Hydrolyzed wheat gluten protein in CMR's and veal feed formulas

Literature review/citations; March 2022; Dave Wood, Animix

Take home messages of these 29 studies in this graph:

Milk fed calf wheat studies - in a glance … Journal of Dairy Sci (JDS); The Professional Animal Scientist (PAS); Reprod Nutr. Dev (Rep. Nutr.); EAAP Pub. (Veal Pub)

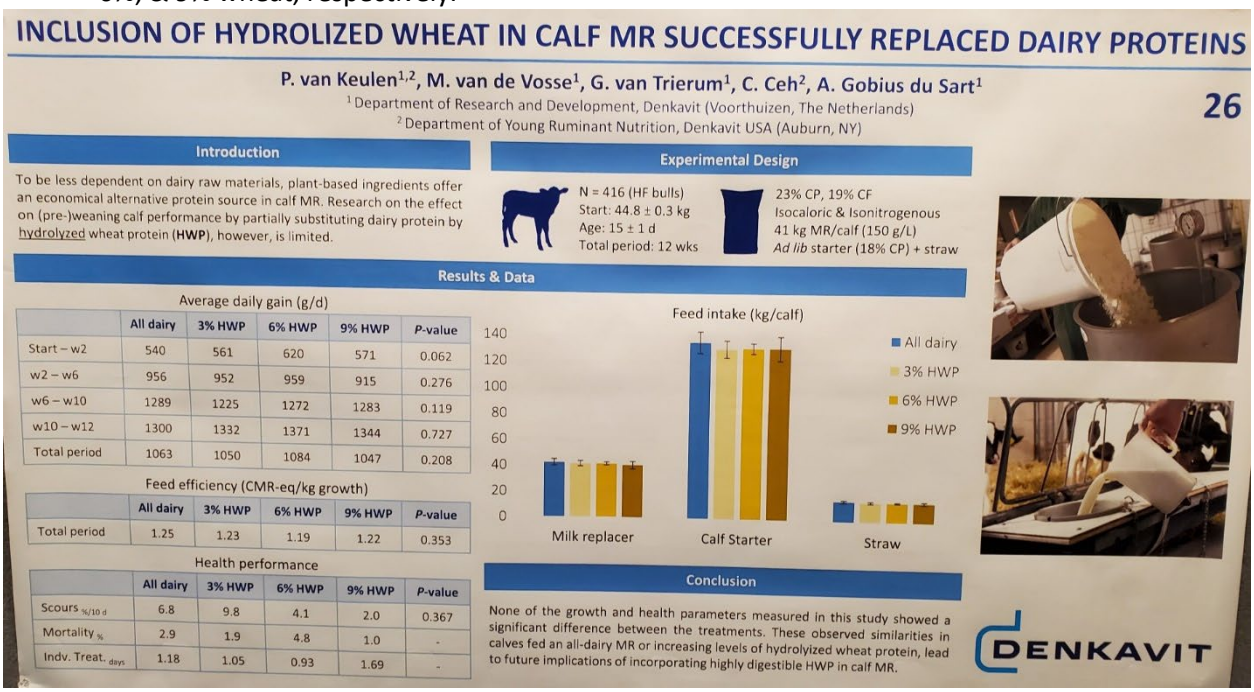
Wheat positive in performance (Blue font) 16 studies. Wheat negative in performance (red font) 7 studies. Wheat mixed in performance (Black font) 6 studies

Researcher	Published?	Year	n	Calf age at start (days)	% Wheat in CMR tested	Wheat brand?	Performance comment
Denkavit, NL	Poster	2021	416	15 ±1	3%,6%,9%	ADM Nutrior	90 lbs. CMR/calf. NSD in ADG, feed efficiency or health.
U of Illinois	JDS	2020	103	3	6.1% wheat + 6.33% plasma	Solpro 508	NSD prewean ADG or in health; ↑starter intake in wheat/plasma post wean. +9.5 lbs. at 12 wks for wheat/plasma over all milk
Waseca & MSG	Poster	2019	103	not reported	36% of CP replaced; wheat, soy, plasma	Not reported	If coconut oil was used at 15% of fat blend, the alternative protein blend performed as well as the all-milk. If all lard (no coco) then AP blend performed more poorly, both in ADG and in scour days.
Mapleview Agri	Poster	2019	240	7	3%	Not reported	NSD prewean ADG or health. Wheat ↓post wean ADG and d 1 - 78 ADG
Waseca & Animix	Poster	2016	130	2 - 5	15%	Manildra & ADM	Study compared ADM Nutrior and Gempro 7700 wheat proteins, and GemPro with Plasma, and Plasma alone. All groups vs. all milk noted NSD in ADG, starter intake, body dimensions or health.
SDSU & MSG	Poster	2015	88	3	20.8% wheat & 33.4% plasma	Not reported	24:18 w/wheat & plasma performed comparably to 24:18 and a 20:20 composed of AM. All fed at 1.5 lbs./d.
Waseca & MSG	Poster	2015	52	2 - 5	22% wheat & 35% plasma	Not reported	23:21 w/wheat & plasma performed comparably to 56 d, but tended poorer ADG prewean (d 42). NSD in health.
Waseca/Hubbard/MPI	Poster	2014	105	2 - 5	50% of CP replaced; wheat/plasma/SPC combos	ADM Nutrior	NSD in pre- or post-wean ADG or in starter intake. Pre-wean G:F was improved for plasma/wheat vs. SPC/wheat or SPC/Wheat/Plasma combo and was similar to all-milk. Fecal score higher for All Milk vs. all other diets and scouring days greater for all--milk vs. soy/plasma and wheat/plasma. Calves 2x BW by 56 d.
Provimi	Poster	2013	100	2 - 3	6% wheat or 3% wheat and 3% plasma	Not reported	1.46 lbs/d CMR to wean d 28. Starter intake, ADG, change in hip width were greatest for calves fed all-milk vs. all others (6% plasma, 6% wheat, 3% plasma + 3% wheat, 6% plasma + 6% wheat). Calves were healthy in the study, NSD between groups. All groups 1.25x (or greater) Birth weight at 56 d
Waseca	Poster	2013	55	2 - 4	33% of CP	Cargill	Performed comparably to all-milk. NSD in health, starter, or feed conversion
U of Illinois	JDS	2016	57	2	21% & 42% of CP	ADM Nutrior	105 lbs. 28:15 CMR; NSD in 56 or 90 d ADG wheat formulas vs. all-milk. NSD in health. Very good paper to determine ideal amino acid content of wheat formulas (amino acid element to the trial). Starter grain introduced d 28.
Waseca & MPI	Poster	2009	125	2 - 4	Not reported	Not reported	Wheat/plasma NSD ADG, reduced scours, and increased starter intake
Animix	Poster	2009	120	App. 7 d	6% wheat & 5% plasma	MGP FP100	All milk improved ADG d 1 - 14, Wheat plasma tended to ↑ADG d 15 - 43 and improved ADG d 29 - 43. Wheat/plasma ↓grain refusals.
Provimi	PAS	2008	32	<1 week	15% of CP	Not reported	Wheat reduced ADG, starter intake and hip width change. NSD in health
Provimi	PAS	2008	48	2 - 4 d	19% & 38% of CP	Not reported	Linear reduction in ADG, hip width change and G:F as wheat increased
Vigortone	Poster	2008	70	10 ±4	50% of CP	Not reported	NSD in body weight gain. Wheat tended to increase grain intake
Waseca/MSG	PAS 2016 Poster 2007	2007	126	2 - 4 d	Wheat 50%, 30%, and 25% + 25% SPC of CP	ADM Nutrior	Wheat replacing either 30% or 50% of CP, or wheat used with SPC (both at 25% of CP) all reduced ADG. 48 lbs. 20:20 over 42d. Calves fed AM noted improved (+9 lbs.) BW gain vs. all other groups. Starter intake ↓
INRA, France	Repro Nutr	2003	39	39	49 & 61%	Solpro 500	Veal Grower and Veal Finisher study. NSD in ADG or G:F. Valuable branch chain amino acid element to study. NSD health. Blood work examining amino acid content
Merrick's	none	2000	60	unsure	5% & 8%	Solpro 508	NSD in weekly body weight measures. NSD in scour days.
INRA, France	A Fd Sci	1998	6	9 - 10 wks	24 & 76% of CP	Solpro 050	Apparent ileal digestibility 91%, 89%, 85% for all-milk, 24% of CP wheat, and 76% of CP wheat, respectively. Soluble wheat gluten protein reduced protein digestibility. However, aggressive use rate and ↓is nominal
Milk Specialties	Poster	1997	150	3	Not reported	MGP?	NSD in ADG or feed conversion
Kansas State U	JDS	1996	120	1 - 3	30% & 50% of CP	MGP FP100	NSD in body weight gain or starter intake.
INRA, France	Rep. Nutr	1995	6	8 wks	52% of CP	Gluten	Vital wheat gluten NOT hydrolyzed. DM digestibility reduced from 96% to 94% in vital wheat gluten fed calves. Nitrogen digestibility numerically reduced from 95% to 93% in wheat. Fat digestibility reduced from 93% to 87% in wheat gluten
Milk Specialties	Poster	1994	240	2 - 4	10 to 20% of CP with SPC	MGP?	NSD in 56 d ADG or total starter intake. Some reductions in d 1 - 14 ADG & in post-wean grain intake depending on the group (7 alternative protein formulas).
Vitek	none	1994	102	Auction	16.5% & 32.5% of CP	MGP	Special milk fed veal. ADG the same between WPC-control and low (16.5% of CP) wheat diet, but high wheat diet (32.5%) resulted in lesser growth d 41 onward
Vitek	none	1994	98	Auction	15% of CP	MGP	Special milk fed veal. ADG between all-milk and wheat (15% of CP) NSD
Milk Specialties	Poster	1993	120	unsure	50% of CP	MGP & Solpro	NSD in ADG or feed conversion. All milk vs. MGP vs. Solpro vs. SPC
INRA, France	Ann Zootech	1992	3	12 weeks	23.7% of CP	Not reported	Digestibility was 87% vs. 93% for wheat vs. casein-based formulas, respectively. Lower. However, use rate is high, product was new, perhaps not optimal, and difference not so great
ILOB, Wageningen NL	Veal Publ.	1991	15	56 - 64	28.5% of CP	Solpro	Digestibility of wheat protein 96%.

Listed in **chronological** order, newest to oldest, and key findings and study parameters listed in in bullet-points or graphs:

Key study: Van Keulen P. M. van de Vosse, G. van Trierum, C. Ceh, and A. Gobius du Sart. **2021**. Inclusion of hydrolized wheat in calf MR successfully replaced dairy proteins. 41st ADSA Discover Conference: Health management of calves: from intrauterine life to successful weaning. Itasca, IL. Poster 26.

- Performed comparable to all milk; 90 lbs. 23:19 CMR/calf over 9 wks, either 0%, 3%, 6%, or 9% wheat.
- Denkavit. n=**416** Holstein bull calves, age 15 ±1d. ADM Nutrior, sole vege protein source. 9.6%, 20.9%, or 31.3% of whey-based protein replaced using 3%, 6%, and 9% inclusion rate, respectively. Ad lib 18% CP starter and chopped straw. NSD in ADG at 0 – 2, 2 – 6, 6 – 10, or 10-12 wks. NSD in grain intake. NSD in health. 12-wk ADG 2.34, 2.31, 2.39, 2.31 lbs./d for 0%, 3%, 6%, & 9% wheat, respectively.



INCLUSION OF HYDROLIZED WHEAT IN CALF MR SUCCESSFULLY REPLACED DAIRY PROTEINS

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26

Introduction

To be less dependent on dairy raw materials, plant-based ingredients offer an economical alternative protein source in calf MR. Research on the effect on (pre-)weaning calf performance by partially substituting dairy protein by hydrolyzed wheat protein (**HWP**), however, is limited.

Experimental Design

N = 416 (HF bulls)
Start: 44.8 ± 0.3 kg
Age: 15 ± 1 d
Total period: 12 wks

23% CP, 19% CF
Isocaloric & Isonitrogenous
41 kg MR/calf (150 g/L)
Ad lib starter (18% CP) + straw

Results & Data

Average daily gain (g/d)

	All dairy	3% HWP	6% HWP	9% HWP	*P*-value
Start – w2	540	561	620	571	0.062
w2 – w6	956	952	959	915	0.276
w6 – w10	1289	1225	1272	1283	0.119
w10 – w12	1300	1332	1371	1344	0.727
Total period	1063	1050	1084	1047	0.208

Feed efficiency (CMR-eq/kg growth)

	All dairy	3% HWP	6% HWP	9% HWP	*P*-value
Total period	1.25	1.23	1.19	1.22	0.353

Health performance

	All dairy	3% HWP	6% HWP	9% HWP	*P*-value
Scours %/10 d	6.8	9.8	4.1	2.0	0.367
Mortality %	2.9	1.9	4.8	1.0	-
Indv. Treat. days	1.18	1.05	0.93	1.69	-

Feed intake (kg/calf)

Conclusion

None of the growth and health parameters measured in this study showed a significant difference between the treatments. These observed similarities in calves fed an all-dairy MR or increasing levels of hydrolyzed wheat protein, lead to future implications of incorporating highly digestible HWP in calf MR.

DENKAVIT

Key study: Grice KD, Glosson KM, Drackley JK, et al. Effects of feeding frequency and protein source in milk replacer for Holstein calves. J Dairy Sci **2020**; 103:10048-10059. https://doi.org/10.3168/jds.2020-19041.

- Holstein calves (n=103; 59 male and 44 female; from the university herd) averaging approximately 95 lbs. with colostrum status of between 33.8 and 37.2 g IgG/L of serum, depending on the group measure reported (i.e., excellent colostrum status), were placed in wheat-straw bedded hutches on the university dairy from December 2014 to January 2016. Only one calf in the entire study had a failure of passive transfer.
- After colostrum, calves were fed a whey-based CMR (Excelerate, MSG; 28:15) for 2 d after initial colostrum feeding, and then started on their respective diet at 520 g/d (d 3 – 10) then 680 g/d d 11 – 20, then 840 g/d day 21 to 42, and finally 420 g/d during a wean d 43 – 45, 47, 49 and 51.
- Calves were fed 75 lbs. of 25:17 milk replacer per calf over a 51-day period in a step-up, step-down feeding strategy peaking at 1.76 lbs. of powder per day weeks 4 - 6 with a weaning

strategy of 0.93 lbs. of powder daily d 43 to 45, d 47, 49, and 51, with no CMR fed d 46, 48, and 50 (an interesting, novel, wean strategy) and a complete wean d 52.

- Calves were fed either a.) an all-milk composed of whey-based proteins, or, b.) 44% of the whey-based protein replaced by a 50:50 blend of hydrolyzed wheat protein (6.1% inclusion, Tereos Starch and Sweeteners, Belgium, I assume Solpro 508) and spray-dried bovine plasma (6.33% inclusion, APC Nutrapro B plasma).
- Both diets were formulated to 2.34% lysine and 0.76% methionine using L-lysine and DL-methionine supplementation, with no standardization for threonine or isoleucine. A pelleted calf starter (Ampli-Calf Starter 20P, 24% C.P.) was offered ad-lib.
- Calves were also fed in either a 2x or 3x per day feeding strategy (with the same daily quantity of milk replacer offered to both groups) with intervals between feeding for the 3x strategy of 7.5, 7, and 9.5 hours, so, in summary, the study was a 2 x 2 factorial examining either an all-milk or a wheat/plasma CMR fed either via a 2x/d or 3x/d feeding strategy.

Results:

- NSD (no significant difference) due to type of milk replacer weeks 0 - 6 in ADG, however, weeks 7 to 9 starter grain intake was greater (P=0.006; avg. 4.15 vs. 4.65 lbs./d) in calves fed wheat/plasma as compared to the all-milk CMR, and,
- this resulted in improved calf body weight (P=0.02) of +9.5 lbs. at 12 weeks age for the calves fed wheat/plasma (215.4 lbs. vs. 225.8 lbs.) as compared to the all-milk CMR. The authors hypothesize that either rumen development was improved, or water intake was greater (not measured) in the calves fed wheat/plasma CMR.
- Avg milk replacer intake was slightly greater weeks 1 - 8 (608 vs. 605 grams/day; P=0.004) for the all-milk vs. the wheat/plasma, and the authors note this was due to slightly fewer milk replacer refusals for the calves fed all-milk milk replacer in the early days of the study.
- A detailed odds-ratio analysis was conducted comparing health parameters and no differences were noted in cumulative days with either diarrhea, sick behavior, or abnormal temperatures. Only four calves in the entire study were treated for a suspected respiratory infection. Calves fed CMR 2x/d tended improved weeks 0 - 6 ADG (P=0.09; 1.21 vs. 1.12 lbs/d) vs. those fed CMR 3x/d, however, NSD weeks 6, 7 or 8
- NSD in blood metabolites (total protein, albumin, total globulin, glucose, or BHB) between wheat/plasma and all-milk, except for serum urea nitrogen being greater (P=0.01) in the calves fed the all-milk protein CMR
- Outside of hip width tending (P=0.06) greater for wheat/plasma-fed calves, no other differences noted in body dimensions.

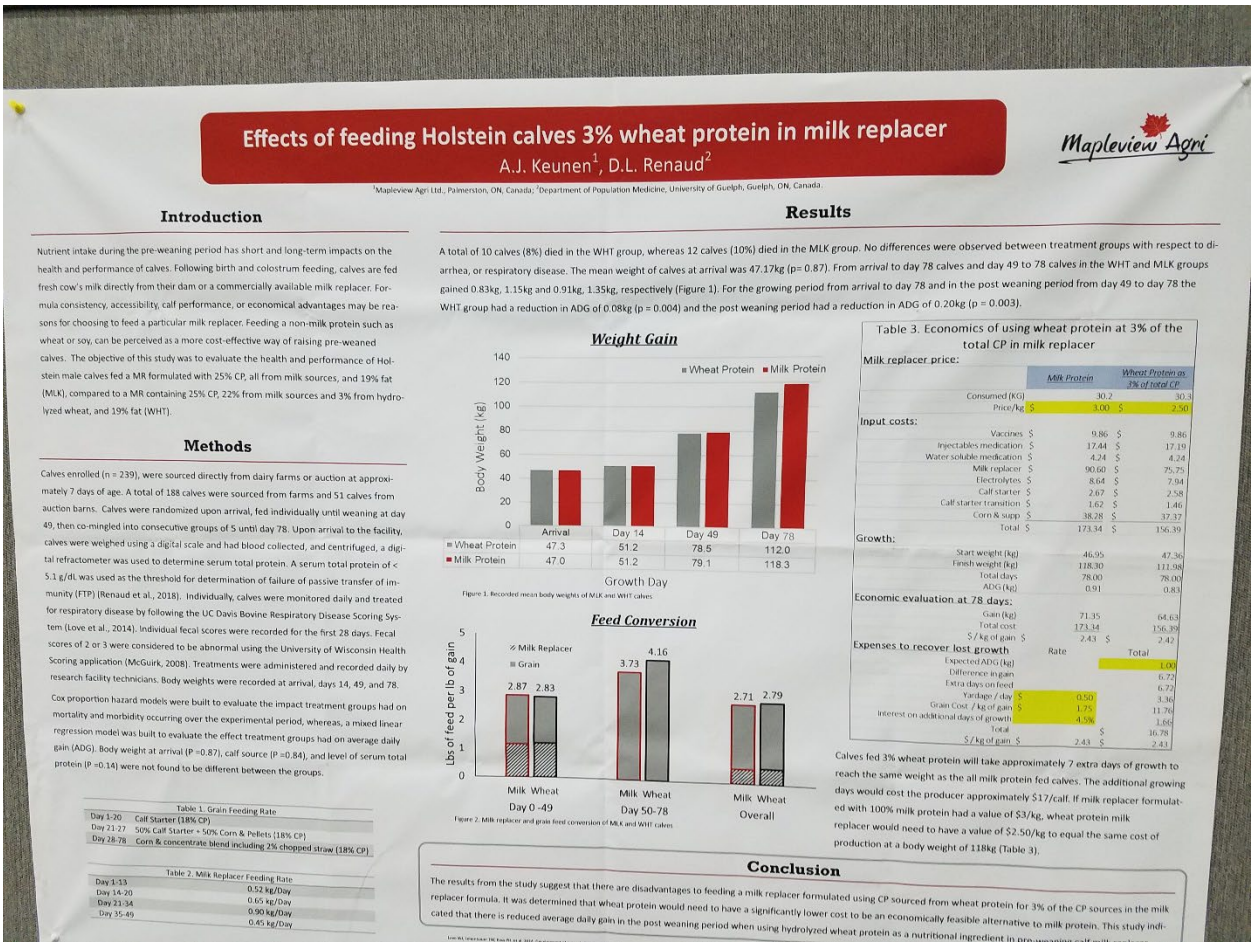
Ziegler D., H Chester-Jones, C. Soderholm and B. Hansen. **2019**. pre-and post-weaning performance and health of dairy calves fed milk replacers formulated with alternative blended protein and fat sources at different levels of protein. *J Dairy Sci* 102, E-Suppl. 1, Abstract M163, 68.

- Bottom line: 25:20 w/35.6% of CP combo plasma/soy/wheat (AP) w/15% fat from coconut performed comparably to 25:20 all milk and ↑ADG vs. same AP w/100% animal fat. U of MN, Waseca.
- *Coconut oil in fat source when feeding alternative protein blend.* Holstein heifer calves were fed 1.5 lbs. per d CMR composed of either a.) 20% C.P., 20% fat, all milk protein, all animal fat, or b.) 25:20 all milk protein, all animal fat, or c.) 25:20 with a combination of plasma, soy isolate and hydrolyzed wheat protein replacing 35.6% of C.P., all animal fat, or d.) 25:20 with the same alternative protein blend, however, with 15% of fat as coconut oil. Weaning occurred d 42 – 49 by cutting to 1x/d fdg (0.75 lbs./d). Neomycin OTC was fed for initial 14 d. Texturized 18% C.P.

starter containing Deccox was offered ad lib. Study occurred May – August. Calves fed the 25:20 all milk, animal fat (1.5 lbs. ADG), and those fed the 25:20 alternative protein blend with 15% of fat as coconut oil (1.43 lbs. ADG) tended (P<0.1) to outgain d 1 - 56 the 20:20 all milk with animal fat (1.34 lbs. ADG) and the 25:20 protein blend with 100% animal fat (1.32 lbs. ADG). No differences in d 56 calf starter intake (avg. 67.7 lbs./calf), G:F ratio, health costs or daily fecal scores across treatments. Scouring days tended higher (P<0.1) for calves fed 25:20 alternative protein blend with 100% animal fat as compared to the other 3 treatments. 103 calves. U of MN Waseca. Milk Specialties Global. M163.

Keunen A.J., D.L. Renaud. **2019**. Effects of feeding Holstein calves 3% wheat protein in milk replacer. *J Dairy Sci* 102, E-Suppl. 1, Abstract W48, 336.

- 12.5% of CP from hydrolyzed wheat protein (25:19 CMR) noted same ADG, no diff in health prewean, but ↓ADG post wean both (d 49 – 78) and d 1 – 78. Mapleview Agri, Ontario.
- *12.5% of CP profile in CMR from hydrolyzed wheat protein. Any effect on growth?* Auction (188 calves) or direct from farm (51) sourced bull calves (app. 7 d age) were individually housed and fed 25% CP, 19% fat CMR composed of either all-milk protein or 22% CP from milk protein and 3% from wheat (12.5% of CP profile). Lysine, methionine, and threonine were balanced. Calves consumed 66.6 and 66.8 lbs. of CMR powder over the 49-d milk feeding period in the all-milk protein and 3% wheat protein CMR's, respectively. Peak CMR intake was 1.98 lbs./calf/d and all calves experienced a 14 d wean period. Texturized calf starter (18% CP) was offered ad lib and a second phase starter composed of 50% whole corn and 50% pellets (18% CP) was transitioned to on d 21 – 27. Mortality was 8% (10 calves) and 10% (12 calves) for calves fed wheat protein and all-milk protein, respectively. No differences noted in the incidence or severity of enteric or respiratory disease and expenditures on injectable meds (averaged $17.32/calf) and water-soluble meds ($4.24/calf, the same between groups) were nearly identical. No differences were noted in ADG or feed conversion during the 49-d milk feeding period and calves gained 68.7 and 70.8 lbs. when fed the wheat protein containing and all-milk formulas, respectively. However, calves fed the all-milk outgained those fed wheat protein during the post-wean d 49 – 78 growth period (wheat-fed calves noted reduced 0.44 lbs. ADG post-wean, P<0.003) and for the entire 78 d study period (wheat-fed calves noted reduced 0.18 lbs. ADG, P<0.004; 1.82 and 2.0 lbs. ADG). Combined milk and grain feed conversion were nearly identical pre-wean (2.83 and 2.87), however, post-wean was 4.16 and 3.73 lbs. of feed per lb. of bodyweight gain for wheat-fed and all-milk-fed calves, respectively. A detailed economic analysis noted cost per **kg** of gain to 78 d nearly identical at $2.43 and $2.42 ($1.10 and $1.097 per pound, US$), however, with 7 extra days yardage to reach the same BW the all-milk CMR provides greater ROI. n=240. Mapleview Agri. U of Guelph. W48.



Effects of feeding Holstein calves 3% wheat protein in milk replacer

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Mapleview Agri

Introduction

Nutrient intake during the pre-weaning period has short and long-term impacts on the health and performance of calves. Following birth and colostrum feeding, calves are fed fresh cow's milk directly from their dam or a commercially available milk replacer. Formula consistency, accessibility, calf performance, or economical advantages may be reasons for choosing to feed a particular milk replacer. Feeding a non-milk protein such as wheat or soy, can be perceived as a more cost-effective way of raising pre-weaned calves. The objective of this study was to evaluate the health and performance of Holstein male calves fed a MR formulated with 25% CP, all from milk sources, and 19% fat (MLK), compared to a MR containing 25% CP, 22% from milk sources and 3% from hydrolyzed wheat, and 19% fat (WHT).

Methods

Calves enrolled (n = 239), were sourced directly from dairy farms or auction at approximately 7 days of age. A total of 188 calves were sourced from farms and 51 calves from auction barns. Calves were randomized upon arrival, fed individually until weaning at day 49, then co-mingled into consecutive groups of 5 until day 78. Upon arrival to the facility, calves were weighed using a digital scale and had blood collected, and centrifuged, a digital refractometer was used to determine serum total protein. A serum total protein of < 5.1 g/dL was used as the threshold for determination of failure of passive transfer of immunity (FTP) (Renaud et al., 2018). Individually, calves were monitored daily and treated for respiratory disease by following the UC Davis Bovine Respiratory Disease Scoring System (Love et al., 2014). Individual fecal scores were recorded for the first 28 days. Fecal scores of 2 or 3 were considered to be abnormal using the University of Wisconsin Health Scoring application (McGuirk, 2008). Treatments were administered and recorded daily by research facility technicians. Body weights were recorded at arrival, days 14, 49, and 78.

Cox proportion hazard models were built to evaluate the impact treatment groups had on mortality and morbidity occurring over the experimental period, whereas, a mixed linear regression model was built to evaluate the effect treatment groups had on average daily gain (ADG). Body weight at arrival (P =0.87), calf source (P =0.84), and level of serum total protein (P =0.14) were not found to be different between the groups.

Table 1. Grain Feeding Rate

Day 1-20	Calf Starter (18% CP)
Day 21-27	50% Calf Starter + 50% Corn & Pellets (18% CP)
Day 28-78	Corn & concentrate blend including 2% chopped straw (18% CP)

Table 2. Milk Replacer Feeding Rate

Day 1-13	0.52 kg/Day
Day 14-20	0.65 kg/Day
Day 21-34	0.90 kg/Day
Day 35-49	0.45 kg/Day

Results

A total of 10 calves (8%) died in the WHT group, whereas 12 calves (10%) died in the MLK group. No differences were observed between treatment groups with respect to diarrhea, or respiratory disease. The mean weight of calves at arrival was 47.17kg (p= 0.87). From arrival to day 78 calves and day 49 to 78 calves in the WHT and MLK groups gained 0.83kg, 1.15kg and 0.91kg, 1.35kg, respectively (Figure 1). For the growing period from arrival to day 78 and in the post weaning period from day 49 to day 78 the WHT group had a reduction in ADG of 0.08kg (p = 0.004) and the post weaning period had a reduction in ADG of 0.20kg (p = 0.003).

Weight Gain

	Arrival	Day 14	Day 49	Day 78
Wheat Protein	47.3	51.2	78.5	112.0
Milk Protein	47.0	51.2	79.1	118.3

Figure 1. Recorded mean body weights of MLK and WHT calves

Feed Conversion

Figure 2. Milk replacer and grain feed conversion of MLK and WHT calves

Table 3. Economics of using wheat protein at 3% of the total CP in milk replacer

Milk replacer price:		Milk Protein		Wheat Protein as 3% of total CP
Consumed (KG)		30.2		30.3
Price/kg	$	3.00	$	2.50
Input costs:				
Vaccines	$	9.86	$	9.86
Injectables medication	$	17.44	$	17.19
Water soluble medication	$	4.24	$	4.24
Milk replacer	$	90.60	$	75.75
Electrolytes	$	8.64	$	7.94
Calf starter	$	2.67	$	2.58
Calf starter transition	$	1.62	$	1.46
Corn & supp	$	38.28	$	37.37
Total	$	173.34	$	156.39
Growth:				
Start weight (kg)		46.95		47.36
Finish weight (kg)		118.30		112.08
Total days		78.00		78.00
ADG (kg)		0.91		0.83
Economic evaluation at 78 days:				
Gain (kg)		71.35		64.63
Total cost		173.34		156.39
$ / kg of gain	$	2.43	$	2.42
Expenses to recover lost growth		Rate		Total
Expected ADG (kg)				1.00
Difference in gain				6.72
Extra days on feed				6.72
Yardage / day	$	0.50		3.36
Grain Cost / kg of gain	$	1.75		11.76
Interest on additional days of growth		4.5%		1.86
Total			$	16.78
$ / kg of gain	$		2.43	$ 2.43

Calves fed 3% wheat protein will take approximately 7 extra days of growth to reach the same weight as the all milk protein fed calves. The additional growing days would cost the producer approximately $17/calf. If milk replacer formulated with 100% milk protein had a value of $3/kg, wheat protein milk replacer would need to have a value of $2.50/kg to equal the same cost of production at a body weight of 118kg (Table 3).

Conclusion

The results from the study suggest that there are disadvantages to feeding a milk replacer formulated using CP sourced from wheat protein for 3% of the CP sources in the milk replacer formula. It was determined that wheat protein would need to have a significantly lower cost to be an economically feasible alternative to milk protein. This study indicated that there is reduced average daily gain in the post weaning period when using hydrolyzed wheat protein as a nutritional ingredient in pre-weaning calf milk

Chester-Jones, H. D. Ziegler, R. Blome, and D. Wood. **2016**. Performance and health of calves pre- and post-weaning when fed milk replacers formulated with alternative protein sources. *J Dairy Sci* 99, E-Suppl. 1. Abstract 1214, poster 31.

- Holstein heifer calves 2 – 5 d age, n=130. 24:20 CMR composed of either a.) all-milk, 2.) 14.6% of CP replaced by Manildra GemPro 7700 hydrolyzed wheat gluten protein, 3.) 14.6% of CP replaced by Manildra GemPro 7700 + 14.6% of CP replaced by APC Nutrapro B plasma, 4.) 15.75% of CP replaced by ADM Nutrior hydrolyzed wheat gluten protein, or 5.) 14.6% of CP replaced by Nutrapro B plasma.
- All diets formulated to standardize to 2.4% lysine, 0.8% methionine, and 1.6% threonine
- No differences in pre- or post-wean ADG. All groups more than doubled initial BW. No differences in calf starter intake, G:F or calf health.

Performance and health of calves pre- and post-weaning when fed milk replacers formulated with alternative protein sources

H. Chester-Jones[1], D. Ziegler[1], R.Blome[2] , and D. Wood[2].

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Abstract 1214,
Poster #31

Introduction

The economics of feeding all-milk protein milk replacers continues to be a challenge as more of this product enters the human food market. Several alternatives in the marketplace show promise as partial alternatives to milk proteins. Two sources of highly soluble hydrolyzed wheat proteins prepared by enzymatic processes have been designed as a component of calf milk replacers. These include Gem Pro 7700 produced by Manildra, USA and Chamtour Nutrior produced in France but distributed in the USA. Plasma is commonly used in milk replacer formulas, and has shown similar performance to all milk proteins along with the benefits of some local gut protection. A study presented by Ziegler et al. at JAM 2015 evaluated pre- and post-weaning performance and health of dairy calves fed all-milk protein 24:20 non-medicated milk replacers replacing 25% of the milk protein with either plasma protein, plant proteins or 12.5% from each source (J. Dairy Sci. 98(Suppl.2):471. Abstract T451). Calf performance was not reduced by partially replacing milk proteins with alternative protein sources.

Objectives

To evaluate health and pre- and post-weaning performance of calves fed milk replacers with two wheat sources and plasma partially replacing all-milk protein.

Material and Methods

Animals: A 56 d study was conducted in the fall of 2015 with 130 (2 to 5 d old) individually fed Holstein heifer calves (38.4 ± 0.71 kg). Calves were housed in individual pens 2.29 X 1.17 m within naturally ventilated curtain side-wall calf barns at SROC. Calves less than 34.1 kg and over 47.7 kg BW were not used for this trial.

Treatments: calves were randomly assigned to 1 of 5 non-medicated 24% CP: 20% fat MR treatments (trt):

1) MR containing all-milk protein fed at 0.34 kg DM with 2.39 L water 2x daily for 35 d and once daily from d 36 to weaning at d 42 **(AM);**
2) MR fed as in trt 1 with **14.6**% of the CP replaced by Manildra GemPro 7700 wheat **(MG);**
3) MR fed as in trt 1 and 2 with **14.6**% of the CP replaced by **MG** and **14.6**% by Nutrapro B plasma **(MGNB);**
4) MR fed as in trt 1, 2 and 3 with **15.75**% of the CP replaced by Chamtour Nutrior wheat **(CN);**
5) MR fed as in trt 1, 2, 3 and 4 with **14.6**% of the CP replaced by Nutrapro B plasma **(NB).**

All diets were formulated to contain standardized 2.4% lysine, 0.8% methionine and 1.6% threonine.

Materials and Methods cont'd

Texturized calf starter (**CS**; 18% CP; with 49.4 mg/kg decoquinate) and water were offered free choice from d 1 to 56.

Measurements and observations:

Statistical analyses: Data were analyzed using the PROC MIXED procedure of SAS and repeated measures analyses applied where appropriate. Initial BW was utilized as a covariate for BW, ADG, and intake data when significant. Initial hip height (**HH**) was utilized as a covariate for HH (d 56) and HH gain.

- **Body weights (BW)** were taken on arrival and d 14, 28, 42, and 56.
- **Hip heights (HH)** were taken on d 1 and 56.
- **Health treatments** were recorded for each calf throughout the study.
- **Fecal scores** were determined and recorded daily (1 = normal; 2 = loose, pudding; 3 = very loose, no watery separation; 4 = very watery).
- **Feed Offered** was recorded daily with refusals taken weekly.
- **Feed samples** were taken from each bag of milk replacer, texturized calf starter and composited by treatment and analyzed for composition.

Results

Table. Nutrient composition of feeds (DM basis)

	AM	MG	MGNB	CN	NB	CS
DM, %	95.90	95.84	95.80	96.06	95.73	84.54
NDF, %	0.45	0.02	<.01	0.15	0.37	15.43
ADF, %						9.78
CP, %	24.62	24.18	24.89	23.94	24.61	21.09
FAT %	23.34	23.68	24.00	23.20	23.12	4.83
Ash, %	7.44	7.19	7.05	7.24	7.12	7.41
Ca, %	0.85	0.82	0.73	0.72	0.73	1.18
P, %	0.82	0.77	0.72	0.73	0.78	3.02
Starch,%						33.25

Performance and health of calves pre- and post-weaning when fed milk replacers formulated with alternative protein sources

H. Chester-Jones[1], D. Ziegler[1], R.Blome[2] , and D. Wood[2].

[1]University of Minnesota Southern Research and Outreach Center (SROC), Waseca, MN. , [2] Animix LLC, Juneau, WI.

Results

Table. Calf performance d 1 to 56

	AM	MG	MGNB	CN	NB	SEM
No. calves	26	26	26	26	26	
BW, kg						
d 1	38.4	38.4	38.3	38.6	38.4	0.70
d 42	66.6	66.1	67.6	66.9	67.3	0.85
d 56	81.3	81.0	82.2	82.3	82.3	1.06
ADG, kg						
d 1-42	0.67	0.65	0.70	0.67	0.69	0.02
d 43-56	1.05	1.06	1.05	1.10	1.09	0.04
d 1-56	0.76	0.76	0.78	0.78	0.79	0.02
HH, cm						
d 1	79.9	79.7	80.4	79.9	79.7	0.48
d 56	92.4	92.1	91.7	92.4	92.4	0.36
Milk DMI, kg						
d 1 to 42	25.0	24.8	24.9	24.9	25.0	0.07
CS DMI, kg						
d 1 to 42	17.1	16.1	18.4	17.4	17.8	1.10
d 43 to 56	31.2	31.1	31.7	31.1	32.1	0.80
d 1 to 56	48.4	47.3	50.0	48.8	50.0	1.59
DMI, kg						
d 1 to 42	42.1	40.9	43.3	42.3	42.8	1.13
d 43 to 56	31.3	31.2	31.7	31.3	32.2	0.79
d 1 to 56	73.4	72.2	74.9	73.8	75.0	1.82
GF,kg						
d 1 to 42	0.67	0.67	0.67	0.67	0.67	0.01
d 43 to 56	0.47	0.48	0.46	0.50	0.47	0.01
d 1 to 56	0.62	0.63	0.62	0.63	0.63	0.01

Table. Calf health parameters d 1 to 56

	AM	MG	MGNB	CN	NB	SEM
Serum Protein mg/dl	5.79	6.08	5.76	5.91	5.96	0.15
Fecal Score[1]						
d 1 to 14	1.85	1.74	1.86	1.67	1.71	0.06
d 1 to 42	1.42	1.35	1.42	1.37	1.35	0.03
d 43 to 56	1.17	1.06	1.09	1.10	1.09	0.04
d 1 to 56[2]	1.36	1.28	1.34	1.30	1.29	0.02
Scouring days[3]						
# Days ≥ 3						
d 1 to 42	2.77	2.37	3.37	2.42	2.19	0.45
d 43 to 56	0.18	0.10	0.00	0.11	0.02	0.08
# Days = 4						
d 1 to 42	0.21	0.29	0.18	0.15	0.06	0.10
Treatment cost						
d 1 to 42	0.41	0.41	0.53	0.84	0.49	0.16
d 43 to 56	0.26	0.31	0.25	0.00	0.00	0.23
d 1 to 56	0.67	0.73	0.77	0.81	0.45	0.27

[1]Fecal score 1 to 4, 1 = normal, 4 = watery
[2] AM vs. MG, and NB (P = 0.06);
[3]Scouring day = any day with a fecal score ≥ 3.

Summary

- One-hundred thirty (2 to 5 d old) individually fed Holstein heifer calves (38.4 ± 0.71 kg) were randomly assigned to 1 of 5 non-medicated 24% CP; 20% fat MR treatments.
- All-milk MR (**AM**) vs. Manildra Gempro wheat replacing **14.6**% of the CP (**MG**) vs. **14.6**% of CP replaced by **MG** and **14.6**% by plasma (**MGNB**) vs. **15.75**% CP replaced by Chamtour Nutrior wheat (**CN**) vs. **14.6**% of the CP replaced by plasma (**NB**).
- There were no differences in pre- and post-weaning ADG. All calf groups more than doubled their initial BW by 56 d with 12.2 cm of HH gain average.
- There were no differences in pre- and post-weaning CS intake.
- Gain/feed were similar across calf groups.
- There were no treatment differences in scouring days and treatment costs.

Conclusions

- Under the conditions of this study replacing milk protein in milk replacers with two different soluble wheat sources (approx. **15**% of CP) with or without plasma (**14.6**% of CP) resulted in very acceptable calf performances.

Acknowledgements

Many thanks to Animix for the financial support of the study. Thanks to the SROC dairy staff for excellent care and management of the calves during the study.

Froehlich K.A., U. Salga Vegas, C. Soderholm, and D.P. Casper. **2015**. Commercial dairy farm evalulation of milk replacers with different protein sources and concentrations. *J Dairy Sci* 98, E Supp. Abstract 160.

- A 24% CP wheat/plasma milk replacer performed comparably to a 24% CP all milk and a 20% CP all milk. SDSU and MSC. 160.
- Compared feeding a 24:20 composed of wheat/plasma to a comparably cost 20:20 all-milk CMR. Calves were fed either a.) a 20:20 all-milk CMR, b.) 24:18 all milk CMR, or c.) 24:18 wheat/plasma (20.8% from wheat protein and 33.4% from plasma protein).

- Calves (n=88) on a commercial dairy were fed colostrum 3 d and then placed on respective test CMR. Calves were fed 1.5 lbs./d CMR to d 35 and then half rate to 42 d wean. All CMRs contained NT (1,330 g/ton each) and Safmannan. 20% CP starter grain offered ad lib.
- ADG 1.3, 1.39, and 1.39 lbs./d for the All-milk 20:20, all-milk 24:18, and wheat/plasma 24:18, respectively. NSD in ADG between the groups. BW gain, hip width, wither height, and body length were not different in the 56-d study. Wheat/plasma tended improved gains in heart girth than calves fed 20% CP all-milk. All-milk 24% CP was intermediary.
- SDSU and MSC. 160.

Max Thornsberry, Steve Younker, Dave Ziegler, Hugh Chester-Jones, and Jim Lin. **2015**. Pre- and post-weaning performance of dairy calves fed a milk-wheat-plasma protein milk replacer. *J Dairy Sci* 98, E Supp. Abstract W395.

- Wheat/plasma performed comparable to an all-milk milk replacer at 56 days, but tended lesser performance at weaning (d 42). U of MN Waseca, MSC. W395.
- Holstein heifer calves (n=52) 2 – 5 d old. 22% CP texturized starter offered ad lib.
- Calves fed 1.2 lbs. per day to d 35 then half rate to d 42 wean of a 23:21 composed of 35% of CP from plasma and 22% of CP from wheat performed comparably to a 23:21 all-milk milk replacer at 56 days (1.92 and 1.83 lbs./d for AM and wheat/plasma, respectively) but tended (P=0.08) lower ADG day 1 – 42 (1.65 and 1.52 lbs./d for AM and wheat/plasma, respectively). 45.9 lbs./calf of CMR was consumed. 56 d starter consumption per calf was not different (142.4 and 134.7 lbs. for AM and wheat/plasma, respectively). Only numeric reductions (1.4 vs. 1.6) in fecal score and scour days (1.27 vs. 1.88) for plasma/wheat calves, no significant differences. 52 calves. U of MN Waseca, MSC. W395

Raeth M, H. Chester-Jones, D Ziegler, D. Schimek, DL Cook, G Golombeski, and AV Grove. 2016. Pre-and postweaning performance and health of dairy calves fed milk replacers with differing protein sources. *Pro Ani Sci* 32:833 – 841. http://dx.doi.org/10.15232/pas.2016-01536. Poster presented ADSA **2014.**

- Calves fed 20:20 1.25 lbs./d performed comparable to an all-milk when 50% of CP was replaced with either combined hydrolyzed wheat and plasma, combined SPC and plasma, or combined wheat, soy, and plasma. Fecal scores were higher (P<0.05) in all-milk diet vs. soy/plasma diet, wheat/plasma intermediary. Solubilized wheat gluten protein used was Nutrior, plasma used was APC Nutrapro B, and SPC used was Profine F, Solae. All CMR's were balanced for total lysine, methionine, threonine, and tryptophan at 2.08%, 0.8%, 1.28%, and 0.37%, respectively. U of MN, Waseca/Hubbard/Milk Products. 1658.
- 105 Holstein heifer calves (2 – 5 d of age) were fed non-med 20:20 CMR at 1.25 lbs./d 1 – 35 d, and then ½ rate, 1x/d until weaning day 42. Neoterra was added d 1 – 14 to all diets. Texturized 18% C.P. starter grain containing Deccox was offered ad lib. CMR contained either a.) all-milk protein, b.) 50% of C.P. from a combination of hydrolyzed wheat protein and spray dried plasma, c.) 50% of C.P. from a combination of soy protein concentrate (SPC) and plasma, or d.) 50% of C.P. from a combination of wheat, SPC and plasma. Osmolarity of CMR was 469, 421, 395 and 412 mOsm/L for a, b, c & d, respectively. No pre- or post-weaning differences in ADG were noted. Calves averaged 1.63 lbs. ADG 1 – 56 d. No differences in calf starter intake. Milk replacer intake was 47.2 lbs. over the 42 d pre-wean period. Grain intake averaged 122.6 lbs. over 56 d.

Pre-weaning G:F was higher (P<0.05) in calves fed wheat/plasma vs. the other two alternative protein diets, and was similar to the all-milk diet. No difference in G:F at 56 days. Across treatments, calves doubled birth weight. Fecal scores were higher (P<0.05) for calves fed all-milk vs. all other diets. Scouring days pre-weaning was higher (P<0.05) for calves fed all-milk diet vs. those fed soy/plasma, and wheat/plasma was intermediary. No differences in med costs. Ziegler. Poster presented ADSA 2014, U of MN Waseca, Hubbard, Milk Products. 1658.

T. M. Hill*, H. G. Bateman III, J. M. Aldrich, J. D. Quigley, and R. L. Schlotterbeck. **2013**. Use of plasma, hydrolyzed wheat gluten, or the combination in dairy calf milk replacers., *J Dairy Sci* 96, E-Suppl. 1, Abstract 644.

- Nurture Research Center, Provimi North America, Brookville, OH.
- 27:17 CMR equalized in amino acids to published optimum concentrations using synthetics, and equalized for vitamin and TM concentrations, and fed at 1.46 lbs./calf/d until weaning at d 28 were studied examining various alternative proteins. Treatment groups included: 1.) all milk, 2.) 6% plasma (18% of C.P.), 3.) 6% hydrolyzed wheat protein (replacing 18% of C.P.), 4.) 3% of both plasma and wheat (replace 18% of C.P.) and 5.) 6% of each (replace 36% of C.P.). Study period was 28 d because CMR represents 90% of DMI at that juncture. Calves were monitored in post-wean d 29 – 56. 20% CP texturized calf starter was offered ad-lib. 2 – 3 d old male Holstein calves (n=80) from a single farm housed individually. All-milk CMR outperformed all other treatments in ADG, starter intake and change in hip width (P<0.05). Pre-wean ADG was 0.97, 0.90, 0.87, 0.83, 0.81 for AM, plasma, wheat, plasma/wheat 3%, and plasma/wheat 6%, respectively. Overall, 56 d ADG was 1.23, 1.09, 1.04, 1.14, and 1.03 for AM, plasma, wheat, plasma/wheat 3%, and plasma/wheat 6%, respectively. Health was excellent and no differences were noted. Author notes alternative proteins would need to be 10 – 20% less expensive than milk to equalize feed $/unit ADG. Provimi. Hill. #644.

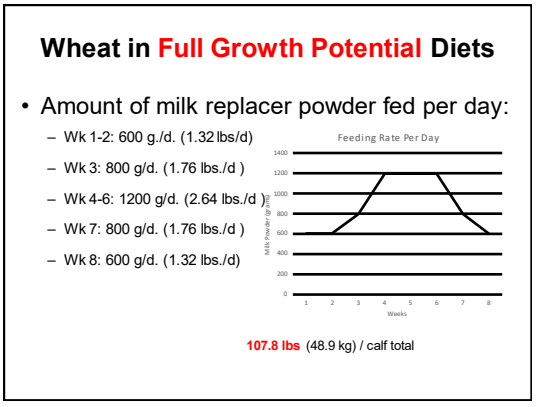
Chester-Jones H., D. Dean. D. Ziegler. K. Halpin, M. Raeth-Knight and D. Carlson. **2013**. Performance and health of Holstein dairy calves fed Peptide Powder 80 or hydrolyzed wheat protein as alternative protein sources in milk replacers. *J. Dairy Sci*. 96, E-Suppl.1, 251. Abstract W70.

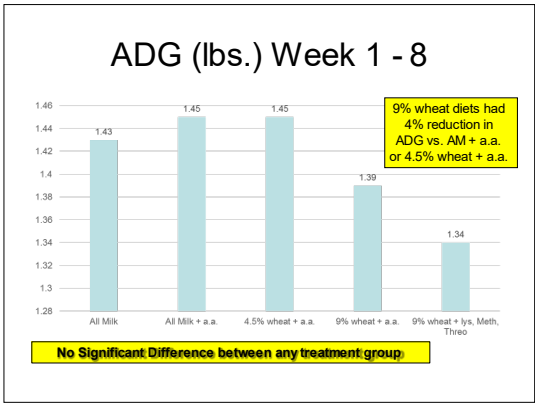
- Performed comparable to all milk; 48 lbs. of 20:20 CMR/calf over 6 weeks. Neoterra administered first 14 d of study. 18% CP starter w/Deccox offered ad lib. U of MN Waseca.
- 33% of CP replaced (Cargill HyProW 21100) milk protein in the wheat diet
- Lysine and methionine balanced in wheat to be equal with all-milk formula
- n=55. Holstein heifer calves direct from 3 dairies in area. 2- 4 d old.
- ADG d 1 – 56 was 1.454 and 1.5 for all-milk and wheat, respectively. ADSA Poster 2013.
- NSD in calf health parameters and costs. NSD in starter intake or feed conversion

Key study: Hwang G.H., J.J. Castro, A. Saito, D.A. Vermeire and J.K. Drackley. **2013**. Protein source and amino acid balance for dairy calves fed milk replacer. *J Dairy Sci* 96, E-Suppl. 2:451. Abstract 467. Subsequent publication: Castro J.J., G.H. Hwang, A. Saito, D.A. Vermeire and J.K. Drackley. **2016**. Assessment of the effect of methionine supplementation and inclusion of hydrolyzed wheat protein in milk protein-based milk replacers on the performance of intensively fed Holstein calves. *J Dairy Sci* 99: 6324-6333. http://dx.doi.org/10.3168/jds.2015-10639. Data presented below is primarily from the Powerpoint shared with me from the abstract:

- Recent research examined two inclusion rates of hydrolyzed (soluble) wheat gluten protein (SWGP; ADM Nutrior, France) with addition of essential amino acids in a 28.5% CP, 15% fat MR fed at 1.32 lbs / day week 1 – 2, 1.76 lbs / day week 3, 2.64 lbs. / day week 4 – 6, 1.76 lbs / day

week 7 and 1.32 lbs / day week 8. All formulas contained the same 36% inclusion rate of skim milk. Whey protein concentrate (WPC) was used to supply additional protein beyond the standardized skim milk contributions in the all-milk protein-based formulas. The authors noted in a ppt, "all diets contained ~36% skim milk protein." SWGP was used at 4.5% or 9.0%, replacing WPC in the formula and contributing 21% or 42%, respectively, of the total protein in the formula. Respective CMR was introduced day 2 of life directly post colostrum feeding using calves from the university dairy. Starter grain (21.8% CP) was introduced to all calves at 28 days age. Calves (n=57) were fed either an all-milk protein formulated MR containing 2.6% lysine from skim milk and WPC, or the same all-milk protein formula with added synthetic amino acids (lysine, methionine, histidine, phenylalanine, valine, leucine) included at rates suggested to optimize growth as recommended by Van Amburgh (Cornell University), or SWGP at 4.5% or 9.0% and with the aforementioned optimized amino acid profile utilizing synthetic lysine, methionine, leucine, valine, isoleucine, threonine and tryptophan, or SWGP at 9.0% with only added lysine, methionine and threonine used at rates prescribed by Van Amburgh. Unfortunately, the two 9.0% SWGP diets were inadvertently manufactured with 10.4% lower lysine content ($P<0.05$) than the all-milk formula without added amino acids, otherwise, diets were not different in CP or fat levels. ADG at 56 days and 90 days did not differ between any treatments. Starter grain intake was lower for the all-milk with added amino acids, but otherwise no differences in grain intake were noted. There were also no differences in body dimensions and no effect on health parameters were noted. Week 1 – 8 ADG was 1.43, 1.455, 1.455, 1.389 and 1.345 lbs / day for the all-milk, all-milk + amino acids, 4.5% SWGP + amino acids, 9.0% SWGP + amino acids and 9.0% SWGP + only added lysine, methionine and threonine, respectively. Although not statistically significant, interestingly the 9.0% SWGP diet with only added lysine, methionine, and threonine, that was 10.4% lower in lysine verses the all-milk diet without added amino acids, also noted 6% lesser ADG at 56 days, possibly pointing toward the necessity to balance wheat-protein based diets optimally with lysine.





Carlson D., S. Hayes, B. Ziegler, R. Larson, M. Raeth-Knight, G. Golombeski, J. Linn, D. Zeigler, and H. Chester-Jones. **2009**. Influence of altering conventional milk replacer feeding rate and protein source on pre- and post-weaning performance and health of dairy calves. *J Dairy Sci* 92, E-Suppl. Abstract W221.

- Holstein heifer calves 2 – 4 d of age (n=125), weaned d 42. 18% CP texturized starter ad lib.

Reference	Diet CP & Fat, %	% of total MR CP as Soluble Wheat Gluten Protein (SWGP)	ADG, lb/d	Scour Score	Death loss %	Starter Intake lbs/day	Age of Calves, d
Carlson D. 2009 JDS 92 Abstract[29]	20% CP	All-milk Control	1.257	5.25 (a) (days)	-	0.639 (a)	1 - 56
(125 calves randomly assigned 4 groups)	20% Fat	All-milk, Step-down	1.322	3.86 (b)	-	0.903 (b)	1 - 56
All-milk Control: 1.25 lb/d 1-35, 0.6 lb/d 36-42		Plasma, Step-down	1.300	4.02 (b)	-	0.837 (b)	1 - 56
Step-down: 1.25/d 1 - 14, 1/d 15-35, 0.5 36-42		SWGP/Plasma, Step-down	1.190	3.8 (b)	-	0.793 (b)	1 - 56

Wood D., J. Sowinski, and R. Blome. **2009**. Effects of combining hydrolyzed wheat gluten and spray dried plasma in calf milk replacer (CMR) on calf performance. *J Dairy Sci* 92, E-Suppl. 1. Abstract W227.

	Wheat/Plasma (WP)	All Milk (AM)	Difference	P Value
Placement Weight, kg	47.31	48.14	+0.83 AM	0.18
ADG, D 1 - 15, kg	0.182	0.226	+0.044 AM	*0.023*
ADG, D 15 - 29	0.765	0.752	+0.013 WP	0.627
ADG, D 15 - 43	0.903	0.857	+0.046 WP	*0.059*
ADG, D 29 - 43	1.039	0.959	+0.08 WP	*0.049*
ADG, D 1 - 43	0.653	0.64	+0.013 WP	0.536
Number of Calves Treated	42 (70%)	44 (73.3%)		
Total No. of Treatments	444	309		
No. treatments wk. 6	201	103		
No. grain refusals	459	602		
Mortality	5	4		
Culls	1	0		

- Animix, 2007. 6% wheat + 5% plasma vs. All-milk
  - 58 lbs 22:20 fed over 42 days. NT + Deccox
  - No difference in ADG vs. all milk
  - Wheat/plasma ↓ADG d 1-15; ↑ ADG d 29 – 43
  - Fewer 6 wk treatments in all milk
  - But, fewer starter grain refusals in wheat/plasma group. More early (4) bloat incidence wheat/plasma
  - n=120, dairy beef calf trial

Hill T.M., H.G. Bateman, J.M. Aldrich, and R.L. Schlotterbeck. **2008**. Effects of using wheat gluten and rice protein concentrate in dairy calf milk replacers *Pro Ani Sci* 24:465-472.

- Two different studies reported in the same journal article.
- Trial 1: Holstein bull calves (n=32) <1 week of age from multiple dairies. 20:20 CMR either all milk or 4.3% hydrolyzed wheat gluten protein (15% of CP; wheat brand not identified), 1.82% lysine and 0.57% methionine in wheat diet, 1.80% lysine and 0.56% methionine in all-milk. 40.5 lbs. fed over 42 d. 18.5% CP starter fed ad lib. Wheat reduced ADG (P=0.01) vs. AM. Starter intake was reduced (P=0.01). Hip width change was also reduced (P=0.02) vs. AM. NSD in health.
- Trial 2: Holstein bull calves (n=48) 2 to 4 d age sourced from a single farm. 26:17 CMR either all milk, or hydrolyzed wheat gluten replacing 19% or 38% of CP in the formula fed at 60.8 lbs. per calf over 42 d. 18.5% CP starter fed ad lib. Linear reduction in ADG (P=0.01), hip width change (P=0.02), and gain:feed (P=0.01) as wheat increased in inclusion in the CMR. NSD in health.

Reference	Diet CP & Fat, %	% of total MR CP as Soluble Wheat Gluten Protein (SWGP)	ADG, lb/d	Scour Score	Death loss %	Starter Intake lbs/day	Age of Calves, d
Hill T.M. 2008 Prof. An. Sci. 2424:465 [66]	20% CP	All-milk	1.222	4 d scouring	0	1.352	1 - 42
(16 bull calves/treatment) 40.5 lbs. CMR/calf	20% Fat	15% SWGP	1.051	4.9 d scouring	0	1.132	1 - 42
Hill T.M. 2008 Prof. An. Sci. 2424:465 [66]	26% CP	All-milk	1.411 (a)***	10.8 d scouring	0	0.99	1 - 42
(16 bull calves/treatment)	17% Fat	19% SWGP	1.237 (b)***	9 d scouring	0	0.805	1 - 42
18.5% CP starter		38% SWGP	1.113 (c)***	11.1 d scouring	0	0.836	1 - 42
*** denotes P<0.01							

Chestnut A, D Carr. **2008**. The performance of calves fed a milk replacer containing wheat protein. *J. Dairy Sci.* 91, E-Suppl. 1, 489. Abstract TH258.

- 22:18 CMR with 50% of CP from wheat protein compared to 22:20 CMR all-milk, both with neomycin at 400g/ton and OTC at 200 g/ton. 1.25 lbs./d to d 28 and then half rate to wean d 35.
- 18% CP starter offered ad lib. Holstein bull calves 10 ±4 d of age.
- NSD in ADG. Calves fed wheat CMR tended (P<0.1) greater starter intake

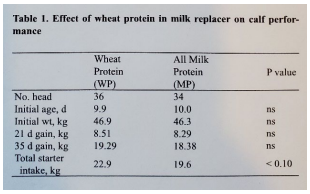


Table 1. Effect of wheat protein in milk replacer on calf performance

	Wheat Protein (WP)	All Milk Protein (MP)	P value
No. head	36	34	
Initial age, d	9.9	10.0	ns
Initial wt, kg	46.9	46.3	ns
21 d gain, kg	8.51	8.29	ns
35 d gain, kg	19.29	18.38	ns
Total starter intake, kg	22.9	19.6	< 0.10

Raeth M, H. Chester-Jones, D Ziegler, D. Schimek, DL Cook, G Golombeski, and AV Grove. 2016. Pre- and postweaning performance and health of dairy calves fed milk replacers with differing protein sources. *Pro Ani Sci* 32:833 – 841. http://dx.doi.org/10.15232/pas.2016-01536. Poster presented ADSA **2007.**

- 2 – 4 d old Holstein heifer calves (n=126) were fed 20:20 CMR containing either 1.) 100% of CP from WPC, 2.) 30% of CP from wheat protein, 3.) 50% of CP from wheat, 4.) 50% of CP from soy protein concentrate (SPC), or 5.) 25% of CP from wheat + 25% of CP from SPC. Wheat used in all formulas was Chamtour Nutrior, France. SPC was Profine F, Solae, St. Louis, MO. All formulas were balanced for lysine, methionine, threonine and tryptophan at 2.08%, 0.8%, 1.28%, and 0.37%, respectively. Neomycin and OTC were administered in all CMRs at 400 and 200 mg/lbs. of MR, respectively. Calves were fed 1.26 lbs./d to d 35 and half rate to 42 d wean. A texturized (18% CP) calf starter containing Rumensin was offered ad lib.
- Starter intake was 125.9, 109.9, 113.6, 119.8, 111.1 lbs. d 1 – 56 for all-milk, 30% wheat, 50% wheat, 50% SPC, and wheat:SPC mix, respectively. Calves fed all-milk CMR consumed more grain than calves fed CMR containing 30% wheat, 50% wheat or the mix of wheat and SPC.
- All-milk control had +9 lbs. 56-d BW gain vs. other groups
- G:F was 0.61(a), 0.58(ab), 0.58(ab), 0.55(b), and 0.56(b) for all-milk, 30% wheat, 50% wheat, 50% SPC, and the mix of wheat and SPC, respectively (subscripts different $P<0.05$)
- Health treatment costs/calf averaged $2.09
- Authors noted in the ADSA poster, "the use of wheat gluten or soy protein concentrate as a partial replacement for milk protein reduced calf performance due mainly to calf starter intake differences."

Key Study. Ortigues-Marty I., J. Hocquette, G. Bernard, C. Martineau, M. Vermorel, and R. Toullec. **2003**. The incorporation of solubilized wheat proteins in milk replacers for veal calves: Effects on growth performance and muscle oxidative capacity. *Reproduc Nutr Dev* 43:57-76. doi: 10.1051/rnd:2003006

- Solpro 500. INRA (France) veal study.
- Skim milk (no wheat) starter formula (d 1 – 29; calves were 8 – 10 d old when placed)
- Solpro provided 49% of CP in the 22.8% CP:19.2% fat grower phase (d 29 – 83)
- Solpro provided 61% of CP in the 21% CP:21.4% fat finisher phase (d 84 – 146)
- All 3 diets standardized using L-lysine, dl-methionine & threonine
- Wheat diets were tested with and w/o branch chain a.a. (BCAA) valine, isoleucine, leucine
- NSD in liveweight gain, feed conversion, carcass yield, color or confirmation. No metabolic disorders noted. Cold carcass wt 621.7, 626.1, and 629.4 lbs. for skim milk, SWGP, and SWGP + BCAA, respectively.
- 3 culled (one in each group) from disease, and 2 in SWGP+BCAA for ulcers and abscesses
- Authors reported high incidence of respiratory disease but NSD between the groups
- Blood samples taken d 7, 55, 69, 84, 106, 126, and 138 and measured for free amino acid levels. Valine concentrations were lower in blood of calves fed Solpro 500 diets. Otherwise, not notable differences in blood amino acid content.
- Results in graph below report performance during veal grower period (d29 – 83) and veal finisher period (d 84 – 146). No grain or forage fed at any time.

Reference	Diet CP & Fat, %	% of total MR CP as Soluble Wheat Gluten Protein (SWGP)	ADG, lb/d	Scour Score	Death loss %	Starter Intake lbs/day
Ortigues-Marty I. 2003. Reprod. Nutr. Dev. 43:57[119]	22% CP	All-milk	2.680	1.38 feed/gain		0
(14 veal calves/treatment)	19% Fat	52.3% SWGP (+ lys., meth, threonine)	2.720	1.40 feed/gain		0
Veal grower MR fed day 29-83		52.3% SWGP(+lys, meth, thr) + BCAA^	2.720	1.40 feed/gain		0
Veal finisher MR fed day 84-146	21% CP	All-milk	3.340	1.88 feed/gain		0
No grain fed at any time	21% Fat	52.3% SWGP	3.270	1.96 feed/gain		0
		52.3% SWGP + BCAA^	3.360	1.91 feed/gain		0

	Total Live Weight Gain	Dress %	Carcass (lbs)	Est. Value ($2.50/lb)	Grower Feed (lbs)	Finisher Feed (lbs)	Est. Feed Savings ($/calf)
Skim Milk	352	58%	204.2	$ 510.40	210.8	375	
SOLPRO 508	351	58.3%	204.6	$ 511.58	214.2	384.6	$75
SOLPRO + BCAA	356.5	57.9%	206.4	$ 516.00	217.3	385.4	

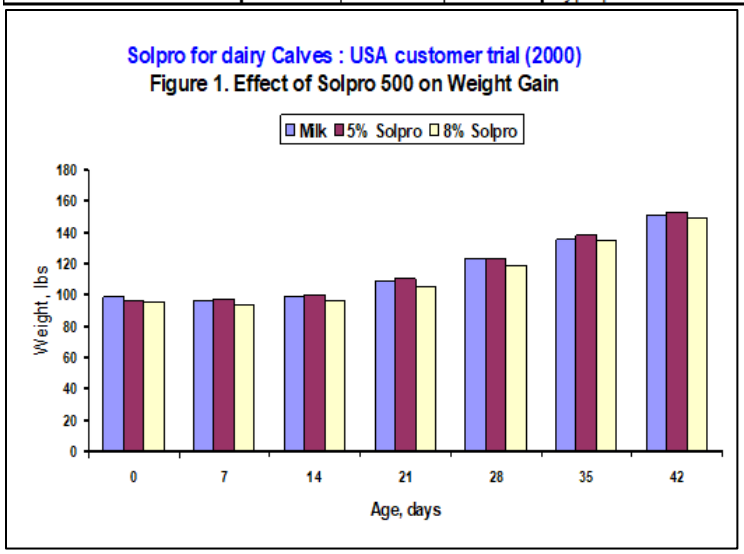
	Skim Milk	SOLPRO 500	SOLPRO 500 + BCAA	SEM (n=12)	Statistics
Live-weight, lbs					
Day 29	132.7	135.8	136.5	1.43	NS
Day 86	285.5	290.8	291.7	3.13	NS
Day 146	486.1	487	492.9	6.74	NS
Live-weight gain, lb./day					
Grower phase	2.68	2.72	2.72	0.05	NS
Finisher phase	3.34	3.27	3.36	0.08	NS
Intake, ozs. / day					
Grower phase	59 a	60.6 b	60.7 b	0.18	$P < 0.001$
Finisher phase	99.8	102.7	102.3	0.84	NS
Feed Efficiency					
Grower phase	1.38	1.40	1.40	0.025	NS
Finisher phase	1.88	1.96	1.91	0.035	NS
Hematocrit level %					
Day 29	29.5	28.8	28.8	0.96	NS
Day 86	24.4 a	26.7 b	27.4 b	0.76	$P < 0.05$
Day 146	24.6	24.8	27.4	0.95	NS
Cold Carcass Wt, lbs	282	284	285.5	0.33	NS

SOLPRO 500 (Tate & Lyle) in calf milk replacers. Data provided by Tate & Lyle in **2000**. Was told by Tate and Lyle technical service PhD that it was Merrick's research.

STUDY DESIGN:

- 60 Holstein bull calves allotted by weight to 3 treatments
- 20 calves per treatments– 1.) 20:20 all milk, 2.) 20:20 with 5% SOLPRO 508, 3.) 20:20 with 8% SOLPRO 508
- All formulas had the same amino acid content– 1.85% lysine, 0.95% methionine + cystine and 1.33% threonine
- 0.5 lbs of milk powder was reconstituted in warm water and fed twice per day.
- Weekly weights and scour scores were measured

Feed composition %				Nutrient content %			
	Control	5 % Solpro	8 % Solpro		Control	5 % Solpro	8 % Solpro
Whey Protein Concentrate	46.41	31.53	22.8	Crude Protein	20.16	20.31	20.16
Solpro 500	-	**4.94**	**7.85**	Crude fat	20.06	19.83	20.06
Whey	33.94	42.76	47.37	Crude fiber	0.02	0.01	0.02
Animal Fat	15.88	16.71	17.47	Ash	7.4	7.26	7.4
Lecithin	1.44	1.28	1.17				
Flow agent	0.69	0.55	0.43	Ca	0.75	0.75	0.75
Dicalciumphosphate	0.89	0.99	1.06	P	0.69	0.69	0.69
Vit.min. Premix	0.75	0.75	0.75				
L-Lysine HCl	-	0.49	0.67	Lysine	1.85	1.85	1.85
DL-Methionine	-	-	0.10	Methionine	0.38	0.37	0.38
L-Threonine	-	-	0.27	Meth + Cys	0.95	0.89	0.95
Tryptophane	-	-	0.06	Threonine	1.33	1.16	1.33
Total	100	100	100	Tryptophane	0.33	0.29	0.33



RESULTS:

- SOLPRO 500 soluble wheat gluten performs on par with All Milk Formulas
- 42 day average daily gain – ALL MILK formula 1.25 lbs; 5% SOLPRO 500 1.365 lbs; 8% SOLPRO 500 1.286 lbs
- SCOUR DAYS – ALL MILK formula 1.68; 5% SOLPRO 500 1.55; 8% SOLPRO 1.72

R. Toullec, Formal M. Digestion of wheat protein in the preruminant calf: ileal digestibility and blood concentrations of nutrients. Anim Feed Sci Tech **1998**; 73:115-130. https://doi.org/10.1016/S0377-8401(98)00126-6

- INRA, France.
- Study conducted on Solpro 050 (Amylum N.V., Belgium, predecessor product to Solpro 508)
- Skim milk diet vs. 17.9% Solpro in the formula vs. 8.9% Solpro in the formula
- 6 female Holstein calves were started on a milk diet and were fitted with an abomasal catheter and re-entrant ileo-cecal cannula at 9 or 10 weeks of age.
- No grain was fed.

Commentary on results of this study from: Thornsberry, R. M., D. Wood, A. F. Kertz, and D. Hutcheson. 2016. Alternative ingredients in calf milk replacer–A review for bovine practitioners. Bov. Pract. 50:1-24:

The second veal calf trial compared digestibility of MR administered via abomasal catheter and composed completely of either milk protein (control) or MR composed of either 24% or 76% of the CP from SWGP. Ileocecal cannulated calves were, on average, 306 lb (139 kg) and 85 days of age. They were switched between the 3 diets every 2 weeks over a 6-week period. Apparent ileal

digestibility of nitrogen was 91%, 89% ($P < 0.05$), and 85% ($P < 0.01$ vs control, and $P < 0.05$ vs moderate SWGP) for the skim milk-based, moderate SWGP- and high SWGP-based diets, respectively.[186]

Waterman D.F, N.K. Keith, and R. Dvorak. **1997**. Evaluation of alternative protein milk replacers containing enzymes on growth and performance of calves. *J Dairy Sci* 80, Suppl. 1, 214. Abstract P278.

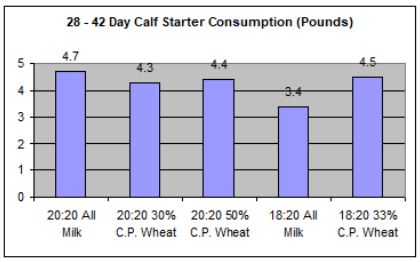
- Holstein bull calves, n=150, approximately 3 d old and 87.8 lbs. BW
- Calves were fed a pound per day of CMR and reared in individual hutches
- 20:20 CMR's either all milk (AM), soy protein concentrate (SPC), soy protein concentrate + 0.1% enzymes (SPC+E), modified wheat (MW), or modified wheat + enzymes (MW+E).
- Replacement % of CP by SPC or MW was not disclosed in the abstract. The enzyme was reported as added at 0.1% and was "Fungal Protease 93." Janusz Sowinski (Animix owner) was the calf researcher at MSG when this study was conducted, and I know he did a lot of research on MGP's wheat protein (KS) during this period of time.
- NSD in ADG or gain/total feed

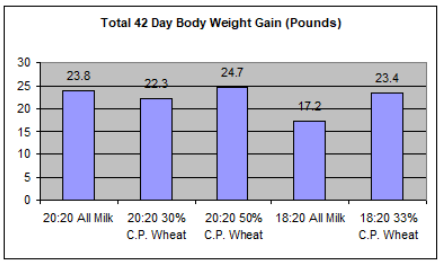
Treatment: Protein source	1 AM	2 SPC	3 SPC+E	4 MW	5 MW+E
ADG, kg					
d 1-14	.11	.09	.10	.12	.15
d 1-42	.23	.19	.21	.23	.25
FE					
d 1-14	.23	.19	.21	.25	.31
d 1-42	.30	.26	.28	.31	.31

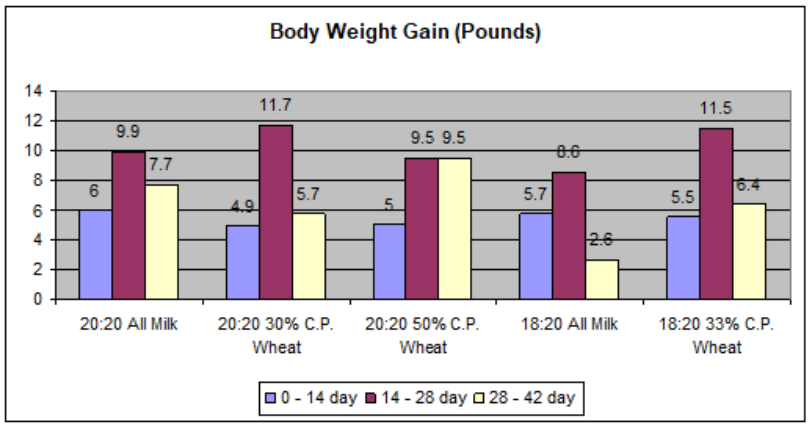
Terui H., J.L. Morrill, and J.J. Higgins. **1996**. Evaluation of wheat gluten in milk replacers and calf starters. *J Dairy Sci* 79:1261-1266.

- K-State. MGP wheat. 1 – 3 days of age. Holstein bull calves, n=120. Performed on-par with an all-milk.

Reference	Diet CP & Fat, %	% of total MR CP as Soluble Wheat Gluten Protein (SWGP)	ADG, lb/d	Scour Score	Death loss %	Starter Intake lbs/day	Age of Calves, d
Terui H. 1996. JDS 79:1261[164]	20% CP	All-milk	0.567 (ab)	-	4.20%	0.5 (a)	1 - 42
(24 calves/treatment)	20% Fat	30% SWGP	0.53 (ab)	-	4.20%	0.451 (ab)	1 - 42
16% CP starter		50% SWGP	0.588 (a)	-	4.20%	0.462 (ab)	1 - 42
Starter grain introduced day 21	18% CP	All-milk	0.409 (b)	-	8.40%	0.357 (b)	1 - 42
Starter intake is avg. lbs. day 21 - 42	20% Fat	33% SWGP	0.556 (ab)	-	0%	0.472 (ab)	1 - 42







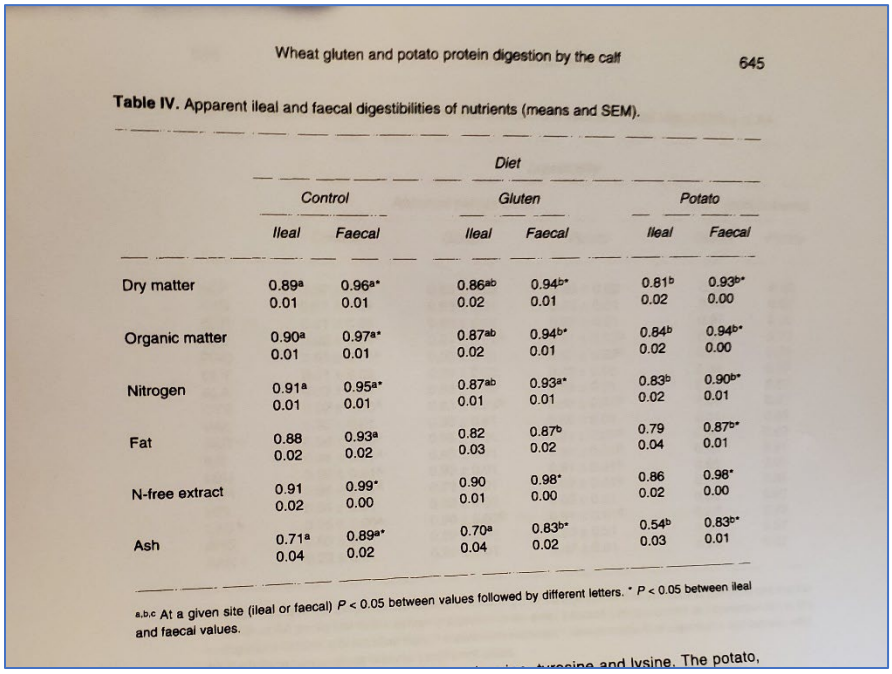
Branco-Pardal P., J. P. Lalle`s, M. Formal, P. Guilloteau, and R. Toullec. **1995**. Digestion of wheat gluten and potato protein by the preruminant calf: digestibility, amino acid composition and immunoreactive proteins in ileal digesta. *Reprod Nutr Dev* 35:639–654.

- 6 Holstein male calves started on skim milk diets were transitioned to experimental diets at about 8 weeks of age and received the experimental diet in open buckets over 14 days fed 2x/d. Total feces were collected during the final 5 days of the experimental period.
- Same experimental design was also implemented on 5 Holstein heifer calves. At about 10 weeks of age calves were fitted with an abomasal catheter and a reentrant ileo-cecal cannula. After two-week recovery, diets were infused into the abomasum and total digesta were collected from the ileum over the final 4 days of the experimental period.
- No grain was fed. Note non-hydrolyzed vital wheat gluten was used in this study

Commentary on this study from: Thornsberry, R. M., D. Wood, A. F. Kertz, and D. Hutcheson. 2016. Alternative ingredients in calf milk replacer–A review for bovine practitioners. Bov. Pract. 50:1-24.

Three MR were evaluated in a single 8-week-old veal calf study: 1) CP provided exclusively by skim-milk powder; 2) skim-milk powder with 52% CP substituted with **native wheat gluten**; and 3) 52% of CP provided as potato-protein concentrate.[19] Utilizing immunochemical detection, protein fractions with a molecular weight of 43,000 and below 14,000 were detected in ileal digesta in calves consuming potato-protein concentrate, but no immunoreactivity was discovered in ileal digesta taken from calves consuming the native wheat-gluten diet. Fecal nitrogen digestibility testing determined potato protein concentrate was less digestible than native wheat gluten, 0.90 vs 0.93, and both alternative protein sources were less digestible than skim-milk protein, (0.95; $P < 0.05$). Undigested amino acids recovered at the Undigested amino acids recovered at the distal ileum in this evaluation were always greater for gluten and potato proteins than for skim-milk protein; potato protein is not used in the US MR market.44,127 Solubilized or hydrolyzed wheat gluten has high digestibility at both fecal180 and ileal22,186 sites, but this trial examined wheat-gluten protein that was not hydrolyzed. Native wheat gluten retains viscoelastic properties, which may limit digestibility.
distal ileum in this evaluation were always greater for gluten and potato proteins than for skim-milk protein; potato

protein is not used in the US MR market.[44,127] Solubilized or hydrolyzed wheat gluten has high digestibility at both fecal[180] and ileal[22,186] sites, but this trial examined wheat-gluten protein that was not hydrolyzed. Native wheat gluten retains viscoelastic properties, which may limit digestibility.



Wheat gluten and potato protein digestion by the calf 645

Table IV. Apparent ileal and faecal digestibilities of nutrients (means and SEM).

	Diet					
	Control		Gluten		Potato	
	Ileal	Faecal	Ileal	Faecal	Ileal	Faecal
Dry matter	0.89[a] 0.01	0.96[a*] 0.01	0.86[ab] 0.02	0.94[b*] 0.01	0.81[b] 0.02	0.93[b*] 0.00
Organic matter	0.90[a] 0.01	0.97[a*] 0.01	0.87[ab] 0.02	0.94[b*] 0.01	0.84[b] 0.02	0.94[b*] 0.00
Nitrogen	0.91[a] 0.01	0.95[a*] 0.01	0.87[ab] 0.01	0.93[a*] 0.01	0.83[b] 0.02	0.90[b*] 0.01
Fat	0.88 0.02	0.93[a] 0.02	0.82 0.03	0.87[b] 0.02	0.79 0.04	0.87[b*] 0.01
N-free extract	0.91 0.02	0.99* 0.00	0.90 0.01	0.98* 0.00	0.86 0.02	0.98* 0.00
Ash	0.71[a] 0.04	0.89[a*] 0.02	0.70[a] 0.04	0.83[b*] 0.02	0.54[b] 0.03	0.83[b*] 0.01

[a,b,c] At a given site (ileal or faecal) $P < 0.05$ between values followed by different letters. * $P < 0.05$ between ileal and faecal values.

...tyrosine and lysine. The potato,

Tomkins T., J.S. Sowinski, and N.K. Keith. **1994**. Growth and performance of male Holstein calves fed milk replacers with different rates of replacement and different sources of non-milk protein (including modified wheat protein, soy protein concentrate, animal plasma and combinations thereof). *J Dairy Sci* 77, Suppl 1. 296. Abstract 1141.

- 2 – 4 days of age. Holstein bull calves (n=240). weaned d 42. NSD in health parameters. No starter offered until 15 days age. NSD in 56-d ADG or in total starter intake. Differences in d 1 – 14 ADG and in post-wean starter intake are noted in the table below.

Reference	% of total MR CP as Soluble Wheat Gluten Protein (SWGP)	56 d ADG, lb/d	day 1 - 14 ADG, lb./d	Death loss %	Starter Intake lbs/day	Post Wean Starter Intake lbs/d	Age of Calves, d
Tomkins T. 1994. JDS 77 Abstract[167]	(A) All-milk	0.882	0.48 (a)	0.0%	1.398	2.787 (b)	1 - 56
(240 calves randomly assigned 8 groups)	(B) 50% SPC	0.961	0.3 (a, b, c)	6.7%	1.63	3.212 (a,b)	1 - 56
Mortality column are morbidity/removed	(C) 50% SPC, 10% SWGP	0.871	0.26 (b, c)	6.7%	1.446	2.945 (a,b)	1 - 56
50 lbs MR/calf	(D) 50% SPC, 20% SWGP	0.780	0.21 (b, c)	13.3%	1.387	2.724 (a,b)	1 - 56
starter grain intake day 15 - 56	(E) 40% SPC, 10% SWGP	0.800	0.359 (a, b, c)	3.3%	1.382	2.693 (b)	1 - 56
Abstract reports no difference in health	(F) 40% SPC, 20% SWGP	1.070	0.33 (a, b, c)	10.0%	1.882	3.779 (a)	1 - 56
Day 1 - 14 ADG was superior for all-milk vs.	(G) 50% SPC, 10% Plasma	0.860	0.311 (a,b)	10.0%	1.516	2.992 (a, b)	1 - 56
treatments C, D or H	(H) 50% SPC, 10% SWGP, 10% Plasma	0.811	0.161 (c)	20.0%	1.403	2.882 (a,b)	1 - 56
Subscripts different denotes p<0.05							

Doppenburg, J. **1994**. The effect of low or high levels of modified wheat protein on the growth of calves fed milk replacers. Not published. Veal research conducted at Vitek (Animix predecessor company), Juneau, Wisconsin.

- 102 male Holstein calves, auction sourced.
- Veal feed prestarter (23% CP, 17% fat) was fed at 25 lbs. per calf, and starter formulas was fed at 75 lbs. (20 – 21% CP, 16% fat) per calf. Wheat was assumed to be 85% as digestible as milk protein and thus over-formulated (21% vs. 20%) in the two wheat diets. Formulas contained

either milk protein alone or 16.5% or 32.5% of total protein from hydrolyzed wheat protein (MGP)

- Veal feed grower (18 – 18.6% CP; 18% fat) was fed at 100 lbs. per calf, and finally, veal finisher was fed at 361, 370, and 346.9 lbs. to calves in the all-milk, low-wheat (16.5% of CP), and high-wheat (32.5% of CP) groups.
- Feed intake started at roughly 1% of BW, was brought up to 2% in 3 weeks' time, maintained at that level until the age of 100 days when it was leveled slowly back to 1.6%.
- Live weight and weight gain was similar between the WPC-control and the low wheat (16.5% of CP) throughout the trial, however, at 41 d the high wheat (32.5% of CP) tended lesser gains and difference was significant (P<0.05) at 92 d and 128 d. At 92 d the high wheat calves were lighter and thus their feed intake was reduced d 92 to 128.
- 128 d feed conversion was 1.78, 1.80, and 1.85 for WPC-all milk, low wheat (16.5%), and high wheat (32.5%), respectively. Dress % was 60.1%, 59.4%, and 60.2% for all-milk, low wheat, and high wheat, respectively. Dressed weight was 247.5, 246.9 and 239.7 lbs., respectively.
- Death loss and culls were 2+0, 3+1, and 2+2, for all-milk, low-wheat, and high-wheat, respectively.

Title	Location	Author	Ingredient	Wheat % of Formula	No. of Calves	Initial Weight (lbs)	ADG (lbs)	F/G	Age - No. Days in study	Results	General Comments NOT BY TREATMENT GROUP LINE ITEM
Non-Published MGP	Vitek	Doppenburg	All milk	0.0%	32	98.4	1.32	1.53	0 - 41		Prestarter: 23:17, 25 lbs / calf
1994	16.5% of Protein from MGP Wheat Isolate			4.5%	32	98.7	1.35	1.54	0 - 41		Starter 20:16, 75 lbs / calf. (Wheat lowered 10%)
Veal Study	32% of Protein from MGP Wheat Isolate			9.0%	34	99.5	1.24	1.64	0 - 41	NSD in gain	Lysine standardized in all feeds Pstarter - Finisher
			All milk	0.0%	32	152.4	2.99	1.78	42 - 128 ADG, 0 - 128 F/G		Grower: 18:18, 100 lbs / calf
	16.5% of Protein from MGP Wheat Isolate			3.7%	30	154	3.00	1.80	42 - 128 ADG, 0 - 128 F/G		Finisher 16.5:18 (wheat lowered 12%)
	32% of Protein from MGP Wheat Isolate			7.4%	30	150.2	2.85	1.85	42 - 128 ADG, 0 - 128 F/G		Equal performance at lower inclusion, Lower perform.
										at higher inclusion rates only in finisher.	

Doppenburg, J. **1994**. The effect of low or high levels of modified wheat protein on the growth of calves fed milk replacers. Not published. Veal research conducted at Vitek (Animix predecessor company), Juneau, Wisconsin.

- Technical write-up is missing. I (Dave) generated the graph below before misplacing it. Note NSD in BW gain at any weight juncture (d 3 – 27, 28 – 52, 53 – 78, 79 – 104, 105 – 132). 15% of CP from MGP hydrolyzed wheat gluten protein. Lysine standardized in both diets.

Title	Location	Author	Ingredient	Wheat % of Formula	No. of Calves	Initial Weight (lbs)	ADG (lbs)	F/G	Age - No. Days in study	Results	General Comments NOT BY TREATMENT GROUP LINE ITEM
Non-Published MGP	Vitek	Doppenburg	All milk	0.0%	49	98	1.15	1.65	3 - 27		22 C.P.: 17 Fat Prestarters
1992	15% of Protein from MGP Wheat Isolate			4.1%	49	99.3	1.13	1.69	3 - 27		Lysine standardized in all feed Pstarter - Finisher
Veal Study			All milk	0.0%	49	125.8	2.55	1.37	28 - 52		20.5% CP : 17.5% Fat Starter
	15% of Protein from MGP Wheat Isolate			3.8%	49	126.4	2.47	1.43	28 - 52		
			All milk	0.0%	49	189.7	2.72	1.56	53 - 78		18% CP : 18% Fat Grower
	15% of Protein from MGP Wheat Isolate			3.8%	49	188.1	2.62	1.62	53 - 78		
			All milk	0.0%	48	260.3	3.12	1.64	79 - 104		16.3% CP : 19.4% Fat Finisher
	15% of Protein from MGP Wheat Isolate			3.0%	49	256.3	3.08	1.68	79 - 104		
			All milk	0.0%	48	341.3	2.75	1.8	105 - 1.32		16.3% CP: 19.4% Fat Finisher
	15% of Protein from MGP Wheat Isolate			3.0%	48	336.3	2.68	1.84	105 - 132	No significant difference in Gain in any treatment at any time	

Sowinski J.S., T. Tomkins and N.K. Keith. **1993**. Performance of Holstein male calves fed milk replacer diets containing either modified wheat protein or soy protein concentrate. *J. Anim. Sci.* 71, Suppl. 2, 86. Abstract, I assume at either ASAS or ADSA.

STUDY DESIGN –

• 30 calves per treatment. All calves raised individually in a veal production facility
• Reconstituted milk replacer (12.5% solids) fed twice daily from open buckets for 42 days
• All milk replacer diets contained 20% C.P., 20% fat and oxytetracycline and neomycin.
• 50% of the milk protein was replaced with the test proteins (approximately 12.5% of formula)

• Treatments included –
o All milk
o Wheat protein, source 1 (Midwest Grain Products, Inc)
o Wheat protein, source 2 (Amylum n.v., presently Tate & Lyle, i.e. predecessor Solpro 508)
o Soy protein concentrate (brand not identified in abstract)
SUMMARY OF FINDINGS – Researchers reported no treatment differences ($p > 0.1$) in ADG or F:G. Mortality and treatments not reported in abstract.

TREATMENT:	Initial Wt.	ADG day 1 - 14 (lbs)	ADG day 1 - 28 (lbs)	ADG day 1 - 42 (lbs)	F:G day 1 - 14	F:G day 1 - 28	F:G day 1 - 42
All Milk	100.6	0.43	1.1	1.12	2.27	1.49	1.82
Wheat Protein 1	99.27	0.4	0.92	0.98	2.43	1.66	2.04
Wheat Protein 2	97.66	0.35	0.95	0.95	2.85	1.63	2.00
Soy Protein Conc.	98.06	0.35	0.96	1.04	2.77	1.66	1.92

Bush R.S., R. Toullec, P. Guilloteau, and P. Barre. **1992b**. Digestibilite ileale d'un gluten de ble partiellement hydrolyse chez le veau preruminant. *Ann Zootech* 41:31-32.

- Three two month old calves were fitted with ileal re-entrant cannula and an abomasal catheter and were provided either a 25.5% CP milk replacer formula composed entirely of milk protein or a 23.7% CP formula composed of protein drived from hydrolyzed wheat gluten protein, whey powder and L-lysine at 75, 21, and 4%, respectively.
- Calves were infused milk into their abomasums twice daily and illeal digesta was collected for four days with each milk replacer formula.
- Apparent digestibility of total nitrogen and total nitrogen dosed amino acids was 0.85 ±0.03 and 0.87 ±0.03 and 0.92 ±0.01 and 0.93 ±0.01 for the casein (milk)-based vs. hydrolyzed wheat based formula.
- Bottom line : digestibility was 87% vs. 93% for wheat- and casein-based formulas respectively in two month old veal calves fed no grain. Brand of wheat fed is not disclosed in the paper.
- With the exception of a small one-paragraph summary, the paper is in French only.
- Both Toullec and Guilloteau are authors, so I'm sure this is a meticulous, excellent calf study. Two of the best. INRA, France, 1992.

Key study: Tolman G.H. and M. Demeersman. **1991**. Digestibility and growth performance of wheat soluble protein for veal calves. *In: New Trends in Veal Calf Production* (JHM Metz, C.M. Groenestein, eds), Pudoc Press, Wageningen, 227-233.

- ILOB-TNO, Wageningen, NL. Special milk fed veal. 35 days old. No grain or forage fed

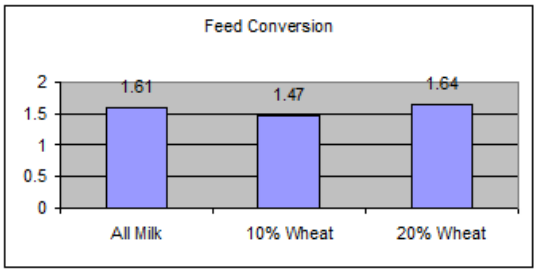
STUDY DESIGN:

- 15 Friesian Dutch X Holstein Friesian bull calves were transported to the institute at approximately five weeks of age. The calves averaged 117 lbs and were placed in individual calf stalls.
- All calves were started for eleven days on a commercial skim-milk-powder based formula to allow acclimation to new facilities.
- After this adjustment period, calves were blocked into three groups based on hemoglobin and body weight.
- Each group was randomly assigned to one of the test formulas listed in Table 1. Test formulas were introduced by replacing 25% of the commercial formula to the appropriate experimental diet over four feedings. Each group was fully transitioned to the test diet for 5 days prior to commencement of the digestibility trial.
- Calves were individually bucket fed 104° F milk replacer twice daily. Milk replacer was prepared with a hand mixer separately for each calf prior each feeding to ensure precise intake measures. Feed refusals were weighed individually.
- Feed refusals, drinking time, feeding assistance, fecal scores, color and consistency were tabulated daily. Feeding schedule was calculated based on metabolic weight, quantity of metabolic energy per kg of feed, maintenance requirement and a 1.76 lb per day weight gain.
- Feed intake was determined from the morning feeding December 17 until the evening feeding December 21. Feces were collected in plastic bags attached to the calves with a harness from the morning of December 18 until the morning of December 23.
- The soluble wheat gluten protein tested was manufactured by Amylum, N.V., currently owned and operated by Tate & Lyle. Brand tested in the study was KALPRO S. SOLPRO 508 is the same technology with slight improvements. SOLPRO nutrient specifications are in Table 2.

Title	Location	Author	Ingredient	Wheat % of Formula	No. of Calves	Initial Weight (lbs)	ADG (lbs)	F/G	Age - No. Days in study	Results
Digestibility Study	ILOB -Holland	Tolman	All milk	0%	5	117	N/A	N/A	56 - 61	94.1% CP digestibility
	SOLPRO hydrolyzed wheat gluten (28.5% of CP)			10%	5	117.7	N/A	N/A	56 - 61	95.3% C.P. di All diets balanced for amino acid levels using synthetics
1991		SOLPRO (47.33% of CP)		20%	5	118.6	N/A	N/A	56 - 61	94.9 C.P. digestibility

Table 5: Avg. digestibility coefficient & s.d. (%)

Treatment	Dry Matter	Organic Matter	Crude Protein	Fat	Carbohydrate
All-Milk	96.6 +/- 0.7	97.1 +/- 0.6	94.1 +/- 1.0	94.9 +/- 0.3	99.1_a +/- 0.3
10-% wheat	96.8 +/- 0.9	97.2 +/- 0.8	95.3 +/- 1.1	96.5 +/- 1.5	98.7_{ab} +/- 0.4
20% wheat	96.0 +/- 1.0	96.5 +/- 0.9	94.9 +/- 1.6	95.6 +/- 1.8	98.1_b +/- 0.2
Statistics	NSD	NSD	NSD	NSD	$P < 0.05$



RESULTS:

- The researchers reported calf health as excellent. One calf in group 2 (10% wheat) was successfully treated for pneumonia.
- All milk replacers remained stable and had no off odors. The transition to the test diets was conducted without difficulty. All calves consumed formulas in 2–3 minutes and there were no refusals.
- Quantity, color, smell and consistency of feces were reported as typical with only slight variance in two calves (stiffer stool in one calf in 10% wheat formula group and darker stools in one calf in the 20% wheat formula group)
- No significant difference reported in body weight gain, ADG or feed conversion across treatments. Hemoglobin was not effected by treatment.
- The digestibility coefficients of soluble wheat gluten proteins for dry matter, organic matter and crude protein were estimated at 95% each and were independent of the amount of the wheat protein incorporated (10% or 20% of formula).
- Fat digestibility was not impacted by treatment.

BOTTOM LINE: Authors note wheat protein digestibility is 96%.

Kilshaw PJ and H. Slade. **1982**. Villus atrophy and crypt elongation in the small intestine of preruminant calves fed with heated soyabean flour or wheat gluten. *Res Vet Sci* Nov ;33(3):305-8.

Abstract – « Serial biopsies were removed from the jejunal mucosa of preruminant calves given single or multiple feeds containing heated soyabean flour or wheat gluten. Morphometric investigation using a microdissection technique revealed partial villus atrophy and crypt elongation. The first exposure to soyabean protein caused slight shortening of villi but after a succession of experimental feeds of heated soyabean flour or gluten, animals developed marked mucosal abnormalities and severe diarrhoea. Villus atrophy and crypt elongation were seen 24 hours after challenge with an experimental feed and restoration of normal morphology on a diet of milk alone took about 10 days. The data are discussed in relation to coleliac disease of man and the use of soya products in milk replacers for calves »

I (Dave) can't find anything more than the abstract. Unsure of procedures and how wheat gluten fit into the sequence with soy flour in testing.