Effects of Iron Supplementation on the Performance, Blood Hemoglobin, Iron Concentration and Carcass Color of Veal Calves

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Effekte einer Eisensupplementierung auf die Mast- und Schlachtleistung, den Hämoglobin- und Eisengehalt im Blut sowie die Schlachtkörperfarbe von Mastkälbern

1. Introduction

The practice of fattening calves for veal production is under increasing economic pressure because of the public discussion about animal welfare and veal quality. In most countries the pale ("white") color of veal is one of the most important criteria by which the consumer judges its quality. The color of the veal is positively correlated to the amount of supplemental iron in the diet (MOREL, 1996). Calves subjected to iron restriction become anaemic (BERNIER et al., 1984), which many consumers view as cruelty to the animals.

Zusammenfassung

In einem Kälbermastversuch mit 48 Tieren wurde der Einfluß einer Eisenzulage zu einem handelsüblichen Milchaustauschfutter auf die Mast- und Schlachtleistung, den Eisen- und Hämoglobingehalt im Blut sowie die Fleischfarbe untersucht. Es wurden zwei Gruppen zu je 24 Tieren gebildet, wobei das Futter der Versuchsgruppe während der ersten 38 Masttage mit 25 ppm Eisen(II)-fumarat angereichert wurde. 14 Tage nach dem Absetzen der Eisenzulage wurden 7 Kälber pro Gruppe geschlachtet. Weitere 9 Kälber pro Gruppe wurden 28 Tage und die restlichen Tiere wurden 41 Tage nach der Umstellung auf das Milchaustauschfutter mit praxisüblichem Eisengehalt geschlachtet. Die Kälber der Versuchsgruppe wiesen während der ersten 5 Mastwochen signifikant höhere Tageszunahmen auf. Die Futterverwertung war über die gesamte Versuchsperiode deutlich verbessert. Die Eisen-Supplementierung wirkte sich auch auf den Verlauf des Eisen- und Hämoglobingehaltes im Blut der Kälber aus, was sich in der subjektiv beurteilten Fleischfarbe der Schlachtkörper widerspiegelte.

Auf Grund dieser Ergebnisse wurden in einem zweiten Mastversuch 48 Kälber während der ersten sechs Versuchswochen in zwei gleiche Gruppen zu je 24 Tieren und für die verbleibenden 29 Versuchstage wurde die Versuchsgruppe in 2 Subgruppen (2a und 2b) zu je 12 Kälbern geteilt. Während des ersten Mastabschnittes (6 Wochen) wurde ein handelsübliches Milchaustauschfutter eingesetzt, wobei jenes der Versuchsgruppe mit 25 ppm Eisen(II)-fumarat supplementiert war. Das im zweiten Mastabschnitt verwendete Milchaustauschfutter setzte sich zu 50 % aus einem handelsüblichen Produkt und zu 50 % aus einem Milchaustauschfutter zusammen, das 53,7 % Molkepulver, 14,5 % Sojaprotein und 4,5 % Kartoffeleiweiß enthielt. Eine Anreicherung mit Eisen(II)-fumarat in der Höhe von 15 ppm erfolgte nur im Futter der Gruppe 2a. Im Gegensatz zu den Resultaten aus dem ersten Versuch ergaben sich durch den Zusatz von 25 ppm Eisen(II)-fumarat keine Auswirkungen auf den täglichen Zuwachs der Kälber während der ersten 6 Wochen. Die Futterverwertung war jedoch im ersten Mastabschnitt signifikant besser. Eine deutliche Steigerung des täglichen Zuwachses (P = 0,034) sowie der scheinbaren Verdaulichkeit des Eisens (P = 0,047) konnte in Gruppe 2a beobachtet werden. Keinen signifikanten Einfluß gab es hinsichtlich des Eisen- und Hämoglobingehaltes im Blut sowie der subjektiv beurteilten Fleischfarbe. Aus den Versuchsergebnissen kann geschlossen werden, daß durch eine Eisenzulage zu den handelsüblichen Milchaustauschfuttermitteln eine Steigerung der Mastleistung möglich ist, wobei eine negative Beeinflussung der Fleischfarbe von der Höhe und der Dauer der Eisen-Supplementierung abhängt.

Schlagworte: Eisen, Mastleistung, Hämoglobin, Kalbfleisch, Fleischfarbe.

Summary

The effects on the performance, blood hemoglobin, iron concentration and carcass color of an extra 25 ppm of iron(II)-fumarat added to a commercial milk replacer, given until the 38th day of the trial, were studied during a fattening period of 79 days on two groups of 24 calves. Two weeks, four weeks and 41 days after the withdrawal of the supplemental iron 14, 18 and 16 calves were slaughtered, respectively. The dietary regimen had a significantly positive impact on the fattening performance only within the time when the milk replacer was supplemented with extra iron. The feed efficiency was also clearly improved. The effects of the supplementation on the progression of the iron concentration and blood hemoglobin values were reflected in the visual assessment of the carcass color of the surface muscles.

Because of the results obtained in the first experiment, a second feeding trial was conducted with 48 calves which were divided into two groups. The commercial milk replacer fed to the experimental group was supplemented with 25 ppm of iron(II)-fumarat. After six weeks the experimental group was split into two subgroups (2a and 2 b) with 12 animals each, whereas only the milk replacer for group 2a was supplemented with 15 ppm of iron(II)-fumarat. During that time (29 days), the milk replacer used was a 50 /50 % mixture of a commercial product and a milk replacer containing 53,7 % whey powder, 14,5 % soyprotein and 4,5 % potato protein as protein sources. Contrary to the results of the first experiment, no significant differences in average daily gain were found between the two groups during the first fattening period (36 days). Supplemental iron had a positive influence on the feed conversion within the first 6 weeks. A significantly higher average daily growth performance was only observed in group 2a, which was fed supplemental iron until the end of the experiment. The apparent digestibility of iron was also markedly higher in group 2a. In contrast to the findings made in experiment one, no change in the blood hemoglobin and iron concentration was observed. Supplementing iron during the whole fattening period did not negatively affect the veal color.

It is concluded that an extra iron supplementation to the commercial milk replacers can improve the fattening performance without necessarily having a detrimental impact on the color of veal, although it must be noted that the meat color depends on the amount of iron supplemented and on the length of time it is administered.

Key words: Iron, Performance, Hemoglobin, Veal, Color.

In former times, veal calves were nourished only with whole milk and the animals were slaughtered at about 100 kg bodyweight. The findings of an extensive experiment conducted with calves given large quantities of whole milk by Roy et al. (1964) disclosed the marked importance of Fe in the nutrition of the veal calf.

More than 30 years ago the first milk replacers (MR) were developed, and as a result veal production was intensified. Originally only the milk fat was substituted, which made the fattening of heavier animals possible. It is well known that the iron content of whole milk (about 3,5 to 4,0 mg/kg dry matter) is much too low to avoid deficiencies, especially when the finishing period is extended. Milk replacers for calves with less than 70 kg bodyweight have to contain at least 30 mg of iron according to Austrian regulations.

The object of the present experiment was to study the influence of a 25 ppm iron(II)-fumarat supplementation within the first 5 weeks of the fattening period on the performance, blood iron and hemoglobin concentration, as well as on the carcass color. Because no negative influence on the overall visual color of the carcass surface muscle could be determined, a second experiment was conducted to investigate the effect of an additional 15 ppm iron(II)-fumarat supplementation after week 6 of the trial.

2. Materials and Methods

2.1 Experiment 1

44 female and 2 male Simmental calves as well as 2 male Brown Swiss calves were divided into two groups of 24 each, one control group and one experimental group. The calves had an average initial weight of 101,5 kg. They were kept six to a pen in a barn with straw bedding. The whole experiment lasted for 79 days. Table 1 presents a review of the feeding regimen.

For the first 20 days of the experiment the calves received MR I, which consisted of 60,0 % skim milk powder, 21,8 %

Table 1: Feeding regimen (Experiment 1 and 2)
Tabelle 1: Tränkeplan (Versuch 1 und 2)

Week of fattening period	Liters of feed per calf per day	Grams of milk replacer per liter feed
1	6	150
2	7	160
3	8	170
4	9	170
5	10	180
6	11	180
7	12	190
8	13	190
9	14	190
10	14	190

whey powder, 17,0 % fat mixture and 1,2 % mineral and vitamin premix. They were then switched to MR II which contained 56,0 % skim milk powder, 21,2 % whey powder, 21,3 % fat mixture and 1,5 % mineral and vitamin premix. Until day 38 of the feeding trial the MR of the experimental group was supplemented with 25 ppm iron(II)-fumarat.

The results of the chemical analysis of the four milk replacers are listed in Table 2.

2.1.1 Data collection

Fattening performance: The animals were weighed individually at the beginning and the end of the experiment as well as on days twenty, thirty-eight, fifty-two, and sixty-six. The feed consumption per pen was recorded. Daily gain and feed efficiency were calculated from these data.

Blood tests: At the beginning of the experiment, also on days thirty-two, fifty-two, sixty-six and at the end of the trial, blood samples were drawn from the jugular vein of every animal for determination of hemoglobin concentration (Hb) and plasma iron concentration (PI). Hb was analyzed according to the "cyanmethemoglobin-method" using EDTA-blood samples (SCHLERKA and BAUMGARTNER, 1983). Iron concentration was determined colorimetrically (BOSTEDT et al., 1990; SCHLERKA, 1996)

Slaughter performance: Seven, nine and eight animals per group were slaughtered on days fifty-two, sixty-six and seventy-nine, respectively. The dressing percent values were based on the live weight taken at the slaughter-house. The carcasses were evaluated according to the EUROP-Classification (1991).

Color of meat: One day after slaughter, the overall carcass muscle color was assessed visually on the outside surface of the carcasses by five experienced graders using a scoring system from one point (dark) to five points (light).

2.1.2 Statistical analysis

Data of fattening and slaughter performance and data of blood samples were analyzed using Model 1 of the LSMLMW computer program (HARVEY, 1990). Results of the carcass evaluation as well as data of subjective assessment of meat color were analyzed using Kruskal and Wallis' H-Test (ESSL, 1987). Values of fattening performance were adjusted to an average initial weight of 101,5 kg. On day 66 and day 79 of the experiment, the average initial weight for the animals in question was 106,6 kg and 112,1 kg, respectively. Differences were considered statistically significant at $P < 0{,}05$.

Table 2: Nutrient content of milk replacers (Experiment 1)
Tabelle 2: Nährstoffgehalt der Milchaustauschfuttermittel (Versuch 1)

Components	Control MR I	Experimental MR I	Control MR II	Experimental MR II
Dry matter %	96,7	96,6	96,9	96,9
Crude protein %	23,0	23,4	22,7	23,0
Total fat %*	18,4	17,5	22,6	22,1
Ash %	7,7	7,9	7,3	7,3
Calcium %	1,18	1,25	1,16	1,15
Phosphorus %	0,74	0,83	0,74	0,76
Sodium %	0,36	0,37	0,35	0,35
Copper ppm	9	12	7	9
Iron ppm	25	51	14	36

* After hydrolysation

Table 3: Nutrient content of milk replacers (Experiment 2)
Tabelle 3: Nährstoffgehalt der Milchaustauschfuttermittel (Versuch 2)

Components	Control MR I	Experimental MR I	Control MR II*	Experimental MR II
Dry matter %	96,7	96,6	97,1	97,0
Crude protein %	23,8	23,8	19,8	19,7
Total fat %**	18,0	16,0	19,8	19,5
Ash %	8,1	8,2	8,4	8,7
Calcium %	1,25	1,26	1,14	1,23
Phosphorus %	0,79	0,83	0,72	0,74
Sodium %	0,40	0,41	0,39	0,39
Copper ppm	2	4	5	4
Iron ppm	24	48	37	52

* Control MR II was also fed to the subgroup 2b

** After hydrolysation ·

2.2 Experiment 2

At the beginning of the experiment 48 female Simmental calves with an average weight of 101,6 kg were randomly divided into two groups, one control group (group 1) and one experimental group (group 2). They were kept in the same barn and fed in the same manner as the animals in experiment one. Within the first six weeks of the trial a commercially used MR I was fed, whereas MR I for the experimental group was supplemented with 25 ppm iron(II)-fumarat. Six weeks after the onset of the trial, the experimental group was split into two subgroups (2a and 2b) with 12 animals each. MR II, which was fed after the sixth week of the experiment, was handled according to the "two-bag-method", which means half of the MR II was a commercially used one and the other half consisted of 53,7 % whey powder, 23,0 % fat mixture, 14,5 % soyprotein DANPRO A, 4,5 % potato protein ROQUETTE, 3,3 % mineral and vitamin premix, 0,7 % L-lysine and 0,3 % DL-methionine. Only the MR II for group 2a was supplemented with 15 ppm iron(II)-fumarat.

The investigation lasted for 71 days.

The values of chemical analysis of the four milk replacers are given in Table 3.

2.2.1 Data collection

Apparent digestibility: After the calves were fed MR II for a period of 3 weeks, fecal samples were taken from 3 animals in each box, i.e. 12 calves from the control group and 6 calves from each experimental group. The content of HCl-insoluble ash was taken as the indicator for determining apparent digestibility (ENDERS, 1973; WUENSCHE et al., 1984).

Fattening performance: Initial and final weight of each individual animal, fattening period and feed consumption per pen were recorded. Daily weight gain and feed efficiency were obtained from these data.

Blood tests: At the onset, at the end of week 6 and at the end of the experiment, blood samples were collected from each animal from the jugular vein for determination of hemoglobin concentration (Hb) and plasma iron concentration (PI), according to the method described in chapter 2.1.1.

Slaughter performance: All calves were weighed shortly before slaughter; then carcass weight (slaughtering weight) was measured. Dressing percentage, EUROP-Classification (1991) and overall carcass muscle color were obtained as described in chapter 2.1.1.

2.2.2 Statistical Analysis

The same statistical methods were used as in experiment one. The results of fattening performance were adjusted to an average initial weight of 101,6 kg. Differences between group least squares means were analyzed using the BONFERRONI-HOLM test procedure (ESSL, 1987).

3. Results and Discussion

3.1 Experiment 1

Least squares means, pooled standard errors and significances for the most important results of fattening and slaughter performance are shown in Table 4.

The experimental group reached a significantly higher daily weight gain within the time when the MR was sup-

Table 4: Fattening and slaughter performance (Experiment 1)
Tabelle 4: Mast- und Schlachtleistung (Versuch 1)

Character	n per group	Group 1	Group 2	Pooled standard error	Significance (P)
Body weight (kg): initial	24	101,5	101,5	12,5	0,999
day 20	24	117,3	120,2	3,2	0,004
day 38	24	139,0	145,8	3,9	< 0,001
day 52	24	158,4	163,8	4,2	< 0,001
day 66	17	189,4	195,3	6,5	0,012
day 79	8	212,3	216,1	7,8	0,360
Daily weight gain (g):					
period 1	24	790	934	162	0,004
period 2	24	1204	1423	137	< 0,001
period 3	24	1390	1286	239	0,139
period 4	17	1804	1880	270	0,418
period 5	8	1465	1145	351	0,100
overall average	24	1202	1281	148	0,072
Feed efficiency (kg kg^{-1} growth)	24	1,64	1,53	0,03	0,005
Dressing percentage	24	60,6	60,6	2,0	0,986

plemented with iron(II)-fumarat. The feed conversion was also markedly improved. Studies done by ROY et al. (1964) demonstrated the enormously positive impact of an Fe supplementation on weight gain up to 12 weeks of age and until the time of slaughter.

BURGSTALLER et al. (1979) obtained the best fattening performance with 70 and 100 ppm Fe in the MR. The observations made by BERNIER et al. (1984), who added 30 and 50 ppm (dry basis) supplementary iron to the MR, are also in agreement with the figures above.

WEBSTER et al. (1975) found no significant differences in weight gain, food conversion or energy retention between calves receiving 20, 40 or 100 mg iron/kg dry matter in their high-fat MR diet. In an experiment conducted by MCFARLANE et al. (1988), dietary treatments (5 mg/kg versus 105 mg iron/kg dry milk replacer) did not affect the 8-week live weight of the calves.

The results of the experiment in question are also contradictory to the results of EGGER (1991), who observed no improved performance and health status when the iron content of the MR was increased from 20 to 50 mg/kg dry matter. In this case, the higher iron supply had a negative impact on the color of the veal.

Extensive investigations conducted in Switzerland on 224 male veal calves between 1989 and 1995 showed that an Hb-value of less than 8 g/100 ml at the beginning of the fattening period and a constant iron content of 21 mg/kg MR dry matter caused reduced growth and a significantly worse feed efficiency (MOREL, 1996).

The amount of iron stored in the liver and other organs at birth varies from individual to individual (MOREL, 1996). The best indicator for an iron deficiency is the Hb in the blood (BOEHNCKE and GROPP, 1979). The correlation between Hb and the iron content of the feedstuff is not very high, which can be explained by different availability of the various iron sources and the different amounts of iron stored in the liver.

The results of the blood tests for Hb and PI are presented in Table 5.

At the onset of the experiment the Hb and the PI were unintentionally higher in the control group. Since the results from the analysis of these blood samples were not available right away, the animals were not assigned equally to the groups according to their initial Hb and PI. The iron supplementation within the first 38 days of the experiment negated the significant differences in Hb and PI between the groups at the beginning of the experiment. These results are in agreement with the findings of MILTENBURG et al. (1991). Contrary to this, concentrations of Hb in calves fed approximately 5 mg iron/kg dry milk replacer and calves fed 140 mg/kg through day 18 and then approximately 5 mg/kg did not differ significantly until week 5 (MCFARLANE et al., 1988).

In the literature, the threshold value for Hb varies between 6 and 10,5 g hemoglobin/100 ml blood (EGGER, 1991). MOREL (1996) observed an average Hb at slaughter (116 days) between 8,6 and 9,0 g/100 ml when the veal calves were fed a diet containing 22,7 mg Fe/kg dry matter.

Table 5: Hemoglobin and plasma iron concentration (Experiment 1)
Tabelle 5: Hämoglobin- und Eisengehalt (Versuch 1)

Character	n per group	Group 1	Group 2	Pooled standard error	Significance (P)
Hemoglobin, g/100 ml					
Initial	24	12,5	11,0	2,0	0,019
Day 32	24	11,5	9,9	1,7	0,002
Day 52	7	10,1	10,3	1,4	0,715
Day 66	9	8,8	8,2	1,3	0,292
End	8	9,6	9,1	1,1	0,337
Plasma iron, µmol/l					
Initial	24	20,5	11,8	11,2	0,010
Day 32	24	14,0	9,9	8,2	0,088
Day 52	7	15,2	9,2	8,9	0,230
Day 66	9	6,3	4,6	3,4	0,326
End	8	10,3	6,6	4,0	0,086

Calves showing an Hb value of lower than 8 g/100 ml would be considered to be anemic by most authors (LINDT and BLUM, 1994).

Results obtained by the EUROP-Classification and the visual carcass color scoring are shown in Table 6. The supplemetation of iron had no effect on the subjective evaluation of meatiness and fat cover of the carcasses. At first slaughter, which took place 14 days after the supplemental iron withdrawal, there was no significant difference between the veal carcass color of the two groups, even though the Hb and PI were significantly lower in group 2 at the onset of the experiment. This seems to reflect the influence of the dietary iron regimen. Thereafter carcasses of the experimental group obtained a significantly higher number of points.

MILTENBURG et al. (1991) concluded that different iron concentrations in the milk replacer during the first 7 weeks of fattening did not cause measurable differences in the overall visual color evaluation of the carcass surface muscles.

EGGER (1991) found out that the Hb at the beginning of the fattening period is a useful indicator for the subsequent color of the veal. Investigations done by DUFEY (1991) showed significant differences between the color of veal from calves that had an average Hb of 7,2 g/100 ml and those that had an average Hb of 12,7 g/100ml blood at slaughter. WENSING et al. (1991) showed that supplementing a commercial milk replacer containing 13 ppm of iron, with an extra 5 ppm during the whole fattening period, resulted in meat which was qualified as too red.

3.2 Experiment 2

In Table 7 least squares means, pooled standard errors and significances for the most important results of the fattening and slaughter performance are shown.

Contrary to the results of the first experiment, no significant differences in average daily gain were found between the two groups during the first fattening period (36 days). Feed efficiency of group two was improved by 9,2 % (P = 0,075) within that period of time. MCFARLANE et al. (1988) also did not see any dietary influence on the 8 week live weight, even though the highest iron level was approximately 105 mg/kg throughout the study. Similar conclusions can be drawn from results of an experiment conducted by MILTENBURG et al. (1992), in which an iron concentration of up to 150 mg Fe per kilogram of feed during the first 7 weeks of the fattening period had no influence on the mean carcass weights in week 29.

Table 6: EUROP-Classification and visual carcass color score (Experiment 1)
Tabelle 6: EUROP-Klassifizierung und subjektive Beurteilung der Schlachtkörperfarbe (Versuch 1)

Character	n per group	Group 1	Group 2	Significance (P)
EUROP-Classification (points)				
Meatiness	24	2,92	2,67	0,196
Fat cover	24	2,00	2,17	0,253
Meat color (points)				
First slaughter	7	2,74	2,66	0,990
Second slaughter	9	2,65	3,78	< 0,001
Third slaughter	8	2,68	3,08	0,050
Overall average	24	2,68	3,26	< 0,001

Table 7: Fattening and slaughter performance (Experiment 2)
Tabelle 7: Mast- und Schlachtleistung (Versuch 2)

Character	Group 1	Group 2a	Group 2*	Group 2b	Pooled standard error	Significance (P)
n	24	12	24	12		
Initial weight (kg)	101,6		101,5		5,6	0,970
Weight on day 36 (kg)	141,9		145,3		8,7	0,178
Final weight (kg)	171,4[a]	179,5[b]		170,0[a]	9,6	0,034
Daily weight gain (g)						
First period	1185		1286		255	0,177
Second period	1340	1364		1311	238	0,862
Overall average	1246[a]	1392[b]		1221[a]	172	0,034
Feed efficiency (kg kg^{-1} growth)						
First period	1,30		1,18		0,20	0,075
Second period	1,71	1,68		1,76	0,10	0,310
Overall average	1,47	1,37		1,42	0,15	0,267
Dressing percentage	59,9	61,1		59,9	1,4	0,098

* Observations made before the experimental group was divided into 2a and 2b

[a, b] Means within a row with different superscripts differ (P < 0,05)

Several authors observed no significant effects on weight gain and feed conversion of veal calves through different dietary iron regimens (WEBSTER et al., 1975; BURGSTALLER et al., 1979; EGGER, 1991; MOREL, 1996;). Dietary iron contents of about 10 ppm are known to cause growth depressions (MOREL, 1996).

However, Table 7 shows that the dietary iron concentration had an effect on the average daily weight gain. Calves in group 2a gained 146 g per day more than animals in group 1.

This is in accordance with findings from BERNIER et al. (1984) and observations made by ROY et al. (1964).

Table 8 shows that the apparent digestibility of the iron was increased when the diet contained supplemental iron(II)-fumarat.

The extra supplementation of iron had no effect on the apparent digestibility of crude protein, total fat and nitrogen-free extracts at 8 1/2 weeks of age. On the other hand, the digestibility of iron was significantly elevated in the experimental group 8 weeks after the onset of the experiment. Contrary to these results, ROY et al. (1964) reported significantly increased apparent digestibility of total solids, fat and protein at 10 weeks in calves given supplemental iron.

The results of the blood tests for Hb and PI are presented in Table 9.

The extra supplementation with iron had no significant impact on the Hb and the PI. This is in contrast to the results observed in experiment one, as well as to the findings made by MILTENBURG et al. (1991). MCFARLANE et al. (1988) did not find significantly different Hb-concentrations until week 5 in calves fed approximately 5 mg iron/kg dry milk replacer, and calves fed 140 mg/kg through day 18, and then approximately 5 mg/kg.

Table 8: Apparent digestibility of nutrients (Experiment 2)
Tabelle 8: Scheinbare Verdaulichkeit der Nährstoffe (Versuch 2)

Nutrient	Group 1	Group 2a	Pooled standard error	Significance (P)
n	20*	7		
Crude protein %	90,9	90,0	2,4	0,410
Total fat %	87,8	88,4	4,8	0,796
NfE %**	95,4	95,6	0,7	0,567
Iron %	53,2	61,3	9,3	0,047

* Includes samples from group 2b

** NfE, nitrogen-free extracts

Table 9: Hemoglobin and plasma iron concentrations (Experiment 2)
Tabelle 9: Hämoglobin- und Eisengehalt (Versuch 2)

Character	Group 1	Group 2a	Group 2*	Group 2b	Pooled standard error	Significance (P)
n	24	12	24	12		
Hemoglobin, g/100 ml						
Initial	10,2		10,3		2,6	0,927
End of first period	10,6		10,2		1,7	0,482
End of experiment	10,5	9,8		9,5	1,8	0,264
Plasma iron, µmol/l						
Initial	25,5		28,0		16,0	0,598
End of first period	13,8		19,1		13,6	0,181
End of experiment	6,5	9,5		8,0	6,5	0,441

* Observations made before the experimental group was divided into 2a and 2b

Results obtained by the EUROP-Classification and the subjective carcass color scoring are shown in Table 10. The dietary iron regimen did not show any influence on the meatiness and fat cover of the carcasses and surprisingly, there was no effect on the visually judged color of the veal as well. MILTENBURG et al. (1992) did not find measurable differences in the overall visual color evaluation of the carcass surface muscles from calves fed different iron concentrations in the milk replacer during the first 7 weeks of fattening. EGGER (1991) concluded that a dietary iron content of 50 mg/kg dry matter instead of 20 mg/kg dry matter did not improve the fattening performance and the health status of the animals but did negatively affect the color of the veal. Similar observations were made by MCFARLANE et al. (1988) and WENSING et al. (1991).

4. Conclusions

Supplementing commercial milk replacers with 25 ppm of iron(II)-fumarat during the first fattening period (5 to 6 weeks) and 15 ppm during the second fattening period resulted in an improved fattening performance without having a negative impact on the overall visual color evaluation of the carcass surface muscles. In order to avoid a detrimental effect on the color of the veal, however, it should be noted that at least 4 weeks should be allowed between withdrawal of the supplemental iron and slaughter.

Providing veal calves with a more appropriate supply of iron would enable producers to better take advantage of the growth capacity of these animals, but still meet the consumers' expectations concerning veal color.

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Table 10: EUROP-Classification and visual carcass color scores (Experiment 2)
Tabelle 10: EUROP-Klassifizierung und subjektive Beurteilung der Schlachtkörperfarbe (Versuch 2)

Character	Group 1	Group 2a	Group 2b	Significance (P)
n	24	12	12	
EUROP-Classification (points)				
Meatiness	2,63	2,33	2,75	0,104
Fat cover	2,00	2,00	1,92	0,223
Meat color (points)	3,84	3,48	3,82	0,113

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