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INDUSTRIAL WASTE DIVERSION PROGRAM

CORRUGATED PAPER FEED PROJECT

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Report prepared for:

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This report was prepared for the Ontario Ministry of the Environment as part of a ministry-funded project. The views and ideas expressed in this report are those of the authors and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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GLOSSARY

ADF — Acid detergent fiber (a poorly digested feed fraction)

ADG — Average daily gain (lbs or kg/day)

CORPAP — Waste corrugated paper (brown cardboard)

CP — Crude protein

DM — Dry matter

in vitro digestion — Laboratory technique to estimate feed digestion in an animal using a small feed sample in an inoculum of rumen fluid

in vivo digestion — Laboratory technique to determine digestion of a feed ingredient by passing it through a live animal

IU — International units

IVDMD — *in vitro* dry matter digestibility

MSW — Municipal solid waste (normally curbside garbage)

NDF — Neutral detergent fiber (a generally well digested feed fraction)

PTO — Tractor power take off

TDN — Total digestible nutrients (a measure of overall feed quality)

WBG — Wet brewers grain (high protein residue from cereal grain used in beer production)

CORRUGATED PAPER FEED PROJECT

1. Project Objectives

   A. To demonstrate the feasibility and cost of collecting and separating feed grade corrugated paper from other dry waste materials;

   B. To evaluate different processing methods to convert the raw material to a form suitable as a feed ingredient, and methods for mixing the processed material with common farm feeds;

   C. To establish the feeding value of processed corrugated paper in a practical livestock feeding system;

   D. To determine the economic feasibility of using processed corrugated paper as a part of a practical livestock ration.

2. Project Background

The amount of corrugated papers consumed annually in Ontario can be approximated from a U. S. per capita consumption figure, which was estimated to be 52.5 pounds per capita in 1980. Based on an Ontario population 8.88 million people, the amount of waste corrugated paper generated annually in Ontario is in the order of 231,000 tons. According to one study the recovery rates in major Ontario and Quebec centres ranged from 30 - 40% in 1976. At the 40% level of recovery there are about 139, 000 tons of waste corrugated paper that are landfilled annually in Ontario.

This pilot project was designed to demonstrate the feasibility of source separating waste corrugated paper and diverting it from the landfill site to processing as a livestock feed ingredient. The basic laboratory research showing that waste corrugated paper is a digestible source of feed energy for ruminants and some other livestock, such as horses, has already been done. However, field trials have been lacking to demonstrate the feasibility of incorporating it into practical farm feed rations. Also lacking was any evaluation of methods of collecting, separating, processing and storing waste corrugated paper for livestock feed.

Previously reported evaluations of corrugated paper as a livestock feed ingredient relied heavily on laboratory techniques, especially chemical analyses and <u>in vitro</u> digestion methods with very little good data on actual feeding trials. Moreover, much of the data reported is difficult to interpret and relate to this specific situation because of the varied terminology applied to the materials tested, eg. boxboard, brown or grey cardboard, grey corrugated, etc. As well, chemical analyses often revealed large differences in such things as heavy metal content of the various materials within the same report, suggesting that they were produced by significantly different processes. Other laboratories insist on publishing their <u>in vitro</u> digestion trial data as a 72 or 96 hour digestion evaluation, which gives unrealistically high digestion values compared with those obtained at 48 hours. The latter approximates much more closely the actual feeding value of the cellulose waste in practical animal rations.

Additionally, much of the available information is based on materials manufactured over ten years ago and there have been significant changes in manufacturing techniques. Hence there is need for data on currently manufactured materials. The present study was based on corrugated paper waste taken directly from a major supermarket.

3. Sourcing and Evaluation of Waste Corrugated Paper

A supply of clean corrugated waste paper was obtained from the Loeb IGA store in Alexandria. The dry waste materials from the store and warehouse are transferred to a semi-trailer van parked at the loading dock, for disposal at the Town of Alexandria landfill site. The dry wastes from the store are primarily packaging materials, of which corrugated paper boxes are the largest single item. Other corrugated paper products include box liners and product separator panels. Box board and plastics are the other main components of the waste materials.

The major shelf re-stocking is carried out by the night shift, so that the largest volume of material is available by 8:00 AM. A secondary re-stocking during the day provides a lesser volume of material by about 4:00 PM.

Material sorting and collection for the feeding trial was carried out by one man with a pick-up truck, Wednesday through Saturday at 8:00 AM. The high quality corrugated material in the storage van was manually sorted to eliminate undesirable materials (eg. plastics, empty soft drink containers) and other contaminants (eg. broken glass, meat scraps) characteristic of a large food retail operation. The corrugated material was loaded in the truck and covered with a tarpaulin. The average load was estimated to be 242 lbs (110 kg). It occupied a space of approximately 208 cu. ft. (8' X 6.5' X 4'). The material was stored under cover in a building on the farm.

4. Processing Waste Corrugated Paper

Initial equipment selection examined three different machines. They were a wood chipper, a hammermill for feed grinding and mixing, and a standard forage harvester.

The wood chipper tested was standard self-powered, trailer-mounted model that is used commercially by arborists. While the machine was able to shred corrugated paper very well, the material was left in long strips which were not suitable for livestock feed. More recently another type of wood chipper has been identified that appears to be better suited for shredding waste papers.

The hammermill grinder/mixers that were examined were all found to have a series of spiralling vertical mixer rods inside the grain tank. While these rotating rods facilitate the movement of small-diameter material through the tank into the milling throat, they would impede the movement of large corrugated paper sheets and boxes. (While tub grinders have been used for grinding waste paper, none were available for testing in this area.)

The forage harvester was an International Harvester model 720, a mid-range model used for harvesting silage crops. The cutter head is a rotating knife-type, and re-cutter screens can be added to control material size and length. The rate at which material moves into the rotating knives is controlled by the speed of rotation of the crop pick-up head, that can be reduced by changing gear ratios. The system was powered by the tractor power-take-off (PTO), which in this case was a 155 horsepower Case 1390 farm tractor.

Testing of the forage harvester was conducted by bringing the unit up to operating speed in a stationary position. Corrugated boxes were flattened or cut open and fed by hand into the crop pick-up head, which in turn fed the material into the rotating cutting head, at a controlled rate. Particle size ranged from dust-like material to about 1 inch square, with the average being in the order of 3/8" X 1". The chopped material was augered to the discharge chute where it was blown into the barn for storage.
An estimate of the rate of processing was obtained by weighing a predetermined volume of corrugated material and recording the time required to feed all of the weighed material through the forage harvester. With two men feeding the material into the pick-up head, about 1400 - 1500 pounds per hour can be processed into particle sizes that are suitable for fresh-mixed feed. For the feeding trial the CORPAP was processed through the harvester with the re-cutter screen in place.

Corrugated material was also processed through the forage harvester without the re-cutter screen in place. While the rate of processing increased without re-cutter screen, the chopped material was in the form of long thin strips, similar to the output from the wood chipper (above).

5. Animal Feeding Demonstration Trial of "CORPAP" (Waste Corrugated Paper) With Young Beef Cattle

A. Feeding Facility and Animals

The 200 head feedlot facility of Mr. Weibe Meyer, Williamstown, Ontario was utilized for this demonstration. The feedlot is a covered shed with sides that could be partially opened in hot weather or closed in cold weather, with slatted floor. There were six pens for group feeding of five animals per pen, with separate manager and water bowl for each pen. The pens were 8' wide and 16' long, except for the Control B restricted feeding pen which was 16' wide to ensure that all animals could feed at the same time.

The cattle were locally obtained and they were variable in terms of breeding, sex, weight and condition. Their average age was estimated to be 8 months. On arrival at the feedlot on June 8, 1989, all animals received the standard veterinary preventative health treatment (by qualified veterinarians) for feedlot cattle which included Triangle 8 (anti-shipping fever vaccine), BRSV (preconditioning treatment, respiratory system), and IVOMEC (de-worming treatment).

A blood sample was taken from each animal and held in storage by the veterinary in case any pathological or physiological information was needed. Veterinary service was available on call throughout the trial as required. All 30 animals were put on a standard backgrounding ration (June 8) to adjust them to the new environment. About June 18 CORPAP was introduced into the ration. On June 28, 1989, the 30 animals were weighed individually and allocated to the six pens, five animals per pen, on the basis of weight, sex and breeding (see Table 1).

From then until July 13, 1989, each pen received their particular experimental ration over a two week adjustment period preceding the main trial. Each animal received an injection of 250,000 IU of Vitamin A on June 28, 1989.

Animals were weighed every 14 days throughout the 98-day trial and the final weight was the average of weights taken on two successive days. Water was cut off about 10:00 PM the night before cattle were weighed. Blood samples were taken at the beginning and end of the feeding trial. Since there was no indication of any pathological disturbances or of toxicity factors in the feeds, it was considered unnecessary to carry out any analysis on these samples.

B. Description of Feeds

The physical properties of CORPAP have already been described under the section on processing (above). Its composition is shown in Table 2. Of particular interest is the very low protein of 0.58% and low Ca and P content, indicating the need for protein and

Table 1 WEIGHT, SEX, BREEDING AND AVERAGE DAILY GAIN OF CATTLE, BY RATION, IN "CORPAP" TEST

Ration	Animal	Sex	Breed	START WEIGHT July 13 (lb)	(kg)	FINISH WEIGHT Oct. 20 (lb)	(kg)	AVE. DAILY GAIN 98 days (lb)	(kg)
CONTROL A	27	S	Ex	880.0	400.0	1190.0	540.9	3.2	1.4
(Appetite)	13	H	Br	732.0	332.7	930.0	422.7	2.0	0.9
	2	S	Ho	625.0	284.1	817.0	371.4	2.0	0.9
	29	S	Ex	581.0	264.1	865.0	393.2	2.9	1.3
	17	H	Br	534.0	242.7	756.0	343.6	2.3	1.0
Pen wt.				3352.0	1523.6	4558.0	2071.8	12.3	5.6
Av. wt.				670.4	304.7	911.6	414.4	2.5	1.1
CONTROL B	15	S	Ex	782.0	355.5	973.0	442.3	1.9	0.9
(Restricted)	3	S	Ho	584.0	265.5	855.0	388.6	2.8	1.3
	8	S	Br	684.0	310.9	907.0	412.3	2.3	1.0
	22	H	Ex	779.0	354.1	975.0	443.2	2.0	0.9
	26	H	Ex	575.0	261.4	778.0	353.6	2.1	0.9
Pen wt.				3404.0	1547.3	4488.0	2040.0	11.1	5.0
Av. wt.				680.8	309.5	897.6	408.0	2.2	1.0
CORPAP 10%	28	H	Ex	732.0	332.7	979.0	445.0	2.5	1.1
(changed	50	H	Ex	728.0	330.9	955.0	434.1	2.3	1.1
from	19	S	Br	582.0	264.5	876.0	398.2	3.0	1.4
50% on	41	S	Br	630.0	286.4	825.0	375.0	2.0	0.9
July 13)	4	S	Ho	479.0	217.7	719.0	326.8	2.4	1.1
Pen wt.				3151.0	1432.3	4354.0	1979.1	12.3	5.6
Av. wt.				630.2	286.5	870.0	395.5	2.4	1.1
CORPAP 20%	10	S	Br	783.0	355.9	1003.0	455.9	2.2	1.0
	21	S	Ex	733.0	333.2	946.0	430.0	2.2	1.0
	7	S	Ho	581.0	264.1	810.0	368.2	2.3	1.1
	5	H	Br	683.0	310.5	888.0	403.6	2.1	1.0
	31	H	Ex	479.0	217.7	679.0	308.6	2.0	0.9
Pen wt.				3259.0	1481.4	4326.0	1966.4	10.9	4.9
Av. wt.				651.8	296.3	870.8	395.8	2.2	1.0
CORPAP 30%	24	S	Ex	830.0	377.3	1088.0	494.5	2.6	1.2
	25	H	Br	727.0	330.5	899.0	408.6	1.8	0.8
	32	B	Br	734.0	333.6	986.0	448.2	2.6	1.2
	12	H	Br	581.0	264.1	710.0	322.7	1.3	0.6
	20	H	Ex	432.0	196.4	741.0	336.8	3.2	1.4
Pen wt.				3304.0	1501.8	4424.0	2010.9	11.4	5.2
Av. wt.				660.8	300.4	884.8	402.2	2.3	1.0
CORPAP 40%	23	S	Ex	877.0	398.6	1090.0	495.5	2.2	1.0
	11	H	Br	728.0	330.9	887.0	403.2	1.6	0.7
	18	S	Ex	632.0	287.3	885.0	402.3	2.6	1.2
	30	H	Ex	484.0	220.0	723.0	328.6	2.4	1.1
	6	S	Ho	531.0	241.4	773.0	351.4	2.5	1.1
Pen wt.				3252.0	1478.2	4358.0	1980.9	11.3	5.1
Av. wt.				650.4	295.6	871.6	396.2	2.3	1.0
TOTAL WEIGHT, CATTLE ON TEST				19722.0	8964.5	26508.0	12049.1	69.2	31.5
AV. WT.				657.4	298.8	883.6	401.6	2.3	1.0

LEGEND: S = steer, H = heifer, B = bull; Ex = Exotic breed, Br = British breed, Ho = Holstein

mineral supplementation. The available energy as indicated by the neutral detergent fiber content of 92.6% is expected to be quite high. The *in vitro* dry matter digestibility of CORPAP (see Table 2) at 48 hour digestion time is 55 to 58% which is equal to medium quality hay. These data categorize the feeding value of CORPAP as a good source of energy but low in protein and minerals.
Analyses of the CORPAP for heavy metals showed the following levels:

Metal	PPM
Pb	4.1
Hg	0.25
Cd	0.09
Cu	4.6

None of these levels of heavy metals would be cause for concern in utilizing CORPAP as a feedstuff for cattle.

Two separate batches of hay were purchased and fed. The first was a high quality red clover. Its chemical composition (Table 2) indicates it was high in protein (14.5%) and relatively acid detergent fiber (ADF) and neutral detergent fiber (NDF). The cattle consumed this hay with relish leaving little or no hay residues. The second batch was a first cut grass hay which was much lower in protein (7.4%) and higher in ADF and NDF. Feed consumption indicated it was less palatable for the cattle with an excess of stemmy material resulting in some feed residue.
Periodic samples of the hays and CORPAP were taken and combined as composite samples for chemical and *in vitro* analyses.

The wet brewers grains (WBG) were obtained from Miracle Feeds, Montreal. They were stored in 8 ft. diameter plastic "ag bags" at the feeding site. Two batches were purchased, both containing approximately 24% DM. The protein content was high (25.7% - Table 2), likewise the mineral content, except for phosphorus (P).
The cattle found the WBG very palatable, however, both batches appeared to be somewhat more acceptable after several days storage on site than when freshly processed.

The corn/soybean meal concentrate mixture contained 15.9% protein (Table 2) and had an excellent mineral profile other than a somewhat low (0.55%) calcium content. Cobaltized/iodized salt was supplied to each pen in block form. A commercial mineral mixture, Master Feeds M+V220, was also supplied containing supplemental Ca, P, trace elements and vitamins (120 gm/animal/day) to ensure adequate mineral intake. Compositional data is given in Appendix C.

The results of the *in vitro* dry matter digestion (IVDMD) showed high values after 72 hour digestion. However, since most of the CORPAP will not likely be retained in the animal's fore-stomach/rumen for more than a 48 hour digestion, the 48 hour

Table 2 CHEMICAL COMPOSITION OF RATION INGREDIENTS (DRY MATTER BASIS)

Chemical Analysis		Hay Red clover	Hay Grass	Wet brewers grains	Corn/soy conc. mix	CORPAP
Dry Matter	%			24.3*	86.9	92.1
Crude Protein	%	14.5*	7.4*	25.7	15.9*	0.63*
Ca	%		0.54	0.18	0.55	0.13
P	%		0.24	0.52	0.62	< 0.05
Mg	%			0.21	0.17	< 0.05
P	%			< 0.05	0.71	< 0.05
Mn	(ppm)			38	36	62
Cu	(ppm)			10	32	5
Zn	(ppm)			20	126	20
Acid Detergent Fiber (ADF)	%	39.9	33.3			83.45
Neutral Detergent Fiber (NDF)	%	45.1	63.8			92.61
In Vitro (48 hr) Dry Matter Digestibility (IVDMD)	%					55 - 58%

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* Average of 2 analyses

in vitro values of 55% TDN are a much more realistic estimate of CORPAP's energy value to cattle. This 55% TDN level was used in the computer formulations.

C. Rations and Feeding Program

The 98-day feeding program commenced July 13, 1989. The basic treatments were Control A, Control B, and CORPAP at 10, 20, 30 and 40% levels (of dry matter), with one treatment per pen (see Table 3). The basic feeds were hay, wet brewers grains (WBG), corn, soybean meal and CORPAP. Molasses was added to the ration in small quantities to improve the palatability of CORPAP. The corn and soybean meal were mixed and ground together as a concentrate.

The ration for each pen was computer formulated using the OMAF Beef Program, based on the nutrient requirements of young growing beef cattle, as outlined in the US NRC Nutrient Requirements of Beef Cattle, Bull. # 4, 1976. No growth stimulants were used in this project.

The rations were also formulated to accommodate changes in nutrient requirements for a two phase feeding program. Phase 1 covered the growth period 700 - 800 lb average weight. Phase 2 met the standards for growth from 800 lbs to the end of the trial. A summary is given in Table 3 and the computer printouts are shown in Appendix B.

Control B animals received the same ration as Control A but were restricted in the amount fed to a level of TDN estimated to equal the TDN from the 30% CORPAP ration. The intent was to provide a method to assess the quality of the 30% CORPAP ration relative to one containing conventional ingredients. With the limited resources available, it was not possible to assess this factor with more sophisticated techniques, eg. digestibility trials.

As far as possible CORPAP was increased in the rations at the expense of hay. This reduced protein levels as can be seen in the computer printouts; however, since the WBG was supplying an excess of protein the high CORPAP rations still contained adequate protein to meet requirements.

D. Results and Discussion

It should be clear that this trial was not a sophisticated experiment but rather a practical "on-farm" demonstration trial with limited facilities and budget. For example, more animals and pens to provide replication of rations plus resources to measure feed efficiency would have given more precise information on ration quality and permitted a more in depth evaluation of the economics of utilizing CORPAP for ruminants.

Table 3 COMPOSITION OF RATIONS FED OVER 98-DAY FEEDING TRIAL

	Control		CORPAP			
	A	B	10%	20%	30%	40%
<u>Phase 1</u>	(....lbs of feed/animal/day, as fed basis.....)					
(657-800 lb)						
Red clover hay, 1st cut	10	10	8	6	4	2
Wet brewers grains	15	15	15	15	15	15
Corn/soy concentrate	6	6	6	6	6	6
Molasses	0.25	0.25	0.25	0.25	0.25	0.25
CORPAP *	0	0	2	4	6	8
<u>Phase 2</u>						
(800 lb - fin. wt.)						
Grass hay, 1st cut	5.5	5.5	4.5	3.2	1.7	0.1
Wet brewers grains	19	19	19	19	19	19
Corn/soy concentrate	9.5	9.5	9.5	9.5	9.5	9.5
Molasses	0.25	0.25	0.25	0.25	0.25	0.25
CORPAP *	0	0	1.8	3.5	5.3	7.0

Control A and all CORPAP rations were fed to appetite. Control B was restricted to the estimated energy intake of 30% CORPAP ration.

* Phase 2 CORPAP requirements/animal/day were slightly less than in Phase 1 because of higher dry matter intake from other feed ingredients in the ration.

Table 4 shows the average daily gains (ADG) of the cattle over the 98-day period. At 2.5 lb ADG, Control A clearly gave the best rate of gain although somewhat lower than expected. Control B group gained at a considerably slower rate of 2.2 lb ADG, which was slightly below the 2.3 lb ADG of the 30% and 40% CORPAP groups. This suggests that the CORPAP consumed by those groups was indeed a good source of energy at least equal to the 55% TDN value assigned to it in the computer program and as a replacement for hay. The 10% CORPAP group demonstrated ADG of 2.4 lb, essentially equal to Control A. Because of the limited number of animals on each treatment and the relatively high variability within groups (Table 1), differences of 0.1 lb ADG are unlikely to be significant.

The dose/response curve shown in Fig. 1 illustrates how CORPAP levels in the rations affected ADG. While the 20% CORPAP ration showed a lower-than-expected (2.2) ADG, it seems likely this was by chance due to a lower genetic capability for growth by this animal group. Especially as the between-animal variability here was exceptionally low (Table 1). The graph suggests that the ADG values for the 20% ration should be at least equal to the overall CORPAP ration average of 2.3 ADG. If this is so, we conclude there was very little, if any, difference in ADG on the 20, 30 and 40% CORPAP rations. Moreover, a rough estimate of CORPAP refusals indicated that intake of CORPAP plateaued at about the 25% level, suggesting that the quality of the CORPAP fiber was superior to that of the hay which it was replacing.

Comparing these animal performance data with those of Stidham et al (1980) where corn silage was substituted with CORPAP in the ration for young steers, it is noteworthy that ADG's were essentially identical. These authors also reported that intake of CORPAP also plateaued at about the 25% level and ADG remained unchanged, as was the case in this trial.

It is well known that the level and quality of fiber in rations fed to young growing/finishing beef cattle are important factors affecting ADG. Since the level of CORPAP fiber is very high (92.6% NDF, Table 2) compared with, for example, the red clover hay at only 45%, quality is a very critical factor. The IVDMD of CORPAP, 55 - 58% at the 48 hour digestion period (Table 2) and 74% at 72 hours (Appendix C) strongly indicates that the quality is high and not likely to be a limiting factor in its utilization. However, in practical rations for ruminant animals the rate of fiber digestion imposes limitations as CORPAP cannot be digested as fast as concentrates and moves through the digestive tract before it is fully digested. This seems to be the main factor limiting the availability of CORPAP energy for ruminant production. However, how fast CORPAP fiber actually leaves the rumen, when fed in different rations, is very poorly understood.

Table 4 AVERAGE DAILY GAIN OF CATTLE DURING 98-DAY DEMONSTRATION FEEDING TRIAL

1989 Weigh Dates	Control A		Control B		CORPAP 10%		CORPAP 20%		CORPAP 30%		CORPAP 40%	
	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg
27/07	2.2	1.0	1.3	0.6	4.6	2.1	1.2	0.5	2.6	1.2	2.0	[illegible]
10/08	2.9	1.3	3.0	1.4	2.0	0.9	3.1	1.4	2.3	1.0	3.1	1.4
24/08	3.1	1.4	2.5	1.1	3.0	1.4	3.6	1.6	2.9	1.3	2.3	1.0
07/09	1.6	0.7	2.0	0.9	1.1	0.5	0.8	0.4	1.7	0.8	1.6	0.7
21/09	3.6	1.6	3.4	1.5	2.9	1.3	3.2	1.5	3.3	1.5	2.8	1.3
05/10	2.8	1.3	1.0	0.5	0.7	0.3	1.7	0.8	1.4	0.6	1.5	0.7
20/10	1.1	0.5	2.2	1.0	2.8	1.3	2.1	1.0	1.9	0.9	2.6	1.2
Ave.	2.5	1.1	2.2	1.0	2.4	1.1	2.2	1.0	2.3	1.0	2.3	1.0

Figure 1 EFFECT OF LEVEL OF CORPAP ON ADG FOR RATIONS FED TO APPETITE

o = average, all CORPAP rations

This trial demonstrated that wet brewers grains (WBG)(a waste product from the brewing industry) can be successfully combined with CORPAP, with or essentially without hay in rations for growing/fattening beef cattle. Moreover, the WBG were satisfactorily stored "on farm" without noticeable spoilage in plastic "Ag Bags" for several weeks in mid-summer.

Although molasses was fed at very low levels, hopefully to enhance the palatability of the CORPAP, no conclusions were drawn as to effect on intake. Neither was it possible to separate effects of of palatability on feed intake versus the "fiber factor" effect.

Finally this demonstration trial provides up-dated information on the feeding value of currently manufactured CORPAP in modern, computer formulated, commercial rations fed to young growing/finishing beef cattle. While limited in scope, it is directly applicable to modern beef production practices.

6. Economic Characteristics of CORPAP as a Feed Ingredient

The cost of CORPAP as a feed ingredient in beef rations was compared against that of hay. The combination of feed ingredients was made so that the only difference in the ratio of ingredients mixed for each pen was that of hay and CORPAP. The ratios of brewers grains: molasses:concentrate, mixed for each pen, remained constant. On this basis it was possible to assess the economic impact of different levels of CORPAP in the ration, compared with hay.

Feed cost comparisons were made on the same group of cattle at two different growth stages, ie. 700 - 800 lbs and 800 lbs to final weight, to reflect differences in protein and energy requirements. Growth comparisons for both weight classes were based on a projected ADG of 2.5 lbs. Comparisons were made on the basis of cost of feed per animal per day.

The OMAF ration balancing computer program was used to compare the cost of feed per animal per day for each of the four rations containing CORPAP, against each other and against hay in the control rations. The price of hay was held constant at $100.00 per ton for these comparisons while the price per ton of CORPAP was varied from $50.00 to $100.00 per ton in $10.00 per ton increments for each of the four CORPAP rations.

Results from the computer program were plotted in Figures 2 & 3 (below). Figure 2 shows the cost of feed per animal per day for the 700 lb weight class. Cost per animal per day of the control ration (hay, no CORPAP) was $1.30. With CORPAP at $50.00 per ton, the cost per day of the four rations ranged from a low of $1.12 per animal per day (40% CORPAP) to $1.25 (10% CORPAP). As the price of

CORPAP was increased, the cost spread between the different rations narrowed and began to approach that of the control ration (Fig. 2). This change is most notable as the cost of CORPAP increased from $70 to $80 per tonne, at which point the maximum cost saving advantage of CORPAP rations over hay has been reduced to a spread of about 7 cents per animal per day, compared with 18 cents at the $50/tonne level. When the price of CORPAP equals that of hay (ie. $100/tonne), the cost per animal per day is the same for all rations.

Figure 3 shows the cost of feed per animal per day for the 800 lb weight class. Cost per animal per day of the control ration (hay, no CORPAP) was $1.50. With CORPAP at $50.00 per ton, the cost per day of the four rations ranged from a low of $1.40 per day (40% CORPAP) to $1.48 (10% CORPAP). At $80.00 per ton for CORPAP, the daily cost of the 10%, 20% and 30% CORPAP rations were the same as hay. The daily cost of the 40% CORPAP ration was the same as hay when CORPAP reached a price of about $82.00 per ton. At $90/tonne for CORPAP, the cost of all CORPAP rations exceeds that of hay, in an irregular pattern.

Figure 2

COMPARISON OF FEED COSTS PER DAY OF FOUR CORPAP RATIONS VERSUS CONTROL RATION, FOR A 700 LB BEEF ANIMAL GAINING 2.5 LB/DAY

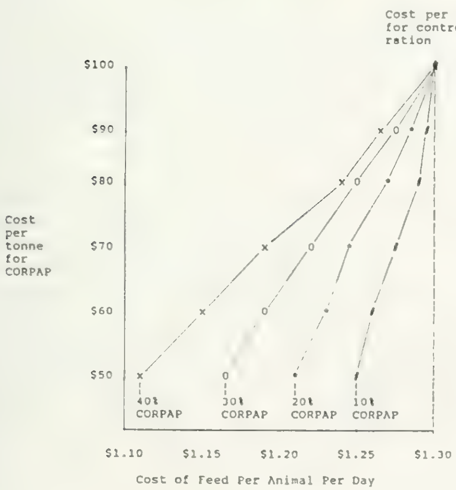

Figure 3

COMPARISON OF FEED COSTS PER DAY OF FOUR CORPAP RATIONS VERSUS CONTROL RATION, FOR A 800 LB BEEF ANIMAL GAINING 2.5 LB/DAY

7. Economic Assessment of Waste Corrugated Paper Diversion & Recycling

Costs for dry solid waste disposal have been rising dramatically in most of Eastern Ontario in the last one or two years, particularly tipping fees. The range of tipping fees is shown below in Table 5.

Table 5 TIPPING FEES AT SELECTED EASTERN ONTARIO LANDFILL SITES

- $5.00 per truckload (Town of Alexandria, 1989);
- $20.00 per ton (Town of Perth, 1990);
- $86.00 per tonne at the Trail Road landfill site in Ottawa-Carleton for MSW from the Township of Montague (1990);
- $43.00 per tonne at the Trail Road site for MSW from within Ottawa-Carleton (1990);
- South Gower Township, from within the Township only (1990):
  - 3/4 - 3 ton truck - $200.00/load
  - truck larger than 3 ton - $300.00/load

While tipping fees for different landfill locations are relatively easy to obtain, it is extremely difficult to accurately identify trucking costs on a per ton (tonne) basis. Industry estimates are based on size and type of truck, hours worked, baled vs loose waste, number of "lifts", number of trips per day or week and distance to landfill site.

Waste disposal costs for two large food stores (one in Alexandria and one in Nepean) were also examined. However, it is not possible to make accurate estimates of pick-up and haulage costs because the composition and weight of the materials in the containers are not recorded. Examination of the two waste systems indicated that a high proportion of the waste material from both locations is corrugated cardboard - in the order of 75% by volume.

Calculations were made for one township (Montague) using the estimated waste output per person per day of 1.2 kg and the total waste hauling cost for the Township. On this basis the pick-up and hauling cost per ton for MSW in 1990 is estimated to be $31.97 per tonne. Together with the Trail Road tipping fee of $86.00, the cost of MSW disposal from Montague Township is $117.97 per tonne (approximately $118.00/tonne). If a local municipality within the Regional Municipality of Ottawa-Carleton had the same pick-up and haulage cost as Montague, the total cost for landfill disposal would be $74.97 per tonne (approximately $75.00/tonne). For the Town of Perth the cost would be $51.97 per tonne (approximately $52.00/tonne).

This provides a range of estimated costs for MSW disposal from $52.00 to $118.00 per tonne against which the cost of collecting and processing CORPAP can be assessed. In the following analysis it is assumed that full loads of clean waste corrugated paper can be picked up and hauled for the same cost as MSW, and that the same tipping fees would apply to it as well. No cost estimates are included for further processing, mixing, storage or utilization of CORPAP after the initial processing, returns for risk and management, or cost of land and buildings.

Waste corrugated paper has been chopped, shredded and ground using a variety of equipment for different uses, without regard to particle size. In the case of livestock feeds small, uniform particle size can be a major advantage for feed mixing, uniformity of feed intake and to minimize the ability of the animal to selectively sort out CORPAP.

Preliminary cost estimates were prepared for two processing systems that appear to have immediate potential to process corrugated materials into small, uniform particle sizes for feed. The first system is essentially the one used in this project; however, a larger heavy duty forage harvester would be used to increase through-put. Some modifications are costed in here to include a self-feeding hopper that can be filled with corrugated material by a front-end loader. The second system costed here is a large tub grinder of the type used in western feedlots. Modifications are costed in to improve volume and rate of removal of ground corrugated material flowing from the screen, as made by one U.S. operator. (Inspection and evaluation of this and other potential processing systems was not possible because of spending restrictions). These estimates are outlined in Tables 6 - 9 below.

Processing cost estimates for the two systems were compared with landfill disposal costs for MSW in three different locations, using the same pick-up and haulage cost per tonne in each case, with the respective tipping fees that apply for each municipality.

Processing costs and hauling costs per tonne for each system were subtracted from total disposal costs per tonne to determine whether or not there would be a saving or additional cost to the municipality for processing versus landfill disposal. There is no provision for risk or profit in the processing estimates. These comparisons are shown in Table 10 below:

The farm equipment system shows a substantial net benefit for processing over disposal cost for Montague, while processing costs exceed disposal costs for RMOC by $7.00 and the Town of Perth by $30.00 per tonne. On the other hand, cost comparisons with the tub grinder system indicate that major cost savings are possible for processing waste corrugated paper from Montague and RMOC, ranging from $18.00 per tonne for RMOC to $61.00 per tonne for Montague Township. Disposal costs are less than processing costs for Perth by $5.00/tonne.

Table 6 ESTIMATED CAPITAL COST FOR TWO PROCESSING SYSTEMS

System	Capital cost of equipment
1. Farm Equipment (est. output/hour with 2 men = 1.5 tonne)	
Forage harvester, modified (used)	$10,000
150 hp tractor/power supply (used)	12,000
50 hp tractor/ front end loader (used)	8,000
Total	$30,000
2. Tub grinder (modified for handling paper, est. output/hour with 2 men = 5 tonnes	
Tub grinder (used)	$50,000
100 hp tractor/ front end loader (used)	15,000
Total	$65,000

Table 7 AMORTIZATION OF EQUIPMENT COSTS

Used equipment, over 2 years @ 15% interest, calculated on a monthly basis:

1. Farm equipment - $30,000 = $1448/mo. (rounded to nearest $
   = $72/day (20 days/mo.)

2. Tub grinder - $65,000 = $3138/mo. (rounded to nearest $)
   = $157/day (20 days/mo.)

Table 8 ESTIMATED OPERATING COST FOR TWO PROCESSING SYSTEMS

System	Operating costs/day
1. Farm equipment	
Labour - 2 men @ $8/hr ea. X 8 hrs	$128.00
Fuel	125.00
Maintenance	100.00
Contingencies + other	100.00
Total	$453.00
2. Tub grinder (modified for handling paper)	
Labour - 2 men @ $8/hr ea. X 8 hrs.	$128.00
Fuel	200.00
Maintenance	300.00
Contingencies + other	100.00
Total	$728.00

Table 9 ESTIMATED COSTS PER DAY AND PER TONNE FOR TWO PROCESSING SYSTEMS

System	Capital & Operating Costs	
	Per day	Per tonne
1. Farm equipment, 1 tonne/hour 7 hours operating	$525.00	$50.00
2. Tub grinder, 5 tonnes/hour 7 hours operating	$885.00	$25.29 ($25.00)

Table 10 COMPARISON OF COSTS AND BENEFITS OF PROCESSING WASTE CORRUGATED PAPER VERSUS LANDFILL DISPOSAL

Municipality	Estimated Cost of Landfill Disposal	Estimate of Cost Saving or Added Cost per Tonne of Processing Materials	
		Farm Equip.	Tub grinder
	(hauling + tipping)	($32 + $50)	($32 + $25)
Montague Twp.	$118	- $36 (saving)	- $61
RMOC	75	+ 7 (added ..)	- 18
Town of Perth	52	+ 30 (added ..)	+ 5

8. Issues & Implications

While it is clear that clean waste corrugated paper can be processed and successfully fed to beef cattle, several issues arise from this work. They are organizational and economic issues to be addressed for a new business venture in a non-traditional activity, as well as the problems of trying to initiate innovation and change within the existing framework and ways of doing things concerning waste disposal.

On the business side they include questions about cost and quality control in the collection and delivery of clean waste corrugated paper for processing, processing systems and costs, ability to fully utilize the volume of processed material, and profitable marketing of the output as a feed ingredient or for other uses. In this regard, while farmers are always interested in ways to reduce input costs, current low feed commodity prices do not provide a major incentive for them to seek out or readily accept non-traditional feed alternatives. This means that specific opportunity situations have to be identified and developed by the CORPAP processor, including feed, bedding, fuel and compost.

While provincial assistance for capital costs would be vital to the establishment of this type of new enterprise, there are a number of other problems. These include obtaining the necessary municipal and provincial approvals for establishing the new system in a given area, including selection and approval of one or more waste processing sites, arrangements for waste diversion, as well as support and encouragement for the operation, including product marketing and use. These supportive actions are of fundamental importance if new waste diversion projects are to be initiated in Eastern Ontario.

The supportive actions of provincial agencies and municipal government are major factors affecting the new enterprise for the following reasons:

A. Financial credibility - it will be extremely difficult for a new business in a new area of activity to obtain any form of financing for start-up and operating costs without this active support and encouragement;

B. Customer credibility - potential users of the processed materials, as well as waste suppliers, will need assurance that the new system meets government approvals and that the materials or products meet all applicable standards;

C. Operational stability - a new enterprise needs clear-cut rules and working arrangements that enable the management to focus on the defined task of waste processing and recycling.

9. Recommended Future Studies

The nutritional and economic characteristics of CORPAP and the experience gained in this feeding trial suggest that some useful additional work could be undertaken. This work could include:

A. Ensiling CORPAP with corn - a major problem in making corn silage is controlling the moisture content at a level suitable for efficient fermentation - a prerequisite for a quality feed and to minimize seepage losses of nutrients. Traditionally many farmers delay harvest until frost has dessicated the corn leaves and some stalk material to reach the desired dry matter content but in so doing some feed nutrients are sacrificed. If CORPAP was added in the ensiling process to increase overall dry matter content, the corn could be ensiled without recourse to the freezing/dessication losses. Additional feed nutrients would be conserved, feed processing and handling of CORPAP would be streamlined, earlier harvesting would improve operational efficiency of silage-making and a new source of feed energy made available. The feasibility of this procedure needs to be demonstrated.

B. Ensiling CORPAP with other materials - high levels of dry matter and feed energy content in CORPAP suggest an attractive material to mix with other high moisture content materials that contain useful feed nutrients. These include wet brewers grain, caged layer manure (a registered feed product), and a variety of wet wastes from food processors and manufacturers. Adding CORPAP to these wet materials has the potential to offset the problem of moisture content that is too high and improve feed quality. Several studies to demonstrate the feasibility of combining CORPAP with other wastes would be valuable.

C. Wintering rations for pregnant beef cows - cows can handle much more fiber in their rations than younger growing beef cattle. Hence levels of CORPAP in their rations could conceivably be as high as 60 - 70%. No data were found to demonstrate this use for CORPAP, hence the need for studies with this class of beef cattle.

D. During the course of this trial and after, additional different machines and modifications with possible good potential for processing waste papers were identified but not evaluated. Processing capability, performance and costs are extremely important factors in determining whether or not waste papers will be recycled or landfilled, or if waste paper products can compete with alternative materials. These machines should be carefully evaluated in the context of agricultural requirements for waste paper processing, particularly CORPAP for feed, as well as processing waste papers for bedding, compost and similar uses where particle size, particle uniformity and unit costs may be very important factors.

10. Summary & Conclusions

While there are increasing amounts of waste corrugated paper being recycled annually, there continues to be large volumes disposed of daily in Ontario landfill sites. Little serious effort has been made to examine ways and means to utilize this material in agriculture for animal feed, animal bedding or in compost as a soil amendment. This project was designed to demonstrate how clean waste corrugated paper could be diverted from landfill disposal for use as a feed ingredient for beef cattle.

Waste corrugated paper was collected and sorted 3 days per week from the Alexandria IGA Food Market from mid-June through September, 1989. The material was hauled by pick-up truck in average loads of 240 lbs to the farm site for storage and processing.

Processing was carried out with a standard medium-duty forage harvester, equipped with a re-cutter screen, and powered by a farm tractor. The rate of material processing was estimated to be in the order of nearly 1 tonne per hour. Particle size of CORPAP (processed clean waste corrugated paper) was relatively uniform, averaging about 0.5 inch square in size.

CORPAP was mixed daily at four different levels of dry matter content in an electric-powered feed mixer cart with wet brewers grain and corn\soy concentrate. All feed rations were computer balanced to achieve a projected daily rate of gain of 2.5 pounds per animal. No growth stimulants were used in this feeding trial. All cattle were weighed at 14 day intervals from beginning to end of the feeding trial.

Six rations were prepared. The two controls were based entirely on hay, wet brewers grain, corn/soy concentrate, molasses and a mineral/vitamin supplement. The other four rations included the same ingredients (except hay), with the addition of CORPAP as a replacement for the hay. Levels of CORPAP in the four rations were 10%, 20%, 30% and 40% of the total dry matter in the feed. The first control group was fed to appetite and the second was fed a fixed amount, based on the same level of feed energy intake as the pen receiving 30% CORPAP ration. Each ration was fed to five young beef animals for 98 days.

Average daily rates of gain (ADG) per animal for each ration in the six pens were as follows:

Control A (fed to appetite)	-	2.5 lbs
Control B (restricted)	-	2.2
10% CORPAP	-	2.4
20% CORPAP	-	2.2
30% CORPAP	-	2.3
40% CORPAP	-	2.3

The results show that the animals performed well on the CORPAP rations and that CORPAP is an excellent source of feed energy. It was observed that the intake of CORPAP levelled off above the 20% level (ie. the animals on the 30% and 40% rations ate essentially the same amount of CORPAP, leaving the remainder).

Feeding experience suggests that a 25% CORPAP ration would be the highest practical level of processed corrugated paper that would be readily consumed by young beef cattle, using these feed ingredients. That amounts to about 4.5 lbs (2.0 kg) of CORPAP per day for an 800 lb animal (ie. 489 animals of this size would eat about 1 tonne/day, larger animals would eat more).

From a nutritional viewpoint CORPAP contains little or no useful protein, minerals or vitamins. Thus its feeding value depends essentially on its available energy content. Its high neutral detergent fiber (NDF) level shows that CORPAP is a rich source of cellulose and hemicellulose. The relatively high IVDMD values and good ADG shows the fiber is well digested and available for productive purposes.

The cost of CORPAP was compared with the cost of hay in beef feeding rations for two weight classes of cattle, using an OMAF ration balancing computer program. The cost of hay in the control ration was held at $100/tonne, while the cost of CORPAP was ranged from $50 to $100/tonne in $10/tonne increments.

The rations with the highest levels of CORPAP showed the greatest cost advantage over hay up to about $80/tonne for CORPAP. For the 700 weight class, the cost advantage of CORPAP continued up to

$100/tonne where the cost of all CORPAP rations were equal to that of hay. The maximum cost advantage was 18 cents per animal per day for the 40% CORPAP ration over hay when CORPAP cost $50/tonne.

For the 800 lb weight class the cost advantages for CORPAP were somewhat less, with a maximum advantage of 10 cents per animal per day for the 40% CORPAP ration at a price of $50/tonne. At $80/tonne for CORPAP, the cost of 10%, 20% and 30% CORPAP rations were the same as hay at $100/tonne. The advantage of the 40% CORPAP ration disappeared at a price of about $82/tonne.

No reliable data were found of the cost per tonne for local collection/hauling of corrugated paper wastes. Estimates of costs were made for collection/hauling, based on per capita costs calculations for municipal solid waste collection/hauling (not including tipping charge) in one township (Montague). This estimate was about $32.00/tonne. Similarly, processing costs had to be estimated from experience gained in this project and from other secondary sources.

Processing costs were prepared for two different scales of operation, based on used agricultural equipment. System 1 (similar to that used for this project) was a modified heavy duty forage harvester, powered by a tractor PTO. The estimated output was 1 tonne/hr at a cost of $50.00. System 2 was a modified agricultural tub grinder (reported US experience). The estimated output was 5 tonnes/hr at a cost of about $25.00/tonne.

Estimated costs for processing were compared with estimates for landfill disposal costs for three municipalities. System 1 processing showed a substantial advantage over landfill disposal costs ($36.00/t saving) for one of the three municipalities, while System 2 processing showed a substantial advantage over landfill disposal costs ($18.00/t and $61.00/t saving) for two of three municipalities.

Four future studies were identified. These include potential advantages of ensiling corn with CORPAP, ensiling CORPAP with other suitable wet wastes, evaluating high CORPAP content rations for wintering beef cows, and evaluation of additional machines and modifications that appear to have processing potential for agricultural use of CORPAP and other waste papers.

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Mr. Wayne Macdonald and his staff in the Alexandria IGA (our source of waste corrugated materials) were extremely cooperative and helpful to us throughout the project, even though the work was of no benefit to them at this stage.

A special thank you is due to Mr. Francis Chretien, who provided 30 head of cattle for the feeding trial. Dr. Brian McNaughton and his staff provided veterinary services during the course of the project. We were able, through the OMAF Agricultural Representative, to make excellent working arrangements with the Glengarry Beef Producers Association for the use of livestock scales and an operator.

In the initial stage of this work we had planned to work with Kraft Ltd., Ingleside, on source separation of waste corrugated materials from the plant to supply our needs. While in-plant changes in waste handling made further working arrangements impractical, we want to thank the senior staff for their cooperation and patient understanding of our project needs.

APPENDIX A

LITERATURE REVIEW ON CELLULOSIC MATERIALS AS FEED INGREDIENTS FOR RUMINANT ANIMALS

LITERATURE REVIEW

The available energy to ruminant animals from cellulosic wastes, eg. newspaper, bond papers and corrugated paper is highly dependent on the extent of chemical processing of the basic pulp. Newspaper, consisting mainly of ground wood, is poorly digestible, hence a very poor energy source. Conversely, bond papers represent as they do the end product of sophisticated chemical processing are highly digestible. Corrugated paper (CORPAP) is intermediate in this regard.

In vitro studies have assigned various digestion values to corrugated and similar products. Mertens et al (1971) reported 77.8% (96 hr.) for brown cardboard; Belyea et al (1979) carried out 96 hr *in vitro* digestions of corrugated paper and reported the digestibility as 72% and NDF values of 96.5%. Belyea et al (1978) classified corrugated cardboard as moderate in digesibility and low in net energy for maintenance. Becker et al (1975) tested cardboard and brown bags in an *in vitro* system and reported 52.5% and 47.9% digestibility respectively. Van Soest and Mertens (1974) reported *in vitro* organic matter digestibility values of 72.0% for cardboard. Overall, these data strongly suggest that the digestibility of CORPAP in the rumen is much less than that found in the 72 to 96 hour *in vitro* digestion because it is likely to remain in the rumen approximately 48 hours.

Feeding trials with corrugated paper are limited in number and scope. Vandepopuliere et al (1977) fed 16% corrugated cardboard in a corn silage/soybean meal ration to lambs and obtained modest growth rates of 0.14 kg. ADG, equal to the control corn silage/soybean meal ration. Feed conversion rates however, were much lower at 12 kg./kg. gain for the paper ration vs. 8.6 kg./kg. gain for the control ration.

Harris et al (1978) fed 10, 20 and 30% corrugated boxes to dairy cows. Feed consumption with the 30% ration was lower than the 10 and 20% CORPAP. Milk production was equal to the control ration on the 10 and 20% CORPAP but lower on the 30% CORPAP ration. These workers estimated the TDN value of CORPAP at about 65%. No contaminants such as polybrominated biphenyls (PBB) were found.

Hintz and Schryver (1976) tested corrugated paper as an ingredient in pelleted rations for horses. They reported 85% NDF and an *in vivo* estimated organic matter digestibility of 72% for the 25% CORPAP in the pellets. The pellets were readily eaten by the horses. Since horses do not digest fiber as well as ruminants this suggests the CORPAP fiber has a high feeding value.

Stidham (1980) fed 5, 15, 25 and 35% CORPAP in rations for growing/finishing steers over a 237 day feeding trial. The CORPAP was substituted for corn silage. Rates of gain and feed/gain ratios over a three year period were as follows:

	CORPAP %				
	0	5	15	25	35
Feed/gain ratios	6.7	6.9	7.3	6.8	7.0
ADG(kg)	1.2	1.1	1.1	1.0	1.0

Thomas et al (1970) fed boxboard paper with corn silage and molasses to dairy heifers. The boxboard, whether finely ground or coarsely shredded, was not very palatable and not well consumed. The _in vivo_ digestibility of the boxboard was about 62%. _In vitro_ tests indicated only 28% digestibility for the boxboard, suggesting it may not be the same as the usual corrugated paper products.

BIBLIOGRAPHY

1. Becker, B. A. et al 1975
   Paper and whey as feedstuff for ruminants
   J. Dairy Sci. 58: 1677

2. Belyea, R. L., Martz, F. A., Madhisetty, M., Davis, T. P., 1978
   Digestibility and net energy of maintenance diets containing corrugated paper
   J. An. Sci. 47:(Suppl. 1) 405

3. Belyea, R. L., Yu, Yu, Jones, K. S. 1979
   Rate and extent of digestion and potentially digestible cell wall of waste papers
   J. An. Sci. 49: 887-891

4. Harris, B. Jr., Peavy, A. H., Van Horn, H. H., 1978
   Waste newspapers and boxes can be used as roughage
   Hoard's Dairyman Vol. 123, No. 15, p. 936

5. Hintz, H. F., Shryver, H. F., 1976
   Corrugated paper boxes as an ingredient in complete pelleted rations for horses
   Feedstuffs Vol. 48, # 44, p. 51

6. Mertens, D. R., Martz, F. A., Campbell, J. R., 1971
   In vitro ruminal dry matter disappearance of selected waste papers
   J. Dairy Sci. 54: 931-933

7. Stidham, W. D., 1980
Chopped corrugated boxes and monensin in growing and finishing rations for steers
M. Sc. Thesis, Clemson Univ., S. Carolina, May 2, 1980

8. Thomas, J. W., Yu, Yu, Hoffer, J. A., 1970
Digestibility of paper and dehydrated feces
J. An. Sci. 31: 255

9. Vandepopulierre, J. M. et al
Lamb performance on cage hen manure ensiled with corrugated cardboard
Poultry Sci. 56: 1764

10. Van Soest, P. J., Mertens, D. R., 1974
Composition and nutritive characteristics of low quality cellulosic wastes
Federation Proc. Vol. 33 # 8

APPENDIX B

COMPUTERIZED FEED RATIONS

RATION # 1

ANIMAL WEIGHT CLASS = 700 - 800 LBS

EXPECTED AVERAGE DAILY GAIN = 2.5 LBS

CONTROL A & B

A = Fed to appetite
B = Feed intake restricted to energy level of 30% CORPAP ration

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	16.80	12.30	1.7800	0.0485	0.0419
NOW HAVE	18.06	12.23	3.1310	0.0936	0.0426
AMOUNT OVER	+1.26	-0.07	+1.3510	+0.0451	0.0007

COST PER ANIMAL PER FEEDING= 1.30

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
10	HAY-GOOD	89.0	56.00	14.50	0.90	0.22	100.00	2200.00
15	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
6	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
0	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

10% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	16.80	12.30	1.7800	0.0485	0.0419
NOW HAVE	18.12	12.24	2.8839	0.0775	0.0387
AMOUNT OVER	+1.32	-0.06	+1.1039	+0.0290	-0.0032

COST PER ANIMAL PER FEEDING= 1.25

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
[illegible]	HAY-GOOD	89.0	56.00	14.50	0.90	0.22	100.00	2200.00
15	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
6	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
2	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

20% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	16.80	12.30	1.7800	0.0485	0.0419
NOW HAVE	18.18	12.26	2.6368	0.0615	0.0348
AMOUNT OVER	+1.38	-0.04	+0.8568	+0.0130	-0.0071

COST PER ANIMAL PER FEEDING= 1.21

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
6	HAY-GOOD	89.0	56.00	14.50	0.90	0.22	100.00	2200.00
15	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
[illegible]	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
4	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

30% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	16.80	12.30	1.7800	0.0485	0.0419
NOW HAVE	18.24	12.27	2.3898	0.0455	0.0309
AMOUNT OVER	+1.44	-0.03	+0.6098	-0.0030	-0.0110

COST PER ANIMAL PER FEEDING= 1.16

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
4	HAY-GOOD	89.0	56.00	14.50	0.90	0.22	100.00	2200.00
15	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
6	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
6	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

40% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	16.80	12.30	1.7800	0.0485	0.0419
NOW HAVE	18.30	12.29	2.1427	0.0295	0.0270
AMOUNT OVER	+1.50	-0.01	+0.3627	-0.0190	-0.0149

COST PER ANIMAL PER FEEDING= 1.12

REPOR<T> <F>EED <R>EQ PAR<M>ER RE<S>TART <E>XIT

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
2	HAY-GOOD	89.0	56.00	14.50	0.90	0.22	100.00	2200.00
15	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
6	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
[illegible]	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

RATION # 2

ANIMAL WEIGHT CLASS = 800 LBS - FINISH WT.

EXPECTED AVERAGE DAILY GAIN = 2.5 LBS

CONTROL A & B

A = Fed to appetite
B = Feed intake restricted to energy level of 30% CORPAP ration

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	17.60	13.70	1.8300	0.0530	0.0460
NOW HAVE	18.54	13.42	2.9950	0.0487	0.0407
AMOUNT OVER	+0.94	-0.28	+1.1650	-0.0043	-0.0053

COST PER ANIMAL PER FEEDING= 1.50

REPOR<T> <F>EED <R>EQ FAR<M>ER RE<S>TART <E>XIT

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
6	HAY-FAIR	89.0	53.00	7.40	0.60	0.20	100.00	2200.00
19	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	36.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
9.5	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
0	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

10% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	17.60	13.70	1.8300	0.0530	0.0460
NOW HAVE	18.86	13.63	2.9061	0.0407	0.0380
AMOUNT OVER	+1.26	-0.07	+1.0761	-0.0123	-0.0080

COST PER ANIMAL PER FEEDING= 1.46

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
4.5	HAY-FAIR	89.0	53.00	7.40	0.60	0.20	100.00	2200.00
19	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
9.5	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
1.8	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

20% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	17.60	13.70	1.8300	0.0530	0.0460
NOW HAVE	19.27	13.87	2.8299	0.0338	0.0357
AMOUNT OVER	+1.67	+0.17	+0.9999	-0.0192	-0.0103

COST PER ANIMAL PER FEEDING= 1.46

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
3.2	HAY-FAIR	89.0	53.00	7.40	0.60	0.20	100.00	2200.00
19	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
9.5	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
3.5	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

30% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	17.60	13.70	1.8300	0.0530	0.0460
NOW HAVE	19.59	14.08	2.7411	0.0257	0.0330
AMOUNT OVER	+1.99	+0.38	+0.9111	-0.0273	-0.0130

COST PER ANIMAL PER FEEDING= 1.43

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
1.7	HAY-FAIR	89.0	53.00	7.40	0.60	0.20	100.00	2200.00
19	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
9.5	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
5.3	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

40% CORPAP RATION

	INTAKE DRY	TDN AS FED	CP AS FED	CA AS FED	P AS FED
REQUIREMENTS	17.60	13.70	1.8300	0.0530	0.0460
NOW HAVE	19.73	14.18	2.6451	0.0172	0.0302
AMOUNT OVER	+2.13	+0.48	+0.8151	-0.0358	-0.0158

COST PER ANIMAL PER FEEDING= 1.40

LBS FED		DM-%	TDN-%	CP-%	CA-%	P-%	$/UNIT	LB/UNIT
.1	HAY-FAIR	89.0	53.00	7.40	0.60	0.20	100.00	2200.00
19	BREWERS GRAIN-WET	25.0	67.00	26.00	0.29	0.54	38.00	2200.00
.25	MOLASSES-WET	75.0	74.00	5.00	1.10	0.11	0.16	1.00
9.5	CONCEN.	87.0	88.00	16.40	0.01	0.05	200.00	2200.00
7	CORPAP	92.0	55.00	0.60	0.00	0.00	50.00	2200.00

APPENDIX C

ANALYTICAL DATA

April 27, 1989

Prof. Elliot Block
Department of Animal Science
Macdonald College
21111 Lakeshore Road
Ste. Anne de Bellevue
Que., H9X 1C0

Dear Elliot,

Please find enclosed four samples of corrugated paper from different types of food packaging containers, for analysis of dry matter digestibility by the "nylon bag" technique. The material is all from the Kraft plant at Ingleside.

For this analysis I have tried to isolate material with glue and tapes that are not an integral part of corrugated paper making. Once we have some indication of their impact on digestibility, we can make some allowance for their presence in bulk material.

Please forward the results by fax as soon as they are available and bill me for the work. If you have any questions or problems with the samples, give a call.

Thank you for your co-operation in this work.

Yours truly,

Bill Graham

William W. Graham, P.Ag.

Results of analysis using <u>in vitro</u> method rather than <u>in vivo</u>, June 12, 1989

In vitro disappearance of DM (%)

Sample		Hours 24	48	72
CP-01	Glued portion only (packages)	48	61	78
CP-02	No glue (packages)	44	58	74
CP-03	No glue (separate sheet)	41	55	75
CP-04	Residue and tape	35	43	63

Note: If diets are based on 50% (or more) grains and supplements I would recommend using an average value of 50% IVDMD due to a high rate of passage from the rumen.

FEED ANALYSIS REPORT
REPORT NO. 00083960 (PG.

SAMPLE: 2/CORRUGATED PAPER
TYPE: MISCELLANEOUS FEED TYPE
NO.: 2
LAB NO: 0864202

	----- ANALYSIS ------ AS FED	DRY MATTER	EXPECTED RANGE (DRY MATTER)
MOISTURE %	7.9		
DRY MATTER %	92.1		
CRUDE PROTEIN (N% * 6.25)	.53	.58	
CALCIUM %	.12	.13	
PHOSPHORUS %	.04	<.05	
MAGNESIUM %	.04	<.05	
POTASSIUM %	.04	<.05	
MANGANESE (PPM)	57	62	
COPPER (PPM)	5	5	
ZINC (PPM)	18	20	
CA:P RATIO		3.55:1	
ACID DETERGENT FIBRE %	76.77	83.45	
NEUTRAL DETERGENT FIBRE %	85.20	92.61	

CORPAP

FEED ANALYSIS REPORT
REPORT NO. 00079258 (PG. 1)

SAMPLE: 1/WET BREWERS GRAINS
TYPE: MISCELLANEOUS FEED TYPE
NO.: 1
LAB NO: 0708001

SAMPLE: 2/HOME GROWN P
TYPE: SWINE - GROWER
NO.: 2
LAB NO: 0708002

	Sample 1 ----- ANALYSIS ------ AS FED	DRY MATTER	EXPECTED RANGE (DRY MATTER)	Sample 2 ----- ANALYSIS ------ AS FED	DRY MATTER
MOISTURE %	74.9			12.9	
DRY MATTER %	25.1			87.1	
CRUDE PROTEIN (N% * 6.25)	6.45	25.70		13.50	15.50 *
CALCIUM %	.04	.18		.46	.55 *
PHOSPHORUS %	.13	.52		.54	.62
MAGNESIUM %	.05	.21		.15	.17
POTASSIUM %	.01	<.05		.62	.71
MANGANESE (PPM)	9	38		31	36
COPPER (PPM)	2	10		28	32
ZINC (PPM)	20	81		110	126
CA:P RATIO		.34:1			.88:1

No submission form received.

* THIS NUTRIENT IS OUTSIDE THE OMAF RECOMMENDED/EXPECTED RANGE.

WET BREWERS GRAINS

CONCENTRATE

COUN

FEED ANALYSIS REPORT
REPORT NO. 00004442 (PG. 1)

SAMPLE: 1/RED CLOVER, 1ST CUT
TYPE: LEGUME HAY, 1ST CUT
NO.: 1
LAB NO: 0181410

	ANALYSIS AS FED	ANALYSIS DRY MATTER		EXPECTED RANGE (DRY MATTER)
MOISTURE %	7.5			
DRY MATTER %	92.5			
CRUDE PROTEIN (N% * 6.25)	11.55	12.50		12.25 - 19.43
CALCIUM %	.86	.94		.91 - 1.69
PHOSPHORUS %	.21	.22		.18 - .28
MAGNESIUM %	.27	.29		.15 - .34
POTASSIUM %	2.91	3.15	*	1.44 - 2.51
ACID DETERGENT FIBRE %	40.42	43.75	*	28.00 - 37.00
TDN (ESTIMATED) %	49.29	53.35	*	56.79 - 66.09
NET ENERGY (LAC) MCAL/KG	1.10	1.19	*	1.32 - 1.50
CA:P RATIO		4.17:1		

Hay sample collected without use of hay core sampler, analysis results may not be indicative of true feed quality.

* THIS NUTRIENT IS OUTSIDE THE OMAF RECOMMENDED/EXPECTED RANGE.

RED CLOVER HAY

6132261146;# 3 15198371242- : 9-25-89 : 3:04PM : RCV BY:Law Firm

FEED ANALYSIS REPORT
REPORT NO. 00083960 (PG. 2)

SAMPLE: 1/GRASS HAY
TYPE: GRASS HAY, 1ST CUT
NO.: 1
LAB NO: 0864301

	ANALYSIS AS FED	ANALYSIS DRY MATTER		EXPECTED RANGE (DRY MATTER)
MOISTURE %	9.5			
DRY MATTER %	90.5			
CRUDE PROTEIN (N% * 6.25)	7.68	8.50		6.55 - 12.82
CALCIUM %	.48	.54		.34 - .86
PHOSPHORUS %	.21	.24		.14 - .25
CA:P RATIO		2.27:1		
ACID DETERGENT FIBRE %	30.07	33.27	*	34.00 - 42.00
NEUTRAL DETERGENT FIBRE %	57.68	63.81		
NET ENERGY (LAC) MCAL/KG	1.30	1.44	*	1.21 - 1.41
TDN (ESTIMATED) %	57.64	63.76	*	54.59 - 63.00

* THIS NUTRIENT IS OUTSIDE THE OMAF RECOMMENDED/EXPECTED RANGE.

GRASS HAY

LAB REPORT NO.: A9-0951

REPORT OF ANALYSES

Client: Weston Graham & Associates

Attn: Mr. Bill Graham

Date. August 15, 1989

Project: CORPAP

Parameter	Units	Sample 1	Sample	Sample	Sample	Sample
Total Nitrogen	%	0.11				
Pb	ppm	4.1				
Hg	ppm	0.25				
Cd	ppm	0.09				
Cu	ppm	4.6				

LAB REPORT NO.: A9-0934

REPORT OF ANALYSES

Client: Weston Graham & Associates Ltd.

Att: Mr. W. Graham

Date: July 17, 1989

Project: WET BREWERS GRAINS, # 1

Parameter	Units	Sample 1	Sample	Sample	Sample	Sample
Fe	mg/L					
Mn	mg/L					
Hardness	mg/L $CaCO_3$					
Alkalinity	mg/L $CaCO_3$					
pH						
Conductivity	umhos					
F	mg/L					
Na	mg/L					
$N\text{-}NO_3$	mg/L					
$N\text{-}NO_2$	mg/L					
$N\text{-}NH_3$	mg/L					
SO_4	mg/L					
CL	mg/L					
Phenols	mg/L					
Turbidity	NTU					
Colour	Pt Co Units					
Ca	mg/L					
Mg	mg/L					
Tannin & Lignin	mg/L					
Total Nitrogen	mg/L					
K	mg/L					
Moisture	%	75.7				

LAB REPORT NO.: A9-1238

REPORT OF ANALYSES

Client: Weston Graham & Associates

Date: September 14, 1989

Project: GRASS HAY
CONCENTRATE
WET BREWERS GRAINS, # 2

Parameter	Units	Sample	Sample	Sample	Sample	Sample
		HAY	[illegible] Sept 7/89	WBG-2 Sept 7/89		
% (protein)*	%	6.4	16.4			
Moisture	%	11.19	13.07	76.34		

LAB REPORT NO.: A9-0950

REPORT OF ANALYSES

Client: Weston Graham & Associates Ltd.

Att: Mr. W. Graham

Date: July 24, 1989

Project: RED CLOVER HAY

Parameter	Units	Sample 1	Sample	Sample	Sample	Sample
Fe	mg/L					
Mn	mg/L					
Hardness	mg/L $CaCO_3$					
Alkalinity	mg/L $CaCO_3$					
pH						
Conductivity	umhos					
F	mg/L					
Na	mg/L					
$N\text{-}NO_3$	mg/L					
$N\text{-}NO_2$	mg/L					
$N\text{-}NH_3$	mg/L					
SO_4	mg/L					
CL	mg/L					
Phenols	mg/L					
Turbidity	NTU					
Colour	Pt/Co Units					
Ca	mg/L					
Mg	mg/L					
Tannin & Lignin	mg/L					
Total Nitrogen	mg/L					
K	mg/L					
Dry Matter	%	83.5				
Crude Protein	%	16.6*				
* Based on dry weight						

ANALYST ____________

CRAMPTON NUTRITION LABORATORY
DEPARTMENT OF ANIMAL SCIENCE

September 21, 1989

Weston Graham & Assoc. Limited
146 Colonnade Road, Suite 200
Nepean, Ontario
K2E 7J5

Dear Sirs:

We have completed the analyses on your samples in our Nutrition Laboratory.

Sample	C. Protein %	ADF %	NDF
Clover Hay ~~Haylage~~	14.07	39.96	45.05
Cardboard	3.55	77.14	88.52

The charge for this service is $130.00 ($65.00 x 2). A cheque in this amount should be made out to the order of Macdonald College, but please make certain that it is mailed to my attention here in the Department of Animal Science. Thank you.

Yours truly,

Edo. C

E.R. Chavez, Director
Crampton Nutrition Laboratory
Department of Animal Science

ERC:jr

c.c.: T. Drury

* Value grossly in excess of normal range, not used in Table 2

Master Feeds - Mineral & Vitamin Supplement

M+V 220

Minerals & Vitamins for Cattle and Horses (14-14-3)

M-1551 Reg. #: 940084

This feed contains added selenium at 8.0 mg/kg.

INGREDIENTS:

Dicalcium phosphate, monocalcium phosphate, salt, calcium carbonate, magnesium oxide, cobalt carbonate, ferrous sulphate, mineral oil, zinc oxide, ferric oxide, manganous oxide, copper sulphate, Vitamin A, Vitamin D, Vitamin E, potassium iodide, antioxidant, sodium selenite, sodium selenate.

GUARANTEED ANALYSIS:

Calcium (act. %)	14.00	Vitamin A (min. IU/kg)	100,000
Phosphorous (act. %)	14.00	Vitamin D (min. IU/kg)	10,000
Magnesium (act. %)	3.00	Vitamin E (min. IU/kg)	200
Salt (act. %)	16.00	Copper (act. mg/kg)	250
Sodium (act. %)	6.40	Zinc (act. mg/kg)	600
Iron (act. mg/kg)	6,500	Manganese (act. mg/kg)	600
Fluorine (max. mg/kg)	1,400	Iodine (act. mg/kg)	20
Cobalt (act. mg/kg)	5		

DIRECTIONS FOR USE:

CATTLE: Provide 120 grams per head per day to dairy and beef cattle fed a mixture of legume hay and silage.