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Effect of Carotenoid Supplement on Production Performance in Mink (*Neovison vison*)

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Abstract

The present study sought to find out how carotenoid supplement influences on body weights, feed consumption and reproductive success in standard farm mink (*Neovison vison*). Carotenoids were from microalgae *Haematococcus pluvialis*. A dose of carotenoid supplement of 0.20, 0.25, 0.20, 0.20, and 0.10 g/animal was added daily in feed in February, March, April, May and June, respectively. Experimental groups were: 1) control group, and 2) carotenoid group. Each group comprised 100 females and 25 males. The results showed that appetite of animals in all groups was good. Significant differences were not found in body weights before breeding. However, weights of control females were significantly ($P < 0.05$) lower compared with those of carotenoid fed animals when kits aged 21 days. At the age of 21 and 42 days, body weights of kits were similar in both groups. However, kits from carotenoid group tended to grow better ($P < 0.1$) than those from control group. Number of whelped females was lower in control group (81 vs 85 females). Number of barren females was higher in control than in carotenoid group (16 vs 13 females). Significant differences were not found in number of kits per mated and whelped female. Number of lost kits was higher in the control group at the age of 21 days (24 vs 20 kits) and the age of 42 days (40 vs 26 kits). The present study showed that carotenoid supplement could be used in mink diet. The results are promising, but require further studies before final implementation.

Keywords

Microalgae, Farmed Mink, Carotenoids, Weight Gain, Reproductive Success

1. Introduction

Carotenoids are molecules that typically consist of carbon, hydrogen and in some cases oxygen. They can be

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found commonly in nature. Mammals cannot form their own carotenoids and are dependent on the carotenoids received from food. Mammals typically have a good ability to metabolize ingested carotenoids, and even reform species-specific carotenoids [1]-[3].

Carotenoids are known to have both antioxidative and immunological effects [4]-[6]. Hence, they are expected to have positive influence on health and wellbeing in general [3] [7]. Carotenoids have been found to have an effect on fertility of animals in several species. This is due to the fact that all animals deposit carotenoids in their egg cells. Carotenoid supplement seems to increase the frequency of successful insemination [7]. It often also leads to larger offspring. A trend has been found that pigs with carotenoid supplement in feed have more piglets born alive. In addition, mortality per litter among the piglets has been documented to be lower [8]-[10]. In mink, the number of corpora lutea, implantation sites and fetuses tended to be slightly higher in animals given carotenoid antioxidant and astaxanthin during breeding season [7].

The mink (*Neovison vison*) is a small-sized mustelid species (Family *Mustelidae*) housed commercially for its excellent fur [11] [12]. The mink typically has an elongated body shape. Due to a high surface-to-mass ratio, it has to sustain higher basal metabolic rate than other mammals of the same body weight [13] [14]. This may set special demands for its energy metabolism and feeding [15]. Metabolic effects of carotenoids are promising [3]. Breeding result of farmed mink has declined during the past decade [16]. Reasons for this are partly unknown. Good breeding performance, however, is essential for profitable fur production. Therefore, all means to improve breeding success should be tested and clarified. While carotenoid supplement in feed seems to improve breeding result in several species, it is reasonable to clarify this important issue also in farmed mink.

The aim of the present study was to find out how carotenoid supplement in traditional farm feed affects mating and whelping performance and kit mortality of farm-raised mink. Effects on body weights were also evaluated in adults and kits of both sexes.

2. Material and Methods

2.1. Experimental Set-Up and Animals

The present study was carried out at the Fur Farming Research Station of MTT, in Kannus, western Finland (63.54˚N, 23.54˚E). The use of experimental animals was evaluated and approved by the Animal Care Committee of MTT Agrifood Research Finland. Health of animals was visually checked daily. Health evaluation was based on general appearance of animals, including consistence of faeces. Solid faeces were considered normal, loose faeces indicated diarrhea.

Experimental animals employed were dark colored standard mink born at the research station. Two experimental groups were formed: 1) control group; and 2) carotenoid group. Each group comprised 100 females and 25 males. Only healthy animals free from plasmacytosis were used. Animals were first mating season juveniles. They were kept in traditional two-row sheds. Animals were singly housed in wire-mesh cages measuring 70 cm long × 30 cm wide × 38 cm high. Males were placed in every fourth cage between the females. After mating, males and unmated females were removed from the experimental shed.

2.2. Experimental Feeds

Fresh feed was manufactured at the feed kitchen of the MTT research station. Same ingredients were used throughout the study. Ingredients were grinded by using Stephan Universal machine grinder, type UM 44. Feed analyses were made three times during the study. Samples for analyses were collected for the following periods: February 9 - 14, April 3 - 11, and May 28 - 31, respectively. Animals were fed once a day by hand. The amount of given feed and leftovers were measured on a group basis with a Mettler SM 15 balance, accuracy ±1 g.

The base of the feed was the same for both groups (**Table 1** and **Table 2**). Carotenoid supplement feed was added as extra amount of carotenoids from microalgae *Haematococcus pluvialis*. In February, March, April-May and June the amount carotenoid supplement in fresh feed was 0.20, 0.25, 0.20 and 0.10 g/animal daily, respectively. During February the amount of feed given was slightly restricted to avoid extra obesity of breeding animals (**Table 3**). In March, feed supply was then slightly increased to achieve proper flushing effect [17] [18]. Feed composition was based on the recommendations of the Finnish Fur Breeders' Association [19].

Vitamins per kg of food were: retinol 1.05 mg; cholecalciferol 0.009 mg; alpha-tocopherol 40 mg; thiamine 15 mg; riboflavin 6 mg; cyanocobalamine 0.02 mg; pantothenic acid 5 mg; nicotine acid 10 mg; pyridoxine 3

Table 1. Composition of experimental diet (%) during study periods.

Ingredient (%)	February-March	April-May	June
Slaughterhouse offal	11.5	12.0	12.0
Poultry offal	11.5	12.0	12.0
Baltic herring	30.0	29.0	29.0
Fishmeal	6.0	7.0	8.0
Cereals[1]	12.5	11.0	10.0
Vitamins[2]	1.5	1.5	1.5
Soybean oil	-	-	0.5
Water	26.0	27.5	26.9

[1]Cooked barley and wheat; [2]See material and methods.

Table 2. Chemical composition and calculated contents of metabolizable energy (ME) in the diet during study periods.

Variable	February-March	April-May	June
Dry matter (DM), %	34.3	34.1	34.6
In DM%, Ash	7.8	9.5	10.0
Crude protein	37.1	39.2	38.9
Crude fat	19.2	20.5	23.4
Crude carbohydr.	36.0	30.8	27.7
ME (MJ/kg DM)	17.2	17.4	18.0
From ME, %: Protein	34.4	36.0	34.5
Fat	40.0	42.2	46.6
Carbohydr.	25.7	21.8	18.9

Table 3. The amount of given and eaten feed (kg/group) during the study. Significant differences were not found between the groups.

Month	Control		Carotenoid supplement	
	Given	Eaten	Given	Eaten
February	582.0	582.0	582.0	582.0
March	630.0	625.1	630.0	625.2
April	562.0	555.0	562.0	556.3
May	530.0	494.3	530.0	499.1
June	444.0	394.8	444.0	417.8
Total	2748.0	2651.2	2748.0	2680.4

mg; folic acid 0.3 mg; biotin 0.04 mg. Furthermore, 1 kg mixture food contains: calcium 16.0%; phosphorus 11.0%; magnesium 4.0%; cobalt 40 mg; copper 150 mg; iron 6500 mg; manganese 3000 mg; zinc 6000 mg. Fresh water was freely available from automatic water device system.

2.3. Matings and Weighings

Initial body weights of breeding females were measured on February 10 with a Mettler SM 15 balance, accuracy ±1 g [12]. In addition, animals were weight before mating season on March 3.

Matings were started on March 9. Each of the breeding females was mated according to the normal mating routines. Before the breeding season, the testicles of breeding males were palpated to check normality. Mink females were mated according to the 1 + 8 system [17] [20].

At whelping, the date of parturition and the number of live-born and stillborn kits were recorded. The whelping result was calculated at the age of 2 and 42 days. Females and kits were weighed at the age of 21 and 24 days.

2.4. Statistics

Statistical analyses were performed by the General Linear Models (GLM) procedure of the Statistical Analysis System [21] using Tukey's Studentized Range (HSD) test and analysis of variance. The assumption of a normal distribution was checked by graphical methods [22] [23]. Data are presented as mean ± Standard Deviation (SD).

3. Results

3.1. Feed Consumption

Feed consumption was measured on a group basis (**Table 3**). Significant differences were not found in feed consumption between the study groups. Appetite of animals in both experimental groups was good in general. In February, all feed given daily was eaten. In other months, the amount of feed intake was lower than the amount of feed given. Feed consumption was highest in March.

3.2. Body Weights

Body weights of breeding animals are shown in **Table 4**. Significant differences in body weights of neither females nor males were found in February or March. However, body weights of control females was significantly ($P < 0.05$) lower than that of carotenoid group 21 days *postpartum*. At 42 days *postpartum*, there were not any significant differences in weights between whelped females. Weighing of kits 21 and 42 days *postpartum* did not reveal any significant differences between study groups. However, a tendency ($P < 0.1$) was seen that kits in carotenoid group grew better than those in the control group.

3.3. Reproduction Success

Males in both experimental groups were very willing to mate. Any abnormal mating behavior was not observed. Reproductive result for females is summarized in **Table 5**. Health of animals was principally good. However, one female from both groups died before actual mating season. Causes of both deaths were not discovered. One female could not be mated in control group whereas all females were mated in carotenoid group. Number of

Table 4. The body weights (g) of breeding females and males in February and May before whelping, and females 21 and 42 days *postpartum*. Body weights (g) of kits at age 21 and 42 days. Statistical significance: *$P < 0.05$. Data are given as mean ± SD.

Variable	Control	Carotenoid supplement
Breeding females, February 10	979.2 ± 132.1	991.0 ± 138.6
Breeding males, February 10	2235.2 ± 227.0	2326.4 ± 195.0
Breeding females, May 3	993.0 ± 106.8	972.6 ± 102.7
Breeding males, May 3	2365.6 ± 237.0	2399.2 ± 227.6
Whelped females at 21 days	1074.1 ± 120.5	1109.8 ± 131.1*
Whelped females at 42 days	978.5 ± 120.0	985.7 ± 151.3
Female kits at 21 days	109.3 ± 20.2	114.2 ± 19.5
Male kits at 21 days	121.9 ± 23.6	125.1 ± 24.6
Female kits at 42 days	254.9 ± 55.0	265.0 ± 53.7
Male kits at 42 days	280.3 ± 66.8	291.2 ± 64.5

Table 5. Reproductive performance in control and carotenoid supplement groups (N = number of animals).

Variable	Control	Carotenoid supplement
Breeding females, N	100	100
Mated females, N	98	99
Died before whelping, N	1	1
Whelped females, N	81	85
Barren females, N	16	13
Kits lost at 21 days, N	24	20
Kits lost at 42 days, N	40	26
Kits per mated female, N	4.5	4.4
Kits per whelped female, N	5.5	5.3

whelped females was lower in the control group. Furthermore, number of barren females was higher in control than in carotenoid group. Significant differences were not found in number of kits per mated or whelped females. Number of kits lost *postpartum* was higher in the control group.

4. Discussion

An intensive effort was made here to clarify possible effects of dietary carotenoid supplement on reproductive outcome and body weights in farm-raised mink of both sexes. Number of females per group was 100. Both groups included 25 males in addition. Such large groups have been seldom employed for breeding experiments in mink [7] [20] [24]. It was expected that if carotenoid supplement have an influence on reproductive success and body weight, the present experimental set-up would bring out differences between the two groups.

Mink diets are typically high in fish and fish products resulting in a high dietary level of long chain polyunsaturated fatty acids. This may cause a kind of oxidative stress to mink [25] [26]. In the present study, carotenoids given were from microalgae called *Haematococcus pluvialis*. They contained carotenoid astaxanthin, which is known to have a high antioxidative activity. The dose of carotenoid supplement in the diet was selected based on experience from other animal species and on previous studies on mink [3] [7]-[9]. Therefore, it was assumed that the amount added into the feed should be high enough to provide significant influence, if such could be achieved.

Data from feed consumption measurements revealed that animals in both study groups consumed the offered feed well. While animals' appetite was good, it tempts us to conclude that the palatabílity of food containing carotenoid supplement was as good as that of a traditional control feed. Rather similar body weights of animals in both study groups also suggest that feed efficiency was good in both diets. This coincides with previous observations in the mink [7].

One previous study has examined the effects of algae meal, with high astaxanthin content, on ovulation rate and reproductive outcome in female mink [7]. Algae meal in that study contained about the same level of carotenoids than the feed in the present study. According to their results the number of corpora lutea, implantation sites and fetuses appeared to be higher in animals fed with algae meal, although the differences were not statistically significant.

In other animals, such as cows and horses, carotenoid supplement has been found to increase the frequency of successful insemination. Furthermore, in rabbits extra carotenoids seem to lead to larger offspring [8]-[10]. In the present study, number of barren females was higher and number of whelped females lower in the control group. This result is in favor of carotenoid supplement, and thus supports previous findings in other animal species. Our result here can be regarded reliable because of the relatively large animal numbers used in present study compared to the previous study. We used as much as 100 females per group, while number of females in previous study [7] was only 10 and 20 in control and treatments groups, respectively.

The percentage of stillborn kits was reduced significantly with algae meal in previous study [7]. Our results are in accordance with this finding, as the kit mortality in present study was lower in animals fed supplementation with carotenoids. This also coincides with previous findings in piglets, showing that pigs with carotenoid supplement in feed tended to have more piglets born alive. Also lower mortality per litter among the piglets has been described [8]-[10].

Previous study also compared milk intake between control and algae meal groups [7]. No differences, however, were found between the study groups. That is probably one explanation to why kits' weight gain was not dramatically affected by the experimental treatment in their study. In the present study, the weights of kits did not significantly differ between treatment groups either. Nor were there any differences in body weights of breeding female or males between the two study groups. Only difference found between the groups was the difference in weight of females 21 days *postpartum*, when females in carotenoid group were heavier than females in control group. This, however, did not affect the breeding result and thus probably has no essential value.

The present results together with previous findings [7] are promising. They suggest that algae-type diets with various carotenoid contents could have a positive effect on breeding result. However, further studies on the effect are needed before the carotenoid supplements can be included as a part of the standard feeding recommendations. Higher doses are recommended to be tested in the future.

5. Conclusion

The present study revealed some differences between study groups. Number of barren females was lower in carotenoid group. Furthermore, number of whelped females was higher in carotenoid diet. The kit mortality tended to be lower and kit growth better in animals from carotenoid group. The results are promising but require further clarifications before studied carotenoid supplement can be implemented.

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