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Summary

A field trial experiment was conducted using 50 steers to evaluate the feeding value of the ultrafiltrated permeate of whey (UFP) and products made from additional processing of UFP. All steers were fed nutritionally balanced grain mixes and hay. Experimental diets were control (C), in which the grain mix contained primarily corn, oats and soybean meal; UFP fed as the only liquid; partially fermented permeate (PFP), which contained 10% dried yeast added to the ultrafiltrated permeate, fed as the only source of liquid; fermented ammoniated condensed permeate (FACP), which replaced soybean meal in the grain mix; and ammolac (AMM), FACP plus vitamins and minerals. Steers fed C, FACP and AMM diets had free choice access to water. The liquid UFP and PFP were readily consumed by steers and supplied 4.8 lb of dry matter which replaced 5.3 lb of grain. Weight gains, total feed dry matter consumption and feed dry matter per weight gain were similar for steers fed all five diets, indicating that all four of these whey products were utilized as well as more traditional feeds. The quality of carcasses from steers fed the whey products were at least as good as and possibly better than from steers fed the control diet. The feeding of UFP or PFP would likely be the most economical alternative for feeding ultrafiltrated permeate of whey. However, some concentrating of the permeate to increase the solids content from the present 5.0 to 5.5% solids to greater than 10% solids may allow UPF or PFP to replace even more grain.

(Key Words: Whey, Ultrafiltrated Permeate, Liquid Protein Supplements, Steers.)

Introduction

Liquid whey, a by-product of cheese production, has been successfully fed to cattle and hogs for many years. With the advent of ultrafiltration technology, many of the whey proteins can be removed from the whey to make whey protein concentrates for use in human foods. This leaves an ultrafiltrated permeate of whey (UFP) which contains 5.0 to 5.5% solids vs 6 to 7% solids in whey, 2.5 to 3.0% of the solids (dry matter) as crude protein vs 12 to 14% in whey and most of the minerals and lactose which were in the original whey.

Limited research is available to demonstrate the suitability of UFP as feed for cattle. Also, since UFP contains less solids and protein than liquid whey, it is not known if additional processing or additives could effectively improve the feeding value of UFP. Liquid protein supplements similar to products containing ammonium or urea with molasses are produced as fermented ammoniated condensed whey. It was not known if similar products could be made using UFP as the starting material in place of whey. Thus, an experiment was conducted to

evaluate UFP as a feed as well as evaluate products produced by additions or further processing of the UFP.

Experimental Procedure

Ultrafiltrated permeate of whey as well as three products resulting from additions or additional processing were evaluated in a feeding trial using steers. The products evaluated were UFP; partially fermented permeate (PFP), which consisted of UFP plus dried yeast[1] added at the rate of 10% of true solids content of the UFP to the farm storage tank at the time of UFP delivery to the farm; fermented ammoniated condensed permeate (FACP); and Ammolac (AMM), fermented ammoniated condensed permeate plus vitamin and mineral additions.

This research was conducted as a field trial at a farm near Pollock in north central South Dakota. The facilities did not allow us to obtain individual intakes of grain or hay but served as a realistic setting for obtaining animal performance data during the winter under practical farm conditions. The lots were open with wind protection from the northwest provided by a 10-foot high board fence.

Fifty Holstein steers weighing 540 to 900 lb (average 755 lb) were blocked into groups of five by weight and one steer from each of the ten blocks randomly assigned to one of five experimental diet groups. Experimental groups were control (C), UFP, PFP, FACP and AMM. All steers were fed grass hay and an appropriate grain mix free choice. Several batches of grass hay were used throughout the trial, but all dietary treatment groups of steers received hay from the same batch at any one time. Steers in the UFP and PFP groups also received those liquids as their only source of liquid via waterer systems which were heated to about 50 to 55° F to prevent freezing, whereas steers in the other groups received water via similar waterers.

The grain mixes (table 1) were formulated so that the total diet dry matter content met or exceeded nutrient requirements for steers weighing 700 to 1300 lb. The amount of oats in the grain mixes varied so that estimated fiber content of total diets would remain rather constant. Dicalcium phosphate, trace mineral salt and vitamin additives varied to maintain essentially equal total diet composition for calcium, phosphorus, trace minerals and fat soluble vitamins. Soybean meal was replaced by FACP or AMM in those grain mixes.

The ultrafiltrated permeate of whey was delivered to the farm every other day and stored in bulk tanks in an insulated room. Additional heat was provided to the room as needed with a Nipco heater to prevent freezing. Each liquid product (i.e., UFP or PFP) was delivered from the tank to the waterer (Ritchie insulated) with the aid of a mobile home type pump.

Steers were adapted to their diets over a period of approximately a month. Liquid permeate products were blended with water in increasing proportions of permeate during this adaptation period. All steers were adapted to diets prior to initiation of the experimental period on December 5, 1985. The growth trial continued for 17 weeks (119 days) until April 3, 1986. Steers were weighed the first Thursday of each month.

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[1]Provesteen-K dried yeast.

At termination of the growth trial, the ten lighter weight steers in the C (3), FACP (4) and AMM (3) groups were separated out to be used in a second trial in which they were fed UFP concentrated to 10% or more solids. Data on that trial are not reported here. The remaining steers were killed and carcass evaluation data collected.

Results and Discussion

The chemical composition of grain mixes and hay are listed in table 2. Contributions from UFP and PFP are not included in this table. The UFP averaged 5.2% dry matter, while the PFP averaged 5.7% dry matter. Protein contents of the dry matter in UFP and PFP were 3.8 and 8.2%, respectively. The FACP and AMM contained 56.4 and 52.4% dry matter. The crude protein content in the dry matter of each of these products was 70.9 and 76.3%, respectively, which provided 40% crude protein for both FACP and AMM on an as fed basis.

Weight gains and feed intake data are presented in table 3. One steer in the UFP group died during the preliminary period, apparently from bloat that resulted from consuming a large amount of UFP during a short period of time. The watering system apparently had not been working for a few hours prior to the time it was repaired and this large consumption occurred shortly after the repair. This pointed out the importance of why we recommend that a steady supply of whey permeate or whey as well as hay be available to animals at all times.

Weight gains were similar ($P>.05$) for steers on all five diets throughout the 119-day experimental period. There appeared to be some differences in weight gains, with steers fed PFP having the greatest gains and those fed FACP having the least gains, but the individual animal variation prevented us from detecting these as statistically significant differences using only 10 animals per treatment. Weight gains tended to be greatest for steers fed UFP and PFP during some earlier monthly periods (data not shown), but these fluctuations may have been due to the amount of grain offered to steers on C, FACP and AMM diets which was less than they may have consumed free choice. Thus, diets containing any of the four whey permeate products supported as good weight gains as the conventional (control) diet. Weight gains were quite respectable, considering that these steers were housed in open lots and during the coldest winter weather.

Total dry matter intake and intake/gain were similar for all groups, although group feed intakes did not allow for a statistical evaluation of these parameters. Hay consumption was estimated each month as between 5 to 10 lb per head per day. The liquid whey products were readily consumed and no other bloat problems occurred throughout the trial. Attempts were made to assure that a steady supply of the liquids were always available. Liquid consumption averaged 92.0 and 83.7 lb per head per day for UFP and PFP, respectively. Consumption of dry matter from UFP or PFP averaged 4.8 lb per head per day for the entire trial. Thus, the liquid whey permeate products replaced 5.0 to 5.5 lb of grain (90% dry matter) per head daily.

Consumption of the liquid permeate products (UFP and PFP) was slightly greater during the first month (about 6 lb of dry matter per day) but declined slightly as the trial progressed to about 4 lb per day the last month. Why this decline occurred is not known, but the steers were consuming more than enough liquid to meet their needs for water. If these products were fed during hot weather which would increase water requirements, it is not known if total

consumption of UFP or PFP would be greater than observed in this experiment. Canadian studies with liquid whey feeding indicated that consumption of liquid may be twice as great in summer as in winter.

Carcass evaluation data are presented in table 4. Data in parentheses for UFP and PFP exclude data from the three lightest weight steers in each of those groups. This comparison was made in the event that including data from all steers fed UFP and PFP diets, whereas data for the other diets excluded the smallest steers because they were held back from market, may have biased the data. All carcass evaluation parameters measured were similar for steers in all groups, considering the statistical precision for the number of animals involved in this trial. Eliminating data from the smallest steers in the UFP and PFP didn't greatly alter the values for those groups. Carcass quality of steers fed whey permeate products, especially UFP or PFP, was at least as good as and possibly slightly better than carcass quality for steers fed the traditional control diet.

We are not attempting to make an economic evaluation in this report but that can be done by applying appropriate dollar values to various feed ingredients, labor and other inputs concerned with when feeding cattle. However, there are some items mentioned below which may merit consideration.

It is difficult to place a dollar value on the UFP, since for some cheese plants particularly small plants without whey drying facilities, the cost of disposal may be the dollar value for comparison. Such plants may provide the UFP to cattle feeders for the cost of hauling with little or no additional charges. Liquid protein supplements such as FACP and AMM would likely be priced competitively with other liquid protein supplements of similar crude protein content.

The simplest procedure from the processing standpoint would be to offer the ultrafiltrated permeate of whey to feedlot operators. This product, fed directly as UFP or with yeast added (PFP), can give acceptable animal performance. However, concerns to the feeder in using these products may include (1) altering a feeding system to accommodate the feeding of a liquid product, (2) a steady supply of this liquid, (3) adaptation period for cattle consuming this liquid and (4) the amount of grain mix which this liquid could replace. Replacing only 5.0 to 5.5 lb of grain per head daily may not attract a cattle feeder's attention, especially with current low grain prices, while replacing 10 lb or more of grain per head daily may make items 1, 2 and 3 listed above worthwhile.

If some water can be removed inexpensively so as to raise the solids content of the ultrafiltrated permeate to >10% solids, such a product may be more attractive to cattle feeders. Such a product could probably be fed as the only source of liquid without causing problems to the animal. However, as the solids content is increased, the mineral content is also increased. One may reach a point, probably around 15 to 20% solids, beyond which water must also be made available to cattle to maintain normal animal health.

Fermenting, ammoniating and condensing the permeate to make FACP or AMM adds cost to the product but produces a more marketable product. These products can be competitively marketed as liquid protein supplements, competing with other nonprotein nitrogen based liquid protein supplements. When protein supplements such as soybean meal are expensive, these liquid protein supplements can have a

definite price advantage over natural proteins. There is less water to transport and the product is more stable, so the potential marketing area can be greatly expanded.

However, if one is concerned with how much whey permeate dry matter is consumed per steer, more cattle will be needed to utilize all of the ultrafiltrated permeate generated by a cheese plant. For instance, in this experiment, steers fed UFP or PFP consumed 4.8 lb of solids per head daily from whey permeate, whereas those fed FACP or AMM consumed .75 lb per head daily. This lower figure was partially due to the fact that the whey permeate was converted from an "energy ingredient" in the UFP and PFP diets to a "protein ingredient" in the FACP and AMM diets. Cattle diets usually don't need as much protein supplement as energy sources.

This field trial demonstrated that the ultrafiltrated permeate of whey (UFP) as well as other products made from the permeate (PFP, FACP and AMM) can be useful feeds for cattle. Improved experimental precision would be needed to determine which of these products tested is the best product for a cheese plant to manufacture for the cattle feeder.

TABLE 1. COMPOSITION OF GRAIN MIXES

Ingredient	Grain mix				
	Control[a]	UF permeate[b]	Partially fermented permeate[b]	FACP[a]	Ammolac
	(%)				
Fermented, ammoniated condensed permeate	--	--	--	5.0	--
Ammolac	--	--	--	--	5.0
Corn, rolled, shelled	88.0	59.5	68.0	84.0	84.0
Oats, rolled	5.0	18.0	18.0	9.0	9.0
Soybean meal, 44% CP	5.0	20.5	12.0	--	--
Dicalcium phosphate	.5	--	--	.5	.5
Limestone	1.0	1.0	1.0	1.0	1.0
Trace mineralized salt	.5	1.0	1.0	.5	.5

[a] Contains 2,000 International Units (IU) of added vitamin A, 400 IU of added vitamin D and .15 IU of added vitamin E per pound of grain mix.

[b] Contains 4,000 IU of added vitamin A, 800 IU of added vitamin D and .30 IU of added vitamin E per pound of grain mix.

TABLE 2. CHEMICAL COMPOSITION OF GRAIN MIXES AND HAY

Item	Grain mix					Hay
	Control	UFP	PFP	FACP	AMM	
	(%)					
Dry matter	90.7	90.5	89.9	85.9	87.6	88.2
	(% of DM)					
Crude protein	12.5	18.2	16.0	12.1	12.1	6.7
Ether extract	2.9	2.8	3.2	3.0	3.0	2.0
Ash	3.7	4.5	4.7	4.0	4.2	10.5
NDF	18.8	20.3	19.9	19.2	19.2	68.8
ADP	4.9	7.5	6.2	5.3	5.3	45.0
Lignin	3.7	4.7	4.5	4.0	4.2	10.5

TABLE 3. WEIGHT GAINS, FEED DRY MATTER (DM) INTAKE AND FEED DRY MATTER INTAKE PER POUND OF GAIN FOR STEERS FED CONTROL (C), ULTRAFILTRATED PERMEATE OF WHEY (UFP), PARTIALLY FERMENTED PERMEATE (PFP), FERMENTED AMMONIATED CONDENSED PERMEATE (FACP) AND AMMOLAC (AMM) DIETS (DEC. 5, 1985, TO APR. 3, 1986)

Item	Diet					SE
	C	UFP	PFP	FACP	AMM	
No. of animals	10	9	10	10	10	
Preliminary wt[a], lb	750	744	754	763	762	--
Starting wt[b], lb	894	887	888	918	918	34.3
Ending wt[c], lb	1184	1183	1198	1167	1212	37.0
Gain, lb/day	2.43	2.48	2.61	2.10	2.48	.137
Feed intake, lb DM/day						
Hay[d]	5.3	5.3	5.3	5.3	5.3	--
Grain mix	21.9	17.4	17.5	20.6	21.4	--
UFP	--	4.8	--	--	--	--
PFP	--	--	4.8	--	--	--
Total DM	27.2	27.5	27.8	26.0	26.7	
DM intake/gain	11.2	11.1	10.6	12.4	10.8	

[a] Weights on 10/19/85, when brought into the feedlot.
[b] Weights on 12/5/85, after adjusted to diets.
[c] Weights on 4/3/86, at the end of the experiment.
[d] Amounts of hay consumed were estimated.

TABLE 4. CARCASS TRAITS FOR STEERS FED CONTROL (C), ULTRAFILTRATED PERMEATE OF WHEY (UFP), PARTIALLY FERMENTED PERMEATE (PFP), FERMENTED AMMONIATED CONDENSED PERMEATE (FACP) AND AMMOLAC (AMM) DIETS

Item	Diet					SE
	C	UFP	PFP	FACP	AMM	
No. of animals	7	9 (6)	10 (7)	6	7	
Carcass wt, lb	661	656 (706)[e]	663 (699)[e]	673	678	23.9
Dressing %						
Farm wt, %	53.2	55.4 (55.7)	55.2 (55.5)	55.0	53.8	.54
Delivery wt, %	57.8	59.0 (59.4)	58.9 (59.0)	58.9	58.1	.56
Fat thickness, in.	.11	.13 (.19)	.16 (.12)	.11	.14	.023
Rib eye, sq. in.	10.80	10.27 (10.51)	10.16 (10.50)	10.78	10.40	.423
Kidney, pelvic, heart fat, %	.93	1.33 (1.67)	1.50 (1.50)	1.08	1.28	.253
Yield grade[a]	2.10	2.28 (2.47)	2.56 (2.68)	2.14	2.37	.142
Maturity[b]	A	A	A	A	A	--
Marbling[c]	3.29	5.33 (6.33)	4.90 (5.00)	4.33	4.29	.566
Quality grade[d]	4.14	5.44 (6.33)	5.70 (6.00)	5.33	5.29	.542

[a] Yield grade calculated on actual fat thickness measure. Grades may have adjusted preliminary yield grade slightly higher to account for fat distribution in other locations. Actual yield grades may have been slightly higher but relative differences would have been as indicated here.

[b] All cattel were in A maturity category.

[c] Marbling levels: 1 = trace, 3 = slight, 5 = small, 7 = modest, 9 = moderate.

[d] Quality grades: 1 = standard, 4 = good, 7 = choice.

[e] Data in parentheses are after the three lightest weight animals were removed.