol	4%
Mineral supplement	1.5%
Vitamins/ trace element supplement	0.3%

Table 2. The composition of vitamins/ trace element supplement of concentrate.

Composition	Amount
Vitamin A	500000 IU
Vitamin D3	100000 IU
Vitamin E	0.1 g
Se	300 mg

Table 3. Body weight (kg) at birth in calves of three different groups (Mean± SE).

Group	Body weight
Control	43.6± 2.3
Group 1	45.4± 1.7
Group 2	43.5± 2.2

Table 4. Mean values of vitamin A (µg/dl) and β- carotene (µg/dl) concentration in serum of dairy cows of three different groups during last two month of pregnancy (Mean± SE).

Month of pregnancy / Group	Seven month of pregnancy		Eight month of pregnancy	
	Vitamin A	β- carotene	Vitamin A	β- carotene
Control	53.7± 34.0	74.8± 11.9	132.3± 27.2	88.3± 11.0
Group 1	51.1± 21.0	90.2± 17.9	120.8± 35.6	86.6± 41.2
Group 2	61.5± 22.5	88.4± 16.3	114.3± 28.5	84.3± 21.7

Table 5. Mean values of vitamin A (µg/dl) concentration in serum of neonatal calves of three different groups prior and after colostrum feeding (Mean± SE).

Time / Group	Before colostrum feeding	Two days after colostrum feeding
Control	35.5± 14.5	62.5± 22.0
Group 1	90.6± 30.1[a]	120.3± 32.8[b]
Group 2	93.1± 39.2[a]	118.3± 42.2[b]

[a, b] Significantly different (P< 0.05)

Table 6. Mean values of β- carotene (µg/dl) concentration in serum of neonatal calves of three different groups prior and after colostrum feeding (Mean± SE).

Time / Group	Before colostrum feeding	Two days after colostrum feeding
Control	4.2 ± 1.8	5.5± 1.5
Group 1	9.7± 11.5	8.1± 3.2
Group 2	6.4± 3.1	10.1± 4.0

Discussion

Newborn calves have low levels and stores of vitamin A and carotene which is due to considerably limited permeability of syndesmochorial placenta for these substances. It was shown that colostrum is the only source of vitamin A and carotene in early postnatal period of calf life (Steinbach *et al*. 1970; Tomlinson *et al*. 1976). The amount of vitamin A and carotene of colostrum is influenced by the diet, season, breed and by individual differences. Researchers found in the first colostrum 1170 international units (IU) of vitamin A/100 mI (dL), in winter and in the summer 1890 IU/dL. Similar data were also reported by some researchers (Branstetter *et al*. 1973), although others obtained lower vitamin A concentrations (Sutton *et al*. 1947). A significant rise in vitamin A level in colostrum appeared after several weeks of administration of 70 000 IU of vitamin A (per day and cow). During the last weeks of pregnancy, a significant decrease in plasma vitamin A levels occurs, which is 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 (Steinbach *et al*. 1970).

In most animal species under normal conditions, the vitamin A level in blood plasma is about 30 µg/dL. Generally, plasma vitamin A concentrations below 10 µg /dL are regarded as being very low, 10-19 µg /dL as low and the range of 20-50 µg /dL as reasonable (Sebrell and Harris, 1967; Chew *et al*. 1987).

With regard to the results shown in table 4 of the present study, it can be observed that the mean serum concentration of vitamin A in dairy cows of three groups in seven month of pregnancy is in normal range and in accordance with normal reference values reported for cattle (Sebrell and Harris, 1967; Chew *et al*. 1987). But as it can be seen in table 4 there is a significant increase in the mean serum concentration of vitamin A in eight month of pregnancy in dairy cows of three different groups which is the result of administration of vitamin A as supplement in their daily feed, as well as parenteral administration in cows of the two groups (group 1 and 2). However, the intramuscular injection of vitamin A in pregnant dairy cows of groups 1 and 2, which is carried out in seven and eight months of pregnancy respectively, did not significantly increase the vitamin A levels of sera of these groups as compared with dairy cows in the control group ($P > 0.05$).

Plasma carotene levels vary largely with the diet. In cattle, levels of 150 µg/dL are optimum, and in the absence of supplementary vitamin A in the ration, clinical signs will appear when the levels fall to 9 µg/dL (Radostits *et al*. 2007). As it is shown in table 4, the serum β- carotene concentration of dairy cows of three different groups in the last two months of pregnancy was significantly lower than optimum level defined for cattle, which is due to the type of ration and the absence of greens in their daily feed.

In normal calves after colostral nutrition, the vitamin A concentration in liver is 10-50 µg /l g of tissue, and in blood plasma over 25 µg /dL (Bouda *et al*. 1980). Repp and Watkins (1958) found that the vitamin A concentration does not drop below 25 µg /dL in blood plasma, assuming that its reserve is sufficiently high.

The effect of prepartum supplementation of 1 million IU of vitamin A in the forms of ester, alcohol and dehydrated alfalfa leaf meal on the health and performance of the young calf was studied by Spielman *et al*. (1949). They found that plasma carotene levels in calves from dams, fed with the alcohol form of vitamin A during the experimental period were significantly higher than calves from dams in the other dietary groupings. Also, calves from dams receiving the ester form of vitamin A had significantly higher plasma carotene than calves from dams fed with alfalfa leaf meal. Plasma of calves from cows fed vitamin A as either ester or alcohol was significantly higher in vitamin A than that of calves from the basal dams or those fed alfalfa leaf meal. Greater liveweight increases were observed in calves from dams fed either form of vitamin A than in calves from dams fed the basal ration alone or with alfalfa leaf meal. There were no statistical differences in feed consumption. Incidence of scours was significantly lower in calves from dams fed either form of vitamin A than that observed in calves from control dams. Calves from dams fed alfalfa leaf meal had fewer cases of scours than calves from control dams (Moore and Berry, 1944; Spielman *et al*. 1949).

Puvogel *et al*., (2008) studied plasma vitamin A status in calves, fed with colostrum, from cows that were supplemented with vitamin A during late pregnancy. The supplementation of vitamin A in cows during late gestation (dry period) increased cow plasma retinol concentrations, the retinol content of first colostrum, and the plasma vitamin A status of calves during their first month of life. Plasma and colostrum retinol concentrations were higher in vitamin A supplemented cows than in non-supplemented cows. In calves that were, for 5 days, fed with colostrum (milk) from vitamin A-supplemented cows and then mature milk, plasma retinol concentrations were higher from 14 to 30 days after birth than in calves that were fed with colostrum (milk) from cows that were not vitamin A supplemented.

The mean values of serum vitamin A and β-carotene concentration of newborn calves before and two days after colostrum feeding, are shown in tables 5 and 6 of the present study. As indicated in table 5, the serum level of vitamin A in calves of three different groups prior to receiving colostrum is high, which is due to administration of vitamin A in daily feed of their dam. The serum vitamin A concentration of calves of groups 1 and 2 was significantly higher than those in the control group ($P < 0.05$). Parenteral administration of vitamin A, previously received by dairy cows in their daily feed, during the last two months of pregnancy significantly increased the serum vitamin A level of newborn calves at birth and before colostrum intake. Results of the present study showed that serum vitamin A concentration of calves in groups 1 and 2, two days after colostrum feeding, were significantly higher as compared with that of the control group (P< 0.01).

Average β- carotene level of calves of three different groups is shown in table 6 in the present study. As it can be seen, the β- carotene concentration in sera of calves of the control group (4.2 ± 1.8) was not significantly different from those in group 1 (9.7± 11.5) and group 2 (6.4± 3.1). Determination of β- carotene concentration in serum samples of calves, after taking colostrum, in the present study, showed that there is no recognizable increase in β- carotene, and the difference between the three different groups was not statistically significant. Since the dairy cows in the present study did not receive any green roughage during the period of study, the β-carotene concentration of dairy cows and their calves was too low, even lower than the normal values reported for cattle (Radostits *et al*. 2007).

Prepartum supplementation of vitamin A increased body weight of newborn calves at birth (Spielman *et al*. 1949). Nezvesky *et al*. (1950) reported that daily supplementation of 1 million IU vitamin A, for 30 days prior to the calculated date of parturition to dams ration, did not significantly increase calves liveweight (Nezvesky *et al.* 1950). Intramuscular administration of vitamins A, D3 and E (consisting of 2500000 IU vitamin A as palmitate, 2500000 IU vitamin D3 and 1000 IU vitamin E as DL- α tocopherol acetate), two times with 15 days interval, in pregnant buffaloes during the last two months of pregnancy did not increase the body weight of calves at birth. But calves born from treated buffaloes had higher body weight gain during the days after birth than those were not treated (Sikka *et al.* 2002).

As shown in table 3, the live bodyweight of newborn calves in the present study was not significantly different among the three groups and administration of vitamin A to pregnant dairy dams, either at 7 or 8 months of pregnancy, could not significantly increase the bodyweight of newborn calves at birth. The increasing effect of prepartum supplementation of vitamin A in daily feed on body weight of newborn calves at birth was shown by some researcher (Spielman *et al.* 1949), but in some other studies there was not any significant increase in body weight of calves at birth in supplemented as compared to no supplemented dams (Nezvesky *et al*. 1950, Sikka *et al*. 2002). In the present study, the pregnant dairy cows of the three groups received the vitamin A in their daily feed during dry period, different from the study of Spielman *et al.* (1949) in which cows in the control group were not supplemented with dietary vitamin A.

Conclusion

From the results of the present study, it can be concluded that single injection of vitamin A in either 7 or 8 months of pregnancy in dairy cows, which have already received this vitamin in their daily feed, significantly increases vitamin A concentration of neonatal calf serum immediately after birth as well as after colostrum intake as compared with that in non- injected group. This increasing effect may support colostrum deprived calf and maintain calf needs for this vitamin in their early life.

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