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Effects of different types of solid feeds on health status and performance of Swiss veal calves. II. Basic feeding with whole milk

R. Räber[1], T. Kaufmann[2], G. Regula[3], A. von Rotz[4], M. H. Stoffel[4], H. Posthaus[5], M. Rérat[6], I. Morel[6], M. Kirchhofer[1], A. Steiner[1], C. Bähler[1]

[1]Clinic for Ruminants, [3]Veterinary Public Health Institute, [4]Division of Veterinary Anatomy, and [5]Institute of Animal Pathology, University of Bern, Switzerland, [2]Swiss Bovine Health Service, Lindau, Switzerland, [6]Agroscope Liebefeld-Posieux Research Station ALP, Switzerland

Summary

The objective of this study was to identify a suitable alternative to the current practice of complementing the feeding of whole milk with straw. The influence of 3 different solid supplements on the health and performance of Swiss veal calves was investigated during 3 production cycles of 90 veal calves each with a mean initial age of 42 days and a mean initial weight of 68.7 kg. The calves were housed in groups of 30 in stalls strewn with wheat straw without outside pen. Liquid feeding consisted of whole milk combined with an additional skim milk powder *ad libitum*. Groups were assigned to one of the three following experimental solid feeds provided *ad libitum*: Pellet mix (composition: oat hulls, corn [whole plant], barley, sunflower seeds, squeezed grains of corn, molasses and a pellet binder), whole plant corn pellets, and wheat straw as control. Calves of the straw group showed significantly more abomasal lesions in the fundic part as compared to the pellet mix and corn pellets groups ($P < 0.001$), the prevalence of insufficient papillae was highest ($P < 0.05$), and ruminating behavior was unsatisfactory. In contrast to the pellet mix and straw groups, performance of calves in the corn pellets group was good. Additionally, prevalence of abomasal fundic lesions was lowest ($P < 0.001$), and rumen development was best in calves of the corn pellets group ($P < 0.01$). As in part I, the results reveal that whole-plant corn pellets are most consistent with an optimal result combining the calves' health and fattening performance. Therefore, it can be recommended as a solid supplement for veal calves basically fed whole milk under Swiss conditions.

Keywords: *ad libitum* feeding, health, performance, solid feeds, veal calves

Der Einfluss von Festfutter auf die Gesundheit und Leistung von Schweizer Mastkälbern. II. Vollmilch als Grundfutter

Ziel dieser Studie war es, eine geeignete Alternative zur bisherigen Fütterung von Stroh als Zusatz zu Vollmilch zu finden. Dabei wurden die Auswirkungen von 3 verschiedenen Festfutter auf die Gesundheit und Leistung von Schweizer Mastkälbern während 3 Mastdurchläufen mit jeweils 90 Kälbern, einem mittleren Einstallalter von 42 Tagen und einem mittleren Einstallgewicht von 68.7 kg untersucht. Die Kälber wurden in Gruppen von 30 Tieren in mit Stroh eingestreuten Ställen ohne Auslauf gehalten. Die *ad libitum* Flüssigfütterung bestand aus Vollmilch ergänzt mit einem Magermilchpulver. Die Gruppen wurden zufällig folgenden auf ihre Eignung hin zu testenden Raufutter zugeteilt: Mixwürfel (bestehend aus Haferspelzen, Ganzpflanzenmais, Gerste, Sonnenblumensamen, gequetschten Maiskörnern, Melasse, Lignobond DD Pelletbinder), Ganzpflanzen-Maiswürfel und Stroh (Kontrolle). Kälber aus der Strohgruppe wiesen im Vergleich zu den Kälbern aus der Mixwürfel- und der Maiswürfelgruppe ($P < 0.001$) signifikant mehr Labmagenläsionen im Fundusbereich auf, der Anteil an Kälbern mit ungenügend entwickelten Pansenzotten war grösser ($P < 0.05$) und das Wiederkauverhalten war unbefriedigend. Im Gegensatz zur Mixwürfel- und Strohgruppe war die Leistung der Kälber, welche mit Maiswürfeln zugefüttert wurden gut und deren Schlachtkörper wurden den Anforderungen des Marktes am besten gerecht. Zusätzlich war die Prävalenz für Labmagenläsionen im Fundusbereich bei den Kälbern aus der Maiswürfelgruppe am tiefsten ($P < 0.001$) und die Pansenentwicklung war am besten ($P < 0.01$). Wie in Teil I dieser Arbeit weisen die vorliegenden Resultate darauf hin, dass Ganzpflanzen-Maiswürfel eine geeignete Alternative zur bisherigen Strohbeifütterung bei Mastkälbern darstellen.

Schlüsselwörter: *ad libitum* Fütterung, Gesundheit, Leistung, Festfutter, Mastkälber

Table 1: Basic data (Mean ± Standard Deviation SD) of 270 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Feeding treatment	Number of calves	Initial age (days)	Initial body weight (kg)	Sex (%)		Breed (%)		
				F[1]	F[2]	Diary[3]	Cross	Beef[4]
Wheat straw (control)	90	42.1 ± 14.5	68.7 ± 7.8	7.8	92.9	98.9	0	1.1
Pellet mix[5]	90	41.0 ± 14.5	68.7 ± 7.5	10	90	95.6	3.3	1.1
Corn pellets	90	41.7 ± 14.9	68.7 ± 7.1	11.1	88.9	94.4	4.4	1.1

[1] Female
[2] Male
[3] Dairy breeds = Swiss Braunvieh, Holstein, Red Holstein, Swiss Rotfleck
[4] Beef breeds = Limousin, Montbéliard, Normande, Simmental
[5] Composition: Oat hulls (36 %), corn (whole plant, 33 %), barley (8 %), sunflower seeds (8 %), squeezed grains of corn (7.5 %), molasses (5 %), Lignobond pellet binder (2.5 %)

Introduction

Approximately 60 % of the Swiss veal calves are basically fed with whole milk and a supplementing powder (Schweizer Kälbermästerverband, 2011). In alpine regions, excess milk is provided to veal calves. This allows calves that are inappropriate for breeding to be exploited nonetheless and to generate an important income component for the farmers. One third of these calves is gathered and fattened on farms where the milk of all the cows is produced for the sole purpose of feeding the veal calves (Interessengemeinschaft Kalbfleisch, 2011). In contrast to part 1, the present study allowed feed intake to be assessed on an individual level.
The objective of the present study was to provide a rational basis for the selection of a suitable solid feed which complies with the calves' physiology and the demands of the market concerning performance and, therefore, to assess the effect of 3 types of solid feeds in addition to a whole milk diet on health and performance of Swiss veal calves in an *ad libitum* feeding system.

Animals, Material and Methods

Only variations of part 1 are referred to.

Animals

The investigation included 3 production cycles (PC1, PC2, and PC3) with 90 Swiss veal calves each (Tab. 1). Production cycle 1 lasted from April to August 2009, PC2 from September 2009 to February 2010, and PC3 from February to July 2010.

Housing

Calves were housed in 3 stalls in 2 connected buildings at the Swiss Federal Research Station in Posieux. The stalls had concrete floors and were entirely separated from each other. Overall space allowance amounted to 2.8 m²/calf, whereof 60 m² were strewn with wheat straw. In the feeding area (24 m²), no bedding material was present. After each PC, the stalls were thoroughly cleaned with high-pressure water and disinfected with a disinfectant (Virocid, Cid Lines, Belgium).

Table 2: The mean contents of milk by-product, supplementary skim milk powder, and premix fed to 270 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Item	Whole milk	Skim milk powder[1]	Premix[2]
Dry matter (g/kg)	129.8	962.8	919
Crude protein (g/kg DM[3])	255.2	215.3	–
Crude ash (g/kg DM)	54.4	79.7	196.9
Crude fat (g/kg DM)	285.8	219.8	–
Lactose (g/kg DM)	344.3	333.4	–
Iron (mg/kg DM)	< 4	28.3	3263.2

[1] Meliormilk (Melior AG, Herzogenbuchsee)
[2] UFA top-fit (UFAG, Sursee)
[3] Dry matter

Feeding

The basic *ad libitum* feeding plan of calves included a mixture of whole milk, a skim milk powder (Meliormilk, Melior AG, Herzogenbuchsee) and water (Tab. 2). This liquid diet was dispensed from an automatic feeding system (TAK2-SA2-50 S, Förster Technik GmbH, Germany) equipped with 2 artificial teats per stall (for feeding plan see Tab. 3). Each calf was provided with a transponder (Allflex Europe Inc., France) fixed on a collar to determine the amount of milk and solid feed intake except for straw which was provided in racks and whose distributed amount was weighed before provision, noted on a protocol and then divided by the number of animals and days to obtain the average dry matter intake (DMI) per calf. Each group was assigned to 1 of the 3 following experimental

Table 3: Liquid feeding plan of 270 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Week	Liter liquid feeding per day	Concentration g/l (120 g/l as basis for milk)	Skim milk powder[1] (g/l)	Water fraction (%)	Whole milk fraction (%)
1	7	97	25	40	60
2	7–13	97–109	25	30	70
3	13–25	109–115	25	25	75
4	25	115–121	25	20	80
5	25	121–132	30	15	85
6	25	132–138	30	10	90
7	25	138–150	20	0	100
8	25	150–155	35	0	100
9	25	155–165	45	0	100
10	25	165–175	55	0	100
11	25	175	55	0	100
12	25	175	55	0	100
13	25	175	55	0	100
14	25	175	55	0	100
15	25	175	55	0	100
16	25	175	55	0	100

[1] Meliormilk (Melior AG, Herzogenbuchsee)

feeding regimens: wheat straw (control), pellet mix (composition: oat hulls, corn (whole plant), barley, sunflower seeds, squeezed grains of corn, molasses, Lignobond pellet binder) and whole plant corn pellets. Furthermore, calves had free access to water provided in bowls ("Gusstränkebecken mit Schwimmer", Hauptner GmbH, Zürich). Composition of the solid feeds is shown in Table 4.

Statistical analyses

Statistical procedures were the same as in part I, except that the number of feeding treatments was 3 and a total of 3 group comparisons was possible. This resulted in a level of significance of $\alpha = 0.017$.

Health status

Clinical examination and medical treatment

Calves were weighed, underwent clinical examination, and blood samples were obtained at 1 day after arrival. Health status was assessed daily by the animal caretakers and if necessary, a veterinarian examined conspicuous calves and administered individual medication. At the beginning of the fattening period, all calves were in-

Table 4: The mean contents of solid feeds fed to 270 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Item	Wheat straw (control)	Pellet mix[1]	Corn pellets
Dry matter (g/kg wet weight)	880.1	899.1	911.7
Crude protein (g/kg DM[2])	30.5	65.7	72.2
Crude ash (g/kg DM)	42.7	38.0	27.0
Crude fat (g/kg DM)	12	47.8	27.2
Crude fiber (g/kg DM)	416.9	190.8	147.1
Acid detergent fiber (g/kg DM)	470.9	223.1	170.5
Neutral detergent fiber (g/kg DM)	749.6	428.8	344.2
Starch (g/kg DM)	–	220.7	334.4
Iron (mg/kg DM)	58.5	58.4	53.4

[1] Composition: Oat hulls (36 %), corn (whole plant, 33 %), barley (8 %), sunflower seeds (8 %), squeezed grains of corn (7.5 %), molasses (5 %), Lignobond pellet binder (2.5 %)
[2] Dry matter

jected with 5 mL of iron-hydroxide-dextrane-complex Fe^{3+} (Ferriphor 20 %, Graeub AG, Bern) and medicated prophylactically by the automatic feeding system. Calves received 24 mg chlortetracyclini hydrochloricum/18 mg spiramycinum per kg BW (SK-60, Biokema SA, Crissier) for 8 to 17 days. Additional iron and vitamin supplementation was provided by a premix (UFA top-fit, UFAG, Sursee, see Tab. 2).

Results

Feed intake and analyses

The DMI (± Standard Deviation SD) of whole milk averaged 1.66 ± 0.2 kg in the straw group, 1.54 ± 0.3 kg in the pellet mix group (ANOVA $P < 0.01$ compared to the straw group), and 1.56 ± 0.2 kg in the corn pellets group ($P < 0.001$) with no significant differences among the corn pellets and the pellet mix group. The results of the final multivariable regression model are presented in Table 5. The daily DMI (± SD) of skim milk powder was 0.40 ± 0.06 kg in the straw group, 0.36 ± 0.05 kg in the pellet mix group ($P < 0.001$), and 0.37 ± 0.07 kg in the corn pellets group ($P < 0.00001$) whereas no significant differences among the corn pellets and the pellet mix group were detected. The daily DMI (± SD) of the different solid feeds was 0.13 ± 0.03 kg for straw, 0.57 ± 0.4 kg for pellet mix (ANOVA $P < 0.00001$ compared to straw), and 0.44 ± 0.2 kg for corn pellets ($P < 0.00001$). Dry matter intake of solid feeds was higher in the pellet mix group compared to the corn pellets group ($P < 0.001$).

Health status

Clinical examination

At the beginning of the fattening period, 81 % (219/270) of calves showed at least 1 pathological finding with no significant differences among groups ($P > 0.05$). Coat signs were found in 38 % (103/270) of the calves, 32.2 % (87/270) showed at least one Respiratory Sign (RS), 31.1 % (84/270) were in a poor body condition, an umbilical abnormality was present in 17.4 % (47/270) of the calves, 13.3 % (36/270) had Digestive Signs (DS), and 1.5 % (4/270) had an elevated body temperature. In the weekly examinations, a total of 195 individual clinical examinations were performed if the calves were conspicuous in the group observation. In these examinations, RS were found most frequently (total score of 512). Further findings included elevated body temperature with a score of 51, reduced general condition with a score of 39, poor body condition with a score of 36, DS with a score of 34, umbilical abnormalities with a score of 4, and coat signs with a score of 1. No significant differences among groups were detected.

Medical treatment

Each feeding group was medicated with antibiotics once at the beginning of each PC. In the straw and corn pellets groups, number of Daily doses of Antibiotics (DDA; ± Standard Deviation SD) as group treatment averaged 11.7 ± 2.9 and in the pellet mix group 12.3 ± 3.7. Additionally, 34 % (94/270) of the calves were treated individually with antibiotics at least once. Individual DDA (± SD) averaged 1.9 ± 3.7 in the straw group, 1.3 ± 2.7 in the pellet mix group, and 3.5 ± 6.9 in the corn pellets group. The combination of individual and group treatment resulted in a mean total DDA (± SD) per calf of 14.1 ± 6.0. Antibiotics were administered significantly more often during PC1 than PC2 ($P < 0.001$) and there was also a significant interaction between feeding group and PC (Fig. 1).

Ruminating behavior

The number of ruminating movements per feeding bolus (± SD) averaged 49 ± 11.1 in the straw group, 55 ± 19.6 in the pellet mix group ($P < 0.01$), and 53 ± 11.2 in the corn pellets group ($P > 0.05$). Between the pellet mix and the corn pellets group, no significant difference was detected.

Table 5: Final multivariable regression model for the effect of initial weight, feeding treatment, sex, initial hemoglobin concentration (Hb) and production cycle on the dry matter intake (DMI) of whole milk of 270 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Variable	Group comparison	F-ratio	Regression coefficient	95 % confidence interval	P-value
Intercept			1.08	0.76–1.40	< 0.0001
Initial weight		8.34	0.006	0.002–0.01	0.004
Feeding treatment	Corn pellets vs. straw Pellet mix vs. straw	5.92	−0.01 −0.12	−0.17–−0.02 −0.19–−0.05	0.009 0.001
Initial Hb		10.2	0.003	0.001–0.004	0.002
Sex	Female vs. male	4.12	−0.1	−0.2–−0.003	0.04
Production cycle	PC1 (spring) vs. PC2 (summer) PC3 (winter) vs. PC2 (summer)	0.3	−0.03 −0.02	−0.1–0.04 −0.09–0.05	0.45 0.59

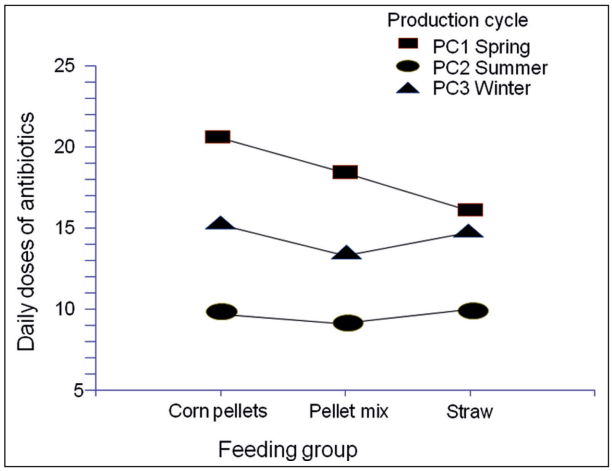

Figure 1: Daily doses of antibiotics administered to 270 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

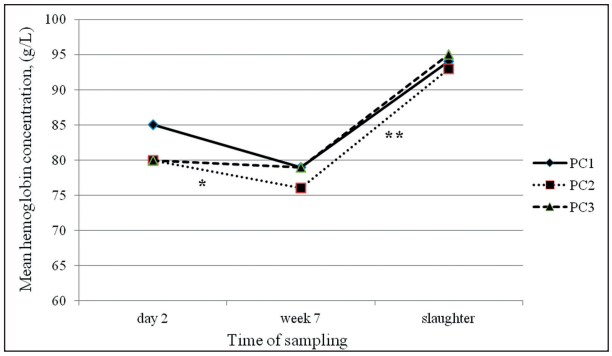

Figure 2: Development of mean hemoglobin concentration in 259 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system during PC1 (summer), PC2 (winter), and PC3 (spring).
* $P = 0.004$ referred to mean values of all 3 PCs from day 2 to week 7
** $P < 0.0001$ referred to mean values of all 3 PCs from week 7 to slaughter

Hematological status

Over all feeding treatments and samples, hemoglobin (Hb) averaged 84 ± 13.6 g/L, packed cell volume (PCV) 0.24 ± 3.4 L/L, mean corpuscular volume (MCV) ± 3.2 fL, mean corpuscular hemoglobin (MCH) 8.8 ± 1.3 pg, mean corpuscular hemoglobin concentration (MCHC) 345 ± 12.8 g/L, and concentration of hemoglobin per reticulocyte (CHr) 13.8 ± 0.8 pg. At slaughter, the pellet mix group had significantly higher Hb concentrations (98 ± 13.5 g/L) than the straw group (94 ± 10), the pellet mix group was also significantly higher for PCV (0.28 ± 3.4 L/L vs. 0.27 ± 3.03), MCV (25.3 ± 3.7 fL vs. 23.6 ± 3.4), and MCH (8.8 ± 1.5 pg vs. 8.2 ± 1.3). These hematological parameters were highly correlated with each other; Pearsons r ranged from 0.55 to 0.89 for the correlation among Hb, PCV, MCV and MCH, respectively. Consequently, the multivariable models for the different parameters were very similar. For this reason, only the model for Hb concentration at slaughter is presented (Tab. 6). The Hb concentration declined in all groups from week 1 to week 7 with an average level of 78 ± 12.4 g/L in week 7, and then increased again until slaughter (Fig. 2).

Abomasal lesions

The overall prevalence of mucosal lesions was 75 % (189/252) in the pylorus and 38 % (98/256) in the fundus. As opposed to pyloric lesions, prevalences of fundic lesions revealed significant differences among groups: 53.5 % (46/86) of calves of the straw group showed at least 1 mucosal lesion in the fundic part which is significantly more as compared to the corn pellets (25.6 %, 22/86, $P < 0.001$) and the pellet mix (35.7 %, 30/84, $P < 0.05$) groups (Fig. 3). Among the corn pellets and the pellet mix group no significant difference was detected. The results of the final multivariable logistic regression model are presented in Table 7.

Table 6: Final multivariable regression model for the effect of initial age, feeding treatment, initial hemoglobin concentration (Hb), sex and production cycle on hemoglobin concentration at slaughter of 244 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Variable	Group comparison	F-ratio	Regression coefficient	95 % confidence interval	P-value
Intercept			53.72	45.12–62.32	< 0.0001
Initial age		23.35	0.24	0.14–0.33	< 0.0001
Feeding treatment	Corn pellets vs. straw Pellet mix vs. straw	10.94	–3.72 4.28	–7.07–-0.37 0.86–7.71	0.03 0.01
Initial Hb		85.93	0.34	0.27–0.42	< 0.0001
Sex	Female vs. male	6.08	5.97	1.20–10.75	0.01
Production cycle	PC1 (spring) vs. PC2 (summer) PC3 (winter) vs. PC2 (summer)	2.56	3.42 0.18	0.06–6.78 –3.26–3.63	0.05 0.92

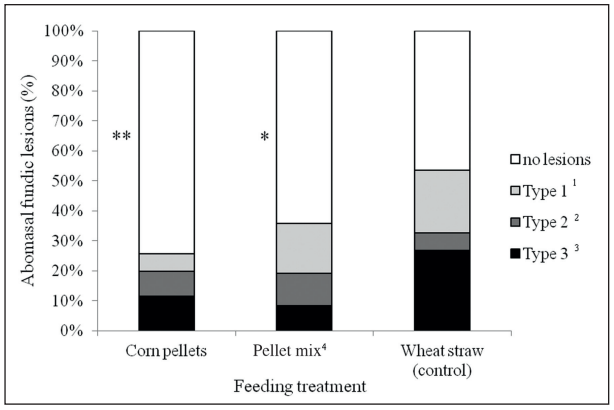

Figure 3: Distribution of macroscopic abomasal lesions in the fundic part of 256 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

[1] Superficial erosions with minimal mucosal defects and mucosal discolorations
[2] Deeper erosions, the center of the lesions being clearly depressed
[3] Craters with a superficial coating, apparent loss of tissue, and a central depression
[4] Composition: Oat hulls (36 %), corn (whole plant, 33 %), barley (8 %), sunflower seeds (8 %), squeezed grains of corn (7.5 %), molasses (5 %), Lignobond pellet binder (2.5 %)
* P < 0.05, **P < 0.001 as compared to the control group.
[4] Composition: Oat hulls (36 %), corn (whole plant, 33 %), barley (8 %), sunflower seeds (8 %), squeezed grains of corn (7.5 %), molasses (5 %), Lignobond pellet binder (2.5 %)

Ruminal content, pH and mucosa

The ruminal contents were assessed in 258 calves. Contents of 154 rumina (59.7 %) were considered normal. Abnormal ruminal content was noted in 40.2 % (35/87) of the calves in the straw group, 35.3 % (30/85) in the pellet mix group, and 45.3 % (39/86) in the corn pellets group with no significant differences among groups ($P > 0.1$). The most frequent abnormal finding was liquid content found in 61.5 % (64/104) of the rumina with abnormal content followed by pasty content found in 23 of rumina with deviating content (22 %).

Ruminal pH was determined in 225 calves. The pH of the ruminal liquid (± SD) averaged 6.36 ± 0.31 in the straw group, 6.42 ± 0.43 in the pellet mix group, and 6.33 ± 0.33 in the corn pellets group with no significant differences among groups ($P > 0.1$). Papillae had sufficiently developed in 200 rumina (77.5 %). Insufficient development of papillae was observed in 33.3 % (29/87) of the calves in the straw group, as compared to 17.6 % (15/85) in the pellet mix group ($P < 0.05$), and 16.3 % (14/86) in the corn pellets group ($P < 0.01$). The pellet mix group did not differ significantly from the corn pellets group. The results of the final multivariable logistic regression model are presented in Table 7.

Calf losses and necropsy

In total, calf losses (CL) amounted to 4.1 % (11/270), and no significant differences among groups were observed ($P > 0.5$). Seven calves died and 4 calves were euthanized during the fattening period. Gastro-intestinal disorders were the prevailing cause of death (46 %, 5/11), the most frequent diagnosis being perforated abomasal ulcers (3 cases). One calf died of a volvulus mesenterialis and in 1 calf, an acute abomasitis was diagnosed. Further necropsy findings included bacterial bronchopneumonia in 3 cases, interstitial pneumonia in 1 case, 1 calf died of an anaphylactic reaction due to iron injection and 1 calf suffered from miscellaneous disorders.

Growth performance and carcass quality

Based on the 259 calves slaughtered, slaughter age (± SD) averaged 157 ± 16.1 days, carcass weight (± SD) 120.4 ± 10.0 kg, and the duration of the fattening period (± SD) lasted 114.5 ± 13.2 days. The conformation of most carcasses (66.4 %, 172/259) yielded a medium meat quality (T). Furthermore, 1 % (2/259) were assessed as H, 29 %

Table 7: Final multivariable logistic regression models for the effect of feeding treatment and production cycle on abomasal fundic lesions and on rumen papillae of 258 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Model	Variable	Group comparison	Odds ratio	95 % confidence interval	P-value
Abomasal fundic lesions	Intercept		1.16	0.66–2.04	0.59
	Feeding treatment	Corn pellets vs. straw	0.29	0.15–0.56	< 0.001
		Pellet mix vs. straw	0.48	0.26–0.89	0.02
	Production cycle	PC1 (spring) vs. PC2 (summer)	1.38	0.73–2.60	0.31
		PC3 (winter) vs. PC2 (summer)	0.71	0.37–1.36	0.30
Insufficient rumen papillae	Intercept		0.09	0.04–0.22	< 0.001
	Feeding treatment	Pellet mix vs. corn pellets	1.10	0.49–2.47	0.82
		Straw vs. corn pellets	2.66	1.27–5.58	0.009
	Production cycle	PC1 (spring) vs. PC2 (summer)	3.21	1.45–7.10	0.004
		PC3 (winter) vs. PC2 (summer)	2.14	0.94–4.86	0.07

Table 8: Performance of 259 slaughtered Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Item	Wheat straw (control) n = 87	Pellet mix[3] n = 85	Corn pellets n = 87
Conformation[1] (number of calves)			
C	0 (0%)	0 (0%)	0 (0%)
H	1 (1.1%)	0 (0%)	1 (1.1%)
T	58 (66.7%)	53 (62.4%)	61 (70.1%)
A	24 (27.6%)	28 (32.9%)	23 (26.4%)
X	4 (4.6%)	4 (4.7%)	2 (2.3%)
Fat cover[2] (number of calves)			
1	6 (6.9%)	9 (10.6%)	2 (2.3%)
2	36 (41.4%)	29 (34.1%)	23 (26.4%)
3	43 (49.4%)	43 (50.6%)	58 (66.7%)
4	2 (2.3%)	4 (4.7%)	4 (4.6%)
Meat color (number of calves)			
pale	80 (92%)	70 (82.4%)	80 (92%)
pink	5 (5.7%)	11 (12.9%)	4 (4.6%)
red	2 (2.3%)	4 (4.7%)	3 (3.4%)
Mean (± SD[4]) average daily weight gain (kg)	1.29 ± 0.2	1.28 ± 0.2	1.33 ± 0.2
Mean (± SD) carcass weight (kg)	120.7 ± 9.3	119.7 ± 12.0	120.8 ± 8.5
Mean (± SD) duration of fattening period (days)	116.1 ± 13.6	115.1 ± 12.7	112.3 ± 13.2
Mean (± SD) age at slaughter (days)	159.8 ± 16.5	156.9 ± 17.2	155.0 ± 14.4

[1] C = very high, H = high, T = medium, A = low, X = very low quality
[2] 1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high fat cover
[3] Composition: Oat hulls (36%), corn (whole plant, 33%), barley (8%), sunflower seeds (8%), squeezed grains of corn (7.5%), molasses (5%), Lignobond pellet binder (2.5%)
[4] Standard Deviation

(75/259) and 4% (10/259) as A and X, respectively. The majority of carcasses (55.6%, 144/259) had a fat cover of the favored degree 3, 34% (88/259) of degree 2, 6.6% (17/259) of degree 1, and 3.9% (10/259) of degree 4. The meat color was pale in 88.8% (230/259), pink in 7.7% (20/270), and red in 3.5% (9/259). The average daily weight gain (ADG; ± SD) was 1.30 ± 0.22 kg, and no significant differences among groups were detected ($P > 0.1$, Tab. 8). Feed gain ratio averaged 1.75 ± 0.21 in the straw, 2.07 ± 0.59 in the mix pellets, and 1.83 ± 0.21 in the corn pellets group. Feeding itself did not reveal any significant differences, but there was significant interaction between feeding treatment and PC ($P < 0.001$, Fig. 4).

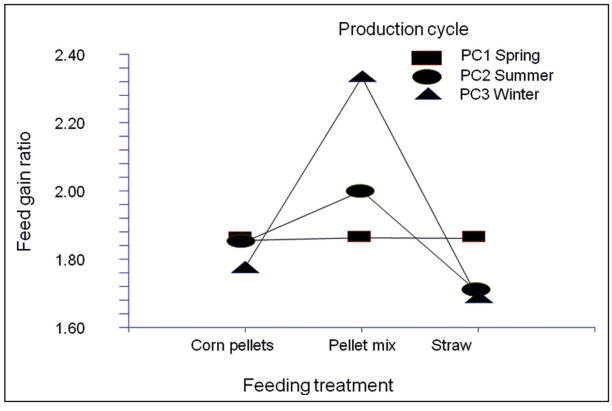

Figure 4: Feed gain ratio of 270 Swiss veal calves fed 3 different types of solid feeds in an *ad libitum* feeding system.

Discussion

In accordance with part I, this study confirms that the additional feeding of corn pellets complies best with the calves' performance, physiology, and health status despite a different setting with respect to housing and management conditions as well as a diet relying on whole milk as opposed to liquid milk by-products.

Straw as the exclusive solid supplement had the most detrimental effect on physiological and health parameters, whereas calves of the corn pellets group generally showed the best results in terms of performance. Overall carcass conformation was low for Swiss standards. It may have been affected by the high proportion of dairy breed calves, their relatively low initial BW, and the unfavorable progression of blood Hb concentrations

over the first 7 weeks. As approximative data in part I showed, but in contrast to Labussière (2009) and Roy (1971), data in this study confirmed that the provision of solid feed *ad libitum* had an adverse effect on the DMI of the liquid feed. The overall prevalence of abomasal fundic lesions (38 %) was high in comparison with part I and preceeding studies (Welchman and Baust, 1987; Bähler et al., 2010a). Some factors like stress due to suboptimal feeding such as one artificial teat per group of 30 calves (parallel suckling was prevented in favor of individual data collection), or housing management (no outside pen), or hypersensitive reactions of the abomasal mucosa due to a high percentage of ingredients of plant origins (Toullec and Lallès, 1996) could also have contributed to the development of fundic lesions (Bähler et al., 2010b). However, the prevalence of fundic lesions in calves of the groups pellet mix and corn pellets was significantly lower as compared to calves of the straw group. In accordance to Bähler et al. (2010a), we suppose that the free access to a palatable feed such as pellet mix or corn pellets superseded the uptake of straw, thus reducing the incidence of fundic lesions in the corresponding groups.

Furthermore, the proportion of calves with inadequate development of ruminal papillae and inadequate ruminating behavior was unsatisfactory in the straw group. Supplementing the liquid diet with the pellet mix or corn pellets had a positive effect on the development of ruminal papillae and on ruminating behavior. No effect of feeding treatment could be found with respect to the occurrence of bovine respiratory disease and the use of antibiotics. Notwithstanding, the use of antibiotics could be kept on a remarkably low level (14 DDA on average) as compared to Bähler et al. (2010b) and Luginbühl et al. (2012) even though 81 % of the calves showed signs of illness at the beginning of the fattening period. We suspect this prudent and effective use of antibiotics to result from the intensive supervision and the immediate interventions by the caretakers and the veterinarian.

As in part I, the mean Hb concentrations at slaughter were similar to the values observed under conventional veal calf fattening conditions (Welchman et al., 1988; Egger, 1991; Lindt and Blum, 1993; Stull and McDonough, 1994; Wilson et al., 2000). Unexpectedly, the Hb concentration declined in all groups despite the injection of iron-dextran and dietary supplementation with a premix containing iron. We assume that the bioavailability of iron in premixes is inconsistent and that blood Hb concentrations may hardly be raised to physiological levels when starting from precarious values at the beginning of the fattening period.

In summary, the higher prevalence of abomasal lesions, of insufficiently developed ruminal papillae and a decreased ruminating behavior of calves fed whole milk supplemented with straw corroborate the findings of precedent studies (van Putten, 1982; van der Mei, 1985; Bähler et al., 2010a) which already established the negative impact of this feeding regimen on the calves' health status. Whole plant corn pellets as a solid supplement to whole milk diet complied best with the calves' physiological requirements and with the demands of the market with respect to the performance including meat color. In future, special attention should be paid to the blood parameters including the provision of iron, and reliable threshold values matching specific environments are needed. Such data are required in order to assess the interrelationship between blood Hb, meat color and serum iron in veal calves.

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Influence des aliments solides sur la santé et la productivité des veaux d'engraissement en Suisse. II: Lait entier comme nourriture de base

Le but de cette étude était de trouver une alternative adéquate à la paille utilisée actuellement en tant qu'adjonction au lait entier. Pour cela, on a étudié l'effet de trois aliments solides différents sur la santé et la productivité de veaux suisses durant 3 périodes d'engraissement avec à chaque fois 90 veaux, une

L'influenza di alimenti solidi sulla salute e le prestazioni dei vitelli da ingrasso svizzeri. II: Latte intero come alimento di base

Lo scopo di questo studio era di trovare una buona alternativa all'alimentazione, tenuta finora, a base di paglia con aggiunta di latte intero. Sono stati studiati gli effetti di 3 diversi foraggi solidi sulla salute e le prestazioni di vitelli da ingrasso svizzeri durante 3 periodi di ingrasso con ognuno 90 vitelli, un'età di inserimento in media di 42 giorni e un peso di inserimento me-

durée d'engraissement moyenne de 42 jours et un poids moyen de 68.7 kg au début de l'engraissement. Les veaux ont été détenus par groupes de 30 dans des écuries paillées sans enclos extérieur. L'alimentation liquide *ad libitum* se composait de lait entier complété par de la poudre de lait maigre. Les groupes ont reçu aléatoirement l'un des trois aliments solides testés, à savoir : cubes mélangés (composés de son d'avoine, de maïs plante entière, de graines de tournesol, de maïs aplati, de mélasse et de LignoBond DD comme agglomérant), cubes de maïs plante entière ou paille (groupe de contrôle). Les veaux du groupe «paille» présentait, comparativement à ceux des deux autres groupes, significativement plus de lésions de la caillette dans la zone du fundus (< 0.001), le nombre de veaux avec des villosités de la panse insuffisamment développées était plus élevé ($P < 0.05$) et la rumination était insatisfaisante. Contrairement à ceux des groupes «cubes mélangés» et «paille», les performances des veaux complémentés avec des cubes de maïs étaient bonnes et leurs carcasses correspondaient au mieux à la demande du marché. En outre, la prévalence de lésions de la caillette dans la zone du fundus était la plus basse chez les veaux nourris avec des cubes e maïs ($P < 0.001$) et le développement de la panse était le meilleur ($P < 0.01$). Comme dans la partie I de cette étude, les résultats présentés indiquent que les cubes de maïs plante entière sont une alternative applicable à l'affouragement de paille tel que pratiqué jusqu'à maintenant pour les veaux d'engrais.

dio di 68.7 kg. I vitelli sono stati tenuti in gruppi di 30 animali in stalle su lettiera di paglia senza possibilità di uscita all'aperto. Il nutrimento liquido preso *ad libitum* era costituito da latte intero completato da latte scremato in polvere. I gruppi sono stati suddivisi in modo casuale per la loro idoneità a testare il foraggio grezzo: cubetti mix (composti di scafi di avena, mais da pianta intera, orzo, semi di girasole, semi di mais schiacciati, melassa, pellet Lignobond DD, cubetti di mais da pianta intera e paglia (controllo). I vitelli del gruppo paglia manifestavano, in rapporto ai vitelli del gruppo cubetti mix e cubetti di mais ($P < 0.001$), più lesioni dell'abomaso nell'area del fondo, una maggiore percentuale di vitelli con uno sviluppo insufficiente dei villi del rumine ($P < 0.05$) e un comportamento durante la ruminazione insoddisfacente. Al contrario dei gruppi cubetti mix e paglia, le prestazioni dei vitelli che erano stati nutriti con cubetti di mais erano buone e le loro carcasse erano le migliori per le esigenze del mercato. Inoltre, la prevalenza delle lesioni dell'abomaso nell'area del fondo nei vitelli del gruppo cubetti di mais era più bassa ($P < 0.001$) e lo sviluppo del rumine migliore ($P < 0.01$). Come discusso nella parte I di questo lavoro, i risultati disponibili indicano che i cubetti di mais da pianta intera sono un'alternativa adeguata al foraggio con paglia esistente nei vitelli da ingrasso.

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Corresponding author

Prof. Dr. Adrian Steiner
Head of the Clinic for Ruminants
University of Bern
Vetsuisse Faculty
Bremgartenstrasse 109a
3012 Bern
Tel.: +41 (0)31 631 23 44
Fax: +41 (0)31 631 26 31
adrian.steiner@vetsuisse.unibe.ch

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