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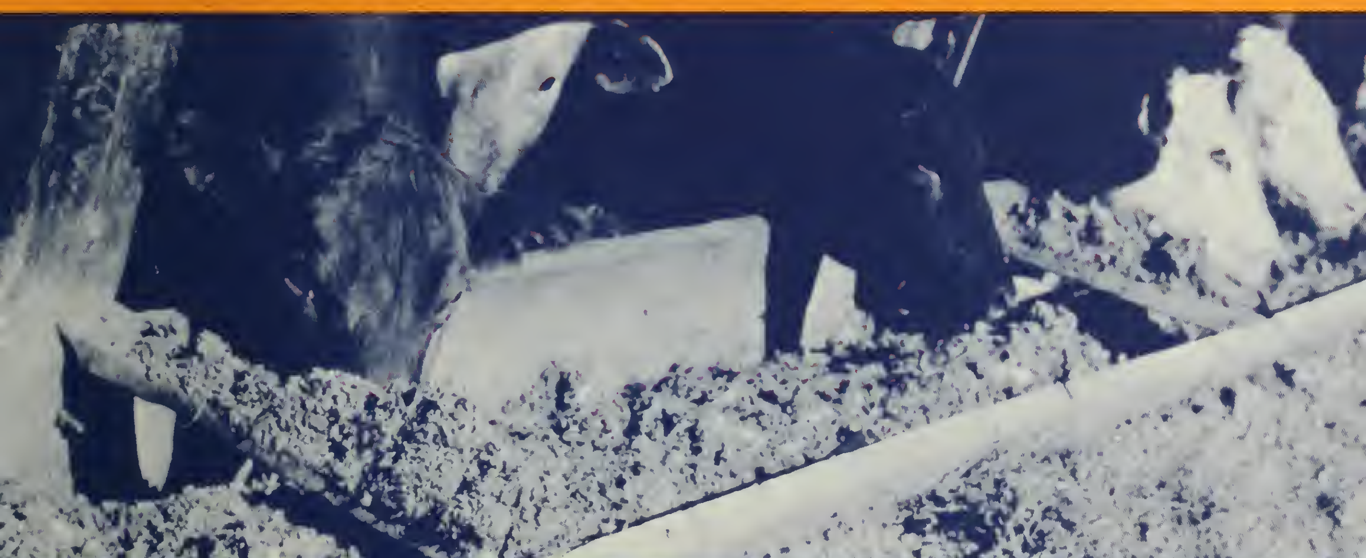
GUIDELINES FOR FEEDING POTATO PROCESSING WASTES AND CULLS TO CATTLE



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HIGHLIGHTS

- **Potato processing wastes and cull potatoes are an excellent source of energy for cattle.**
- **Rations high in potato content must be supplemented with protein, minerals, and vitamins.**
- **Much of the supplementary protein needed for young cattle should be supplied from plant sources such as legume hay, rapeseed meal, or soybean meal.**
- **The total dry matter content of the ration must be maintained by including dry feedstuffs.**
- **Some roughage must be fed with potato to maintain normal rumen function.**
- **Do not feed frozen potatoes because they may cause choking.**
- **Beware of the misuse of pesticides on the growing crop.**
- **Do not feed sprouts or unusually high proportions of sunburned potatoes.**
- **Make provision for coping with the extra volume of urine from animals fed rations low in dry matter.**
- **Adapt cattle gradually to potato rations.**

GUIDELINES FOR FEEDING
POTATO PROCESSING WASTES AND CULLS TO CATTLE

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The waste products from processed potatoes are a disposal problem to the processors but a valuable source of feed for the livestock industry. Cull potatoes and, in some years, surplus production of potatoes are other sources of high-energy feed that often are not used to best advantage.

The amounts of processing waste and cull potatoes available in the potato-growing areas of Canada are not known accurately. About 15% of field-run potatoes go into culls when potatoes are packed for the fresh market, and about 20% by weight of processed potatoes end up as waste. The amount of processing waste varies with the type of processing and with the cost of the raw material, which directly influences the extent of the salvage operation. When potatoes are expensive, processors can afford to hire more workers to salvage undamaged parts rather than discard the whole tuber.

In Canada the annual production of potatoes is about 5.5 billion lb (2.5 billion kg). The processing industry generates about 330 million lb (150 million kg) of potato waste each year, assuming 30% of the crop is processed. Another source of waste is the culls from the remainder of the crop, which amounts to 575 million lb (260 million kg). Therefore, the total waste is over 900 million lb (408 million kg) of fresh potatoes, or about 200 million lb (91 million kg) of dry matter. A small amount of the waste is used for the production of starch and other industrial uses, but most of these wastes are available for livestock feed and would supply enough high-energy feed for finishing 200,000 steers per year.

NATURE OF THE PROCESSING WASTE

Most of the potato processing waste comes from plants producing frozen french fries and potato chips. The production process varies from plant to plant, but the waste consists chiefly of peelings, rejected materials, and starch. For discussion of its feeding value the waste can be divided into two main components: screenings and filter cake.

The screenings consist of peelings and whole or cut portions of potatoes discarded because of size, blemishes, failure to meet quality standards, or other deficiencies. In some plants an effort is made to handle as much of this material as possible by mechanical means to reduce the amount of dissolved or suspended solids in the effluent water. Generally, however, this waste material is flumed to a central collecting area, where the large particles are screened out, as shown in Fig. 1. The waste water is diverted to large settling tanks or clarifiers, where much of the suspended solids settle out as a sludge on the bottom (Fig. 2). The sludge is pumped to vacuum drum filters, which remove some of the water and produce a filter cake containing 12–15% dry matter (Fig. 3). The filter cake and screenings may be combined or handled separately for disposal.

Fig. 1 In a french fry operation, a screen is used to remove solid particles from the effluent.

Fig. 2 The waste water that passes through the screen of Fig. 1 goes to settling tanks, like this one, where the suspended solids settle to the bottom.

Fig. 3 The sludge from the settling tanks passes over drum vacuum filters to remove free water.

In plants that use the "wet alkali peeling process," the effluent at the screens may be strongly alkaline (pH of 10–12). However, bacterial action in the clarifiers quickly produces organic acids, which neutralize the alkali. The sludge dewaters more completely on the vacuum filters when it has a pH of about 6–8. If the sludge becomes more acid (pH below 6), the filter cake will contain more adsorbed water, which cannot be removed by the filters. Consequently, the rate of flow of sludge to the vacuum filters must be carefully adjusted to obtain the desired level of acidity.

The peeling waste from plants that use the "dry alkali peeling process" presents special problems. The concentrated alkali and heat used in this process cause the starch to gelatinize and the waste to form a gel, which can not be pumped or handled in the usual way. When this gel is dumped into storage pits, it resists fermentation and stays in lumps. However, if the peeling waste is mixed immediately with other ungelatinized waste, the formation of a gel is prevented and the material can be handled and fed in the usual way.

Table 1. Dry matter (DM) and crude protein (CP) contents of various potato feeds, and their digestibility coefficients for ruminant animals

	DM, %	Digestibility of DM, %	CP, % of DM	Digestibility of CP, %
Fresh potato	20.8	82	9.5	62
Screenings from a french fry plant	18	82	8.0	49
Dried potato pulp from a potato starch plant	93	75	7.0	20
Scalper waste from production of potato granules	75	95	9.5	59
Classifier waste from production of potato granules	91	92	9.5	65
French fry rejects	47	—	6.2	—
Slurry from a storage pit	13	74*	9.0	—
Dehydrated potato waste (mixed screenings and filter cake)	92	86	6.5	0
Instant mashed	21	—	6.5	—
Filter cake	14	—	5.1	—

— not determined
* Heinemann, W. W., and Dyer, I. A. 1972. Wash. Agr. Exp. Sta. Bull. 757.

In addition to screenings and filter cake, most plants have smaller amounts of other wastes such as rejected cooked french fries, cooked waste from instant mashed potato production, and classifier or screening waste from production of granules. Generally these represent only a small proportion of the total waste and are mixed with the screenings for feeding.

Typical analyses of some potato wastes are given in Table 1.

HANDLING OF POTATO PROCESSING WASTE ON THE FARM

The volume, dry matter content, and proportion of different products in the waste vary greatly from day to day at any plant. To provide a more uniform composition and a feed reserve, the waste is usually trucked from the plant and stored in pits or tanks at the farm or feedlot. The material is often dumped into one end of the pit and removed from the other so that some mixing takes place and fermentation has time to neutralize the alkali.

The slurry in the holding pit crusts over, as in Fig. 4, but it remains fluid underneath the crust. The slurry contains 12–18% dry matter, depending on evaporation, rainfall, and the dry matter content of the wastes put in. Fermentation produces a pH of below 4, which preserves the material if it is left undisturbed.

Fig. 4 A pump operating in a slurry pit shows the creamy consistency of the slurry under the dry crust.

Many different methods are used to get the slurry from the pit to the animals. In large operations it is usually pumped on top of the other ration ingredients in self-mixing trucks, as shown in Fig. 5. In smaller operations the slurry may be handled in a bucket on a front-end loader, as in Fig. 6. The latter is desirable when the screenings are not ground before they are dumped into the storage pit.

Fig. 5 Slurry is pumped onto other ration ingredients in a self-mixing truck.

Fig. 6 Slurry can be handled in a bucket on a front-end loader. The storage pit must have a concrete bottom for this operation.

NUTRITIONAL VALUE OF POTATO PRODUCTS

All potato products are an excellent source of energy for ruminant animals. However, only cooked products such as french fry rejects, instant mash, or waste from dehydrated cooked products (granules, flakes, etc.) are well utilized by simple-stomached animals (poultry and pigs). But because cooking increases the costs, most potato processing waste is fed to cattle. The development of new methods of cooking potato waste could change this recommendation in the future.

Although 74% or more of the dry matter of all potato products tested was digested by ruminant animals (Table 1), the crude protein was not as well digested. Fresh potato and products subjected to little heat during processing had crude protein digestibility coefficients of 60–65%. However, products such as potato pulp or meal that were dehydrated at high temperatures had practically no digestible protein.

Because some fractions of the crude protein are water soluble, material such as filter cake that was recovered from water suspensions was lower in crude protein than were fresh potatoes. The crude protein content of potato slurry from storage pits may be higher than for the original material, because fermentation uses up some of the carbohydrate. About one-third of the crude protein in potato slurry is present as non-protein nitrogen that can be utilized by ruminant animals but is less valuable to pigs or poultry.

Most of the previous recommendations for feeding potatoes restricted the amount that should be fed per day to 25–30 lb (11–14 kg). No basis has been found for these restrictions, and research at Charlottetown and Fredericton has shown that cattle will consume 10–12% of their body weight daily (which for mature cows is over 100 lb (45 kg) of fresh potatoes) without any ill effects. Provided the total ration is properly balanced, the amount of potato fed per day does not need to be restricted. Of course, as with any highly digestible feed, the amount fed should be increased gradually to reach high levels of intake without causing digestive disturbances.

Because potato is practically free of crude fiber, a source of roughage is needed in the ration to maintain normal rumen function. At Fredericton we have successfully fed beef cattle on as little as 2 lb (0.9 kg) of roughage, with protein-mineral-vitamin supplements, and all the potatoes they would eat. More forage can be fed, depending upon its availability and the relative cost of nutrients from this source. The 2 lb (0.9 kg) of roughage per head per day is the minimum amount recommended. Roughage dry matter equal to 1% or more of body weight must be fed to dairy cows to prevent a depression in butterfat content of the milk.

Potato processing waste is low in dry matter. Therefore, if only the minimum amounts of both roughage and supplement are fed, the dry matter consumption and the resulting level of performance will be low. Usually, extra dry feed as roughage or grain is needed to insure maximum feed consumption. In the Western United States, stockmen who buy slurry from processing plants use it to make up only about half by weight of the ration (Fig. 7). Plants that have their own feedlots use slurry for 80% or more of the total ration (about one-third of the total dry matter). The critical factor is probably the dry matter content of the total ration. The optimum dry matter content is not known, but it probably should not be less than 25%. Higher levels are desirable in cold weather to minimize freezing.

FEED SUPPLEMENTS

When high levels of potato material are fed, a supplement fortified with protein, some minerals, and the fat-soluble vitamins A and D is needed. Examples of suitable supplement formulas are given in Table 2.

Protein

Protein is the most expensive ingredient in the supplement. Cull potatoes and mixed processing waste contain 8–9% crude

Fig. 7 Cattle eating a ration containing half by weight of slurry and unground screenings. Notice the whole potatoes.

Table 2. Supplements that can be fed at 3 lb (1.4 kg) per head per day to balance rations high in potato content

	When fed with minimum low-quality roughage, %	When fed with 5 lb (2.3 kg) of high-quality legume hay/day, %
Urea	3.5	2.5
Soybean meal (48% protein)	10	—
Rapeseed meal (34% protein)	30	5
Dehydrated alfalfa meal	7.5	—
Ground barley	37.2	83.7
Molasses	5	5
Dicalcium phosphate	3	3
Ground feeding-grade limestone	3	—
Magnesium oxide	0.75	0.75
Trace mineral premix*	0.05	0.05
Antibiotic to supply	30 mg per lb	30 mg per lb
Vitamin A to supply	20,000 IU per lb	20,000 IU per lb
Vitamin D to supply	2,000 IU per lb	2,000 IU per lb
Vitamin E to supply	10 IU per lb	10 IU per lb

*The trace mineral premix should contain the following parts per million by weight or equivalent trace mineral and sulfur if different salts are used:

Zinc sulfate	100
copper sulfate	7
manganese sulfate	30
cobalt sulfate	1
calcium iodate	1
ferrous sulfate	40

protein in the dry matter. One-third or more of the crude protein is in the form of non-protein nitrogen and only about 60% of the total is digestible. Fattening beef cattle that eat 60–70 lb (27–32 kg) of potato material (12 lb (5 kg) of dry matter) per day receive less than half of their daily requirement of protein from this source, although it supplies about two-thirds of their energy requirement. The supplement and forage must supply about 1 lb (0.45 kg) of crude protein. For young cattle most of this crude protein should be from preformed protein such as is found in rapeseed meal or soybean meal. Older, heavier cattle can utilize a higher proportion of non-protein sources such as urea.

Minerals

High-quality alfalfa or clover hays are an excellent supplement for rations containing high levels of potato. These hays supply not only part of the supplementary protein required, but they are also a good source of minerals, especially calcium. Good-quality alfalfa contains 16% protein and 1.3% calcium, and red clover hay contains about 14% and 1.1%. Potato material contains only about 0.08% calcium in the dry matter, but the requirement for beef cattle is about 0.25% of the ration dry matter. Ground feeding-grade limestone can be added to the supplement to supply the needed calcium if legume hay is not available. Some stockmen like to add 4 or 5 oz (110 or 140 g) of limestone per head per day to strongly acid potato slurry to help neutralize the acid.

In wastes from potato processing plants that use alkali (sodium hydroxide) peeling processes, the sodium content is usually high (about 0.5% of the dry matter). The addition of salt (sodium chloride) to the supplements that are fed with this waste is not recommended. However, salt should be added to the supplements that are fed with cull potatoes. Trace-mineralized salt is a convenient way of adding trace minerals such as cobalt, iodine, zinc, iron, and manganese that are usually added to all rations as insurance against deficiencies. Rations containing high levels of potato may not have enough magnesium. The addition of a low level of magnesium oxide to the supplement is recommended.

Vitamins

Potatoes contain practically no fat and are not a good source of the fat-soluble vitamins A, D, and E. When supplements are formulated for rations containing high levels of potato, the amount of vitamins A, D, and E present in the potato can be ignored and the total daily requirement provided by the roughage or supplement part of the ration. These vitamins can be injected at regular intervals, but it is usually more economical to provide them in the supplement.

There is evidence that cattle on high-energy rations require more vitamin A than has been recommended in the past. They need at least 50,000 IU of vitamin A per day. Cattle fed indoors need 5,000 IU of vitamin D, but cattle in open yards exposed to sunlight do not need as much.

Potatoes contain relatively high amounts of the water-soluble B vitamins. It is usually considered that the microorganisms in the rumen synthesize all the B vitamins required by cattle so that it is not necessary to supplement the ration. However, in tests at Washington State University, it was shown that cattle fed high levels of potato responded to supplements of choline chloride (one of the B vitamins). In two trials at Fredericton, choline chloride slightly increased growth rate, but in a third trial it produced no effects. The need for supplementary B vitamins in rations containing high levels of potato requires further investigation, but on the basis of present knowledge they are not recommended.

POSSIBLE PROBLEMS

Choking

It is possible for cattle to choke on whole potatoes. Although some stockmen pulp the potatoes before feeding them to their cattle to avoid the risk of choking, few difficulties from feeding whole potatoes have been reported. At Fredericton whole potatoes have been used in all the feeding trials, and no animals have been lost from choking. Potatoes that are frozen solid should not be fed, because animals can not chew them and are likely to choke while attempting to swallow them whole.

Glycoalkaloids

Potato sprouts and sunburned (green colored) potatoes contain toxic glycoalkaloids and should not be fed in large amounts to animals. We have not had any difficulty when feeding cull potatoes containing the usual number of sunburned potatoes. However, high concentrations of sunburned potatoes should be fed with care, and sprouts should be removed, especially if they have been exposed to sunlight. The concentration of the toxic compounds is increased by exposure of the sprouts or peelings to light in warm, moist conditions. Animals have been poisoned by eating peelings and sprouts from old potatoes that were left exposed to the sun.

Various symptoms of glycoalkaloid poisoning have been described in the literature. Those most commonly listed are staring eyes, dilated pupils of the eyes, trembling, staggering, weakness, and sometimes convulsions.

Pesticides

Be aware of the potential danger of residues of pesticides used on the growing potato crop or on crops previously grown on the land. Cases have been reported of dairy and beef cattle picking up pesticide residues by eating contaminated potatoes. Similar examples can be found for most other feed crops as well. If pesticide recommendations are followed, there is little danger from pesticide residues. Samples of potatoes from New Brunswick and

Prince Edward Island that were collected and analyzed by members of the Production and Marketing Branch of Agriculture Canada showed insignificant levels of pesticides. Similarly, analyses of samples of fat from cattle fed on high levels of potatoes showed only very low levels of any pesticide.

Cooking fat

Most potato processing waste is similar in nutritive value to cull potatoes when the amount fed is adjusted for differences in dry matter. One exception is rejected french fried material, which may contain up to 30% fat in the dry matter. The fat is an unsaturated vegetable oil that can cause digestive disturbances in the rumen and may depress butterfat tests in dairy cows when fed at high levels. Cattle fed a ration high in roughage can tolerate higher levels of fat than those fed low-roughage rations. In a short-term trial at Fredericton, dairy cows were fed up to 18 lb (8 kg) of overage french fries per day without digestive upsets. This type of fried material contains less fat than the small, thin, irregular particles that are screened out during processing. No problems should occur if the rejected french fries are mixed with other potato wastes, because this material will be only a small proportion of the total waste. Problems may occur, however, where waste fat is collected from the top of the clarifiers and added to the waste, unless this fat is thoroughly mixed with other material before feeding it to the animals.

Gradually increase the amount of potatoes in the ration

Potato processing waste and cull potatoes are a new feed for most cattle and they require some getting used to before they are readily accepted. Cattle arriving in a feedlot after the stresses of being shipped should be allowed to settle in on rations of hay and grain, and then gradually be changed over to rations containing potato.

When animals eat high levels of processing waste or cull potatoes, they are forced to consume more water than usual. The excess water is excreted in the urine and feces, and these create extra management problems in keeping the animals dry. When only the minimum amount of roughage is fed, the feces become less firm than usual, making them difficult to handle. Slatted floors become coated with a thin layer of wet feces and urine, which freezes readily in cold weather causing slippery conditions.

APPENDIX

Summary of potato feeding trials

at the Research Station, Fredericton, N.B.

The digestibility of potato waste collected from the outflow of a processing plant was determined with sheep in 1968. The waste was transferred to the Research Station in plastic bags and dried at 170° F (77° C) for ease of handling. It was compared with pulped field-run potatoes dried in the same manner, and with dehydrated potato pulp produced by a starch plant. The dehydrated potato pulp was similar to material we have previously examined and it contained 2–3% molasses.

The digestibility coefficients were as follows:

	Dry matter	Crude protein
Potato waste	82.1%	49.2%
Dehydrated field-run potatoes	82.2%	61.7%
Dehydrated potato pulp	75.2%	16.9%

The digestibility of the crude protein in the dehydrated potato pulp is very low, probably because of the high temperatures used in drying. The crude protein of the potato waste was lower than for field-run potatoes, probably owing to the loss of water-soluble crude protein during the processing. All three feeds were good sources of energy for ruminant animals, as indicated by the high dry-matter digestibility.

A demonstration of the feeding value of potato processing waste was conducted in 1969. The waste was screened from the plant outflow, placed in pallet boxes and trucked 90 miles (145 km) to the Research Station. The material was shipped once or twice each week, as needed, and stored in the pallet boxes until fed. Although the boxes were metal lined, they were not water tight and the free water seeped away from the boxes. The average dry matter content was 21.9% when it was fed and the DM contained 8.8% crude protein.

The potato waste was fed to 10 Holstein heifers for 42 days. The average daily consumption of wet waste was 74 lb (33 kg) with a high of 125 lb (56 kg). In addition, each heifer was fed 2 lb (0.9 kg) of hay and 2 lb (0.9 kg) of protein-mineral-vitamin supplement containing 38% crude protein per day. The average daily gain for the 42 days following a 2-week changeover period was 3.3 lb (1.5 kg) with a feed dry matter to gain conversion ratio of 5.3.

Potato processing waste is relatively low in digestible crude protein. This deficiency must be made up in the supplement when high levels of potato are fed. Theoretically, urea should be a useful source of crude protein equivalent (CPE), because the potato material is high in readily available energy, which is required by the rumen bacteria for efficient protein synthesis. Cattle refuse to eat supplements containing over 7–8% urea. The problem is to devise suitable carriers for the urea in order to obtain adequate intakes when potatoes are used to replace most of the grain fed. Dr. Karl Winter, Research Station, Charlottetown, P.E.I., proposed diluting the supplement with ground straw to obtain adequate urea intakes without feeding extra grain or exceeding the limits of palatability with urea. He obtained equal performance from a small group of steers fed this type of supplement as from steers fed a supplement containing soybean meal. At Fredericton, we conducted a 4 x 4 latin square design digestibility, nitrogen-balance trial with steers each fed pulped field-run potatoes to appetite, plus 2 lb (0.9 kg) of hay and 3 lb (1.4 kg) of a supplement per day. The supplement contained equal amounts of crude protein supplied from (a) urea as 6% of the supplement, (b) equal CPE from urea and soybean meal, (c) rapeseed meal, or (d) soybean meal. The results are given in the following table:

	Digestibility %			N retained	
	Dry matter	Organic matter	Crude protein	% of consumed	% of absorbed
(a) urea	72.3	72.9	62.5	18.4	30.0
(b) urea-soybean	74.4	75.0	61.6	16.6	26.5
(c) rapeseed	72.9	73.5	48.6	17.6	33.6
(d) soybean	72.1	72.8	54.2	14.8	26.9

These results encouraged us to set up a feeding trial with yearling heifers each fed whole field-run potatoes to appetite, plus 2.2 lb (1 kg) of hay and 2.2 lb (1 kg) of supplement per day. The supplements contained equal CPE from (a) rapeseed meal, (b) urea, or (c) equal CPE from urea and rapeseed meal. The average daily gains for the heifers on each treatment over 91 days were (a) 2.41 lb (1.09 kg), (b) 2.08 lb (0.95 kg), and (c) 2.29 lb (1.04 kg). The results show clearly that the urea ration was not able to sustain gains comparable to the rations containing rapeseed meal. These results differ from the results obtained in Charlottetown and in the nitrogen-balance trial at Fredericton. But, in this feeding trial, the supplements were fed only once each day before feeding the potatoes. In the other two trials, the supplements were fed twice each day after feeding the potatoes, which might account for the better utilization of the urea nitrogen.

The crude protein of potatoes contains a high proportion of non-protein nitrogen (about 50%) and it may be that supplementary non-protein nitrogen or highly soluble protein sources such as rapeseed meal are not well utilized.

Therefore, another feeding trial was set up with nine individually fed beef calves per treatment. They were each fed whole field-run potatoes to appetite, plus up to 8.8 lb (4 kg) of corn silage and 3.3 lb (1.5 kg) of supplement per day. The supplements were designed to contain 19% crude protein supplied from (1) rapeseed meal, (2) formaldehyde-treated rapeseed meal, (3) soybean meal, or (4) rapeseed meal plus a low level of choline chloride. The formaldehyde treatment has been shown to reduce the solubility of the protein and to increase the amount of dietary protein reaching the intestines. The average daily gains of calves during a 71-day feeding trial were (1) 2.0 lb (0.9 kg), (2) 2.2 lb (1.0 kg), (3) 2.5 lb (1.1 kg), and (4) 2.2 lb (1.0 kg). Only the difference between supplements (1) and (3) is statistically significant but the apparent trends led us to set up another feeding trial.

Individually fed beef calves were used to compare six supplements (eight calves per treatment) formulated to test the application of the Urea Fermentation Potential (UFP) hypothesis developed by Wise Burroughs of Iowa to rations containing high levels of potatoes. All the calves, regardless of size, were fed 20 lb (9 kg) of potatoes, 11 lb (5 kg) of corn silage, and 2.6 lb (1.2 kg) of a supplement each day for 84 days. The supplements were designed to provide (a) no supplementary protein except that in the cracked corn (8.0% crude protein); (b) urea to the maximum level of utilization predicted from UFP (17.9% crude protein, 3.6% urea); (c) urea to the maximum level acceptable to the calves without feed refusals (27.8% crude protein, 7.2% urea); (d) soybean meal to supply the metabolizable nitrogen requirements as calculated by Burroughs (40.3% crude protein); (e) urea as in (b) plus soybean to equal CPE of (d); (f) soybean meal as in (e).

The average daily gains of the steers receiving each supplement were (a) 1.1 lb (0.5 kg), (b) 1.4 lb (0.64 kg), (c) 1.2 lb (0.54 kg), (d) 1.6 lb (0.73 kg), (e) 1.5 lb (0.68 kg), (f) 1.7 lb (0.77 kg) and the blood urea nitrogen levels were (a) 3.8 mg/100 ml, (b) 8.8, (c) 10.7, (d) 12.6, (e) 17.3, and (f) 11.4. These results indicate that urea cannot be used to supply more than a small part of the supplementary crude protein needed in rations containing field-run potatoes. This conclusion may not apply equally to processing plant waste from which some of the water-soluble non-protein nitrogen has been lost during the recovery of the waste.

CONVERSION FACTORS FOR METRIC SYSTEM

Imperial units	Approximate conversion factor	Results in.	
LINEAR			
inch	x 25	millimetre	(mm)
foot	x 30	centimetre	(cm)
yard	x 0.9	metre	(m)
mile	x 1 6	kilometre	(km)
AREA			
square inch	x 6 5	square centimetre	(cm^2)
square foot	x 0.09	square metre	(m^2)
acre	x 0 40	hectare	(ha)
VOLUME			
cubic inch	x 16	cubic centimetre	(cm^3)
cubic foot	x 28	cubic decimetre	(dm^3)
cubic yard	x 0.8	cubic metre	(m^3)
fluid ounce	x 28	millilitre	(mℓ)
pint	x 0.57	litre	(ℓ)
quart	x 1 1	litre	(ℓ)
gallon	x 4 5	litre	(ℓ)
bushel	x 0 36	hectolitre	(hℓ)
WEIGHT			
ounce	x 28	gram	(g)
pound	x 0 45	kilogram	(kg)
short ton (2000 lb)	x 0 9	tonne	(t)
TEMPERATURE			
degree fahrenheit	°F-32 x 0 56 (or °F-32 x 5/9)	degree Celsius	(°C)
PRESSURE			
pounds per square inch	x 6 9	kilopascal	(kPa)
POWER			
horsepower	x 746	watt	(W)
	x 0 75	kilowatt	(kW)
SPEED			
feet per second	x 0 30	metres per second	(m/s)
miles per hour	x 1 6	kilometres per hour	(km/h)
AGRICULTURE			
bushels per acre	x 0.90	hectolitres per hectare	(hℓ/ha)
gallons per acre	x 11.23	litres per hectare	(ℓ/ha)
quarts per acre	x 2.8	litres per hectare	(ℓ/ha)
pints per acre	x 1.4	litres per hectare	(ℓ/ha)
fluid ounces per acre	x 70	millilitres per hectare	(mℓ/ha)
tons per acre	x 2.24	tonnes per hectare	(t/ha)
pounds per acre	x 1.12	kilograms per hectare	(kg/ha)
ounces per acre	x 70	grams per hectare	(g/ha)
plants per acre	x 2 47	plants per hectare	(plants/ha)

Examples. 2 miles x 1 6 = 3 2 km 15 bu ac x 0 90 = 13 5 hℓ ha

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IF UNDELIVERED, RETURN TO SENDER EN CAS DE NON-LIVRAISON, RETOURNER À L'EXPÉDITEUR