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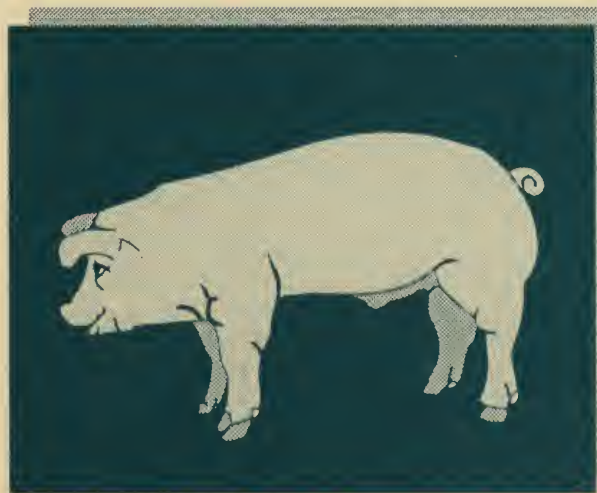
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# Production and feeding of hulless barley



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## **Production and feeding of hulless barley**

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### **Errata**

Page 14    Phoenix is a new two-row hulless cultivar that is adapted to the drier (less than average rainfall) regions of Saskatchewan and Alberta.

Page 14    It has poorer straw strength than Condor.

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# Production and feeding of hulless barley

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## Introduction

Commercial production of hulless barley is a relatively recent event in Canada, with the first cultivar having been developed just over a decade ago. In contrast, the development of conventional hulled barley for use in livestock (mainly cattle) feed is a century-old tradition. Lately, there has been a large, proportional increase in swine and poultry production across the country and, with this, a growing interest in high-density feed sources. Corn has been the high-energy, low-fibre feed commonly used for many years. However, climatic factors limit corn production in Canada, and most of the corn fed has had to be imported at a relatively high cost. Also, corn is low in protein, including some essential amino acids. A practical alternative is hulless barley, which is well adapted to the short growing season

Table 1 Chemical and physical qualities of hulless barley as compared to hulled barley and wheat

Quality	Hulless barley	Hulled barley	Wheat
Test weight (kg/hL)	83.4	66.9	82.1
Protein (% dry matter)	15.0	12.8	15.8
Lysine (% dry matter)	0.53	0.45	0.45
Acid-detergent fibre (%)	0.8	3.5	2.5
Neutral-detergent fibre (%)	7.5	12.9	10.0
True metabolizable energy (kcal/kg)	3460	3300	3600
Digestible energy (kcal/kg)	3250	3100	3425

here. It has feed energy exceeding that of conventional hulled barley and approaching that of feed wheat (Table 1). Also, the levels of protein and lysine in hulless barley are higher than those in wheat or corn, resulting in 2–11 kg less soybean meal per tonne being used in rations. As a result, diets based on hulless barley are less costly than diets using conventional hulled barley.

## **Comparing hulless barley to other feeds**

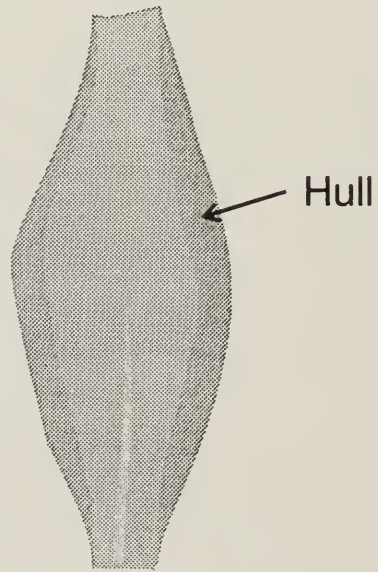
From a production standpoint, hulless barley yields are comparable to those of Prairie Spring (CPS) feed wheat and are less than those of conventional hulled barley (Table 2). The hull in barley accounts for about 10–15% of the total weight of the grain and thus for most of the yield difference in hulless versus hulled barley. Test (bushel) weight is similar to that of wheat, being about 10% above that for hulled barley.

The hull in barley consists of a fibrous lemma and palea that fit like the two halves of a clam shell over the kernel itself (Fig. 1). In hulled barley, the lemma and palea are fused along their edges and the hull adheres to the kernel. In hulless barley, fusion does not take place and the two halves of the hull can be threshed out. Without the relative protection of the hull, the kernel is more prone to cracking and to loss of or damage to the germ (embryo). Hulless barley is almost as prone to this sort of damage as soft white wheat and thus is not as resilient as, for example, hard red wheat. However, hulless barley is less prone to damage than naked oats and, like wheat, does not require polishing to remove the trichomes (hairs) on the kernel. Also, hulless barley largely threshes free in the same manner as wheat.

Loss of the hull in hulless barley has a marked influence on the chemical and physical characteristics of this grain (Table 1). Its removal appreciably decreases the fibre content of hulless barley in contrast to hulled barley. Fibre levels in hulless barley can be lower than those observed in hard red spring wheat. This reduction of fibre leads to higher levels of true metabolizable energy (poultry) and digestible energy (swine) in hulless barley, as the fibre contains little available energy for either animal.

## Kernel after threshing

### *a.* Hulled barley



### *b.* Hulless barley

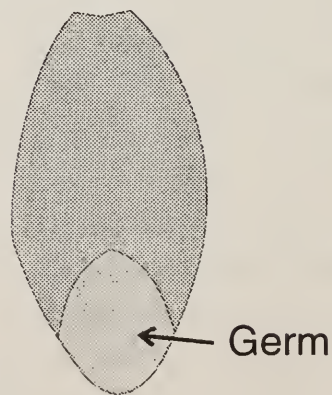


Fig. 1 Comparison of *a.* hulled barley and *b.* hulless barley.

Table 2 Comparison of yields of selected cultivars of hulless barley, hulled barley, and wheat in western Canada

Cultivar	Type	Relative yield (%)	Average yield (t/ha)
<i>Eastern Prairies</i>			
Bedford	Hulled barley	100	4.2
Argyle	Hulled barley	93	3.9
Buck	Hulless barley	90	3.8
<i>Western Prairies</i>			
Bridge	Hulled barley	100	5.2
Harrington	Hulled barley	94	4.9
Condor	Hulless barley	81	4.2
<i>Western Canada</i>			
Biggar	CPS wheat	-	3.4
Genesis	CPS wheat	-	3.6
Oslo	CPS wheat	-	3.3
Katepwa	HRS wheat	-	3.1

The presence of a hull on barley also dilutes nutrient content of the grain. Therefore, when the hull is removed, the concentration of protein increases in hulless barley to near those levels found in wheat. Of special interest in hulless barley is the level of lysine, an essential amino acid, which can be greater than the levels seen in either wheat or hulled barley.

Chemical and physical qualities also vary among hulless barley cultivars (Table 3). For example, both Falcon and CDC Buck have slightly lower test weights and slightly higher levels of neutral-detergent fibre than either CDC Richard or Condor. These differences are characteristic of six-row barley cultivars, because the lateral kernels are typically thinner in six-row barley than in two-row barley.

Table 3 Comparison of chemical and physical qualities among cultivars of hulless barley

Cultivar	Test weight (kg/hL)	Protein (% dry matter)	Fibre (%)		β-Glucan (%)
			Acid detergent	Neutral detergent	
<i>Two-row</i>					
Condor	77.1	16.2	1.1	7.7	4.8
CDC Richard	75.9	14.7	1.2	7.9	3.8
<i>Six-row</i>					
CDC Buck	74.2	14.1	1.2	8.2	4.7
Falcon	74.8	16.4	1.3	8.1	3.9
<i>Hulled two-row</i>					
Harrington	63.7	13.6	4.1	12.7	4.6

Some hulless barley cultivars have lower levels of  $\beta$ -glucan, although differences are not that large (Table 3).  $\beta$ -Glucan is a polysaccharide cell wall constituent in the grain that interferes with digestion and reduces growth rate in poultry. This reduction of  $\beta$ -glucan content is the result of a deliberate effort by barley breeders. However, even cultivars with a lower level of  $\beta$ -glucan can still cause problems when fed to young birds. The deleterious effects of  $\beta$ -glucan can be eliminated by the addition of the enzyme supplement  $\beta$ -glucanase to the feed.

Hulless barley cultivars also have a wide range of protein levels (Table 3). This variability is due to a combination of the genetic properties of the cultivar itself and environmental factors, such as soil and moisture conditions, temperature, fertility levels, and cultural practices.

## **Producing hulless barley**

Production practices required to grow hulless barley are the same as for conventional hulled barley. The only major difference is in handling of the grain. As the kernel does not have the added protection of the hull, rough handling should be avoided. This is particularly true if the grain is very dry, as it can be quite prone to cracking and to loss of or damage to the germ (embryo).

### **Treating the seed**

Prior to sowing, seed can be treated with a water-soluble formulation of the fungicide carbathiin (carboxin). Treatment with carbathiin is recommended, particularly if the barley is to be sown into cold soil. However, it is best to avoid insecticides since they may injure the embryo under certain conditions. Apply the treatment as close to the seeding date as possible. Avoid treating and storing seed for prolonged (more than three weeks) periods of time.

### **Seeding**

Hulless barley should be sown at the same time as conventional hulled barley and at the rates and drill settings recommended for wheat. Sowing depth can be the same as for hulled barley, providing the seed is properly treated with a fungicide. As there are no awns on hulless barley, the seed should not hang up in the seeder, which is a distinct advantage.

### **Threshing**

Reasonable care should be used in threshing the seed. While the exposed seed is not very fragile, cylinder speed should be reduced on the combine and concaves should be set to leave about a 2–3 mm gap between the rub bars and concave wall. This will allow for a gentle threshing action. Examine the threshed grain for cracking or adhering hulls. The former suggests too high a cylinder speed and/or too narrow a concave setting; the latter suggests the opposite, that being too slow a cylinder speed and/or too wide a concave setting. The sample

should contain no more than 10% kernels with adhering hulls. Much more than this will lead to problems with cleaning and feeding. Straight-cutting is preferred over swathing, as this practice tends to encourage loss of grain through shattering in the swath. However, swathing is quite satisfactory if the crop is cut slightly green. Moisture content of the grain should be around 25% before swathing.

## **Cleaning**

*For use as seed* Passing the seed over a gravity table is recommended, as this operation will assist in separating germless seed and cracked or thin kernels. Using standard cleaning sieves is effective but not as efficient as a gravity table.

*For use as feed* The seed can be used as is. The grain only needs to be cleaned of foreign material, such as stones, weed seeds, straw, soil, etc.

*For use as food* In order to remove any adhering hulls, polishing is recommended as well as conventional cleaning to conform to food-grade standards.

## **Storing**

If the grain is dry (12% moisture or less), then storage procedures are identical to those for wheat. The grain should be augered in slowly to prevent loss of the embryo or other physical damage. Hulless barley can spoil at moisture levels of 15% or more. If the grain is tough, then it should be dried and placed in an aerated bin and monitored for heating. Hulless barley can heat and thus spoil more rapidly than conventional hulled barley, as the hull tends to draw moisture from the seed. The bins should be rodent proof and free of insects. Less storage space is required, as the yield in volume terms is lower than for hulled barley.

## Cultivars

In 1994, almost 50 000 hectares of hulless barley were planted in western Canada, up from under 36 000 hectares in 1993. About half of this total area of production is in Alberta. Since hulless barley development is still in its infancy, there are just a few cultivars currently available in Canada. They include CDC Buck, CDC Candle, CDC Richard, CDC Silky, Condor, Falcon, and Phoenix. All of these cultivars were developed in western Canada and are best adapted to prairie conditions. Breeding efforts are ongoing, and new, broadly-adapted cultivars should be available in the near future.

Generally, hulless barley will yield 5–15% less than conventional hulled barley of the same type (two-row, six-row, or semi-dwarf). Under ideal conditions, the highest yielding cultivar to date, CDC Silky, a six-row semi-dwarf hulless barley, can yield up to 81 hL/ha (90 bushels per acre). Due to loss of its hull, the test (bushel) weight for hulless barley averages 10% higher than for hulled barley and is similar to that for wheat.

CDC Buck is a six-row hulless cultivar adapted to all of western Canada. It yields roughly 10–15% less than hulled six-row feed cultivars but almost as much as two-row cultivars. CDC Buck is recommended for wetter areas, owing to its good disease resistance. In certain cases, hull retention can be a problem. Also, shattering may occur when straight-cutting.

CDC Candle is a new, highly-specialized six-row hulless cultivar, which has a waxy kernel suited to food and industrial processing. The uniqueness of its starch makes CDC Candle useful as a food additive high in dietary fibre and as a raw ingredient in bioplastics. This cultivar is not widely adapted and requires special handling. For these reasons, CDC Candle will be produced on a limited-contract basis.

CDC Richard is a two-row hulless cultivar adapted mainly to Alberta and Saskatchewan. It yields approximately 10–15% less than comparable hulled two-row feed cultivars. CDC Richard is recommended for drier areas where straw strength is not a

critical factor. It is resistant to scald and net blotch.

CDC Silky is a new, semi-dwarf six-row hulless cultivar that is particularly well-adapted to the eastern prairie region of western Canada. It has very strong straw, high yield potential, and moderate resistance to leaf and stem diseases affecting barley.

Condor is a plump, two-row hulless cultivar adapted mainly to Alberta and western Saskatchewan. The high energy and protein of Condor are ideally suited to rations for swine and poultry. Condor yields almost as much as conventional hulled barley in this area of adaptation, making it an attractive cultivar for swine and poultry producers as well as for grain producers.

Falcon is a new, semi-dwarf six-row hulless cultivar that is adapted mainly to regions of central Alberta with a high incidence of scald and lodging. It yields up to 14% more than Condor in this area of adaptation. It is reputed to contain high digestible energy and digestible protein for pigs.

Phoenix is a new, semi-dwarf six-row hulless cultivar that is adapted to the high-moisture regions of Alberta. It can tolerate a cool, moist environment better than the other hulless cultivars and has exceptional straw strength. Yields are similar to those of Falcon.

## **Feeding hulless barley**

Hulless barley is a cost-effective alternative to corn-soybean meal or to wheat-barley-soybean meal diets for swine and poultry. It allows for a local source of feed that is widely adapted to Canadian conditions, thus reducing the need for imported corn and soybeans. This is particularly true in western Canada, where corn has very limited production potential and where most swine (and some poultry) producers also grow their own feed.

### **Feeding poultry**

Hulless barley has been used successfully for all types of poultry production in both commercial and farm-mix feed operations. Because it has higher energy and protein content than conventional hulled barley, it is ideally suited to the high-density diets required for poultry. Hulless barley is appropriate for use in commercial feeds. It produces a pellet that in texture is similar to wheat but is firmer than corn. This pellet does not crumble easily and tends to have fewer handling problems. Hulless barley is also appropriate for farm-mix mash diets, where energy may be deficient and where the ability to mix in fats is often limited. Fat is an expensive ingredient and increases the level of protein supplementation that is needed. Inclusion rates for hulless barley in poultry diets can be as high as 95%.

#### *Broiler chickens*

Broiler chickens may be fed hulless barley with excellent results, providing that a dietary enzyme additive is used. The enzyme supplement  $\beta$ -glucanase is essential for both broiler performance and litter quality maintenance. Conventional hulled barley cultivars also require an enzyme additive. However, the level of  $\beta$ -glucan is generally lower in conventional barley, underlining the importance of enzyme supplementation in diets containing hulless cultivars. Sources of  $\beta$ -glucanase are widely available and are priced at about \$2.00 per tonne of complete feed.

Tests comparing hulless barley to a conventional barley-wheat mix, each supplemented with enzyme, have shown equal feed

conversion and higher rates of gain in broiler flocks with hulless barley (Table 4 and 5). The hulless barley used was No. 1 CW Hulless, weighing 85 kg/hL (about 67 lbs/bu) and containing 14.4% crude protein. At the end of the trial (after 42 days), broilers fed the hulless barley diet were 100 g heavier than those fed the control diet, which represents a decrease of approximately 1.5 days to market. Feed conversion was equivalent for the two diets. A conservative analysis of the performance results indicated that hulless barley priced the same as wheat would still result in a saving of \$5.00 per tonne of complete feed.

The feed in this trial was commercially prepared and pelleted. Performance of farm-mix feeds fed as mash would likely be somewhat lower. The diets shown in Table 5 and 7 are intended only as examples and should be reformulated based on individual ingredient lot analyses.

### *Laying hens*

The deleterious effects of  $\beta$ -glucan in hulless barley is related to age and is not a major concern for laying hens. Although some studies have indicated a response to enzyme supplementation, the effect is minimal. Enzymes have been promoted as a means of reducing the incidence of dirty eggs due to manure adherence. However, in trials at the University of Saskatchewan, stained eggs from hens fed hulless barley have not been a problem.

Tests in which hulless barley replaced either 40–80% of the wheat or 36–72% of the conventional hulled barley in the diet found no adverse effects on the productivity of laying hens (Table 6 and 7). Unlike hens fed hulless barley or wheat, those fed hulled barley were not able to consume sufficient feed to maintain both a high rate of egg production and an increase in body weight. While excessive gain is not desirable, low body weight will also impinge on egg production beyond a critical point, as may occur under various environmental stresses. Hulless barley did not affect quality of the egg shell or interior.

Feed conversion for hulless barley was as good as or better than similar diets based on wheat. These findings showed that hulless

Table 4 Performance of broiler chickens (mixed sex) fed diets containing hulless barley

Performance	Control diet	Hulless diet
Broilers placed (number)	8160	8160
Broilers shipped (number)	7558	7651
Mortality (%)	7.4	6.2
Age shipped (days)	42	42
Condemnation (%)	2.65	3.06
Average bird weight (kg)	2.04	2.14
Feed conversion (ratio)	1.97	1.96

Table 5 Hulless barley diets for broiler chickens

Ingredients (%)	Starter (0–21 days)	Grower (22–33 days)	Finisher (34–42 days)
Hulless barley	61.1	67.8	74.3
Soybean meal	16.6	14.6	13.2
Canola meal	10.0	5.0	-
Meat meal	5.0	5.0	4.0
Tallow	3.7	3.9	4.0
Canola oil	1.5	1.5	1.0
L-Lysine	0.13	0.15	0.15
DL-Methionine	0.14	0.15	0.11
Other*	+	+	+

\* Includes supplemental vitamins, minerals, enzymes, and medications.

Table 6 Performance of laying hens\* fed hulless barley in place of either wheat or hulled barley

Hulless barley (%)	Egg production (hen-day)	Feed consumption (g/hen/day)	Body weight (kg)	Feed conversion (kg/12 eggs)
<i>Trial 1 (with wheat)</i>				
0	78.8	111	1.78	1.71
40	80.3	106	1.78	1.61
80	79.5	105	1.76	1.61
<i>Trial 2 (with hulled barley)</i>				
0	81.8	116	1.83	1.73
36	82.3	114	1.81	1.68
72	83.6	117	1.83	1.70

\* Layers were H&N PG2, Hubbard (56 weeks old) in Trial 1 and Shaver 288 (60 weeks old) in Trial 2.

Table 7 Hulless barley diets\* for laying hens

Ingredients (%)	Trial 1	Trial 2
Hulless barley	80.0	71.4
Soybean meal	8.4	7.0
Tallow/oil	1.0	1.0
Limestone	8.7	8.7
Dicalcium phosphate	1.25	1.25
Salt	0.20	0.20
L-Lysine	0.10	0.10
DL-Methionine	0.12	0.12
Vitamin-mineral premix	0.225	0.250

\* Crude protein was 15.6% in Trial 1 and 14.7% in Trial 2.

barley was at least equal to wheat in feeding value. Hulless barley would be especially useful for nutrient-dense diets during early egg production, when laying hens are striving to attain peak levels of productivity while still depositing body tissue.

## Feeding swine

Swine rations can contain up to 95% hulless barley, which usually has higher protein, lysine, and digestible energy than hulled barley. However, the hulls may adhere and not thresh freely at times, in effect raising the fibre content while lowering the energy value of hulless rations. This problem can render hulless barley essentially hulled and thus almost identical to conventional barley in terms of energy. However, studies have not shown any decrease in pig performance that results from hull adherence (Table 8). The main savings are realized in the amount of supplemental protein that must be added to conventional hulled barley rations. Some evidence also suggests that hulless barley is a superior creep feed to hulled barley, wheat, or corn. As well, there are side benefits in grain and manure handling, since the total volume in both cases is reduced.

Table 8 Comparison of pig performance\* using hulless versus hulled barley-based diets

Performance	Hulless diet	Hulled diet
<i>Starter piglets</i>		
Average daily gain (g)	281	298
Average daily intake (g)	545	569
Feed conversion (ratio)	1.9	1.9
<i>Grower pigs</i>		
Average daily gain (g)	740	750
Average daily intake (g)	2320	2460
Feed conversion (ratio)	3.1	3.3

\* Based on data from the Prairie Swine Centre, Saskatoon.

## General considerations

*For production* Hulless barley is no more difficult to produce than either wheat or conventional hulled barley. Moreover, it has the potential to outyield wheat under favourable conditions. Hulless barley is well-adapted to Canada's major areas of farm production. It performs better than wheat on saline soils and matures some five to ten days earlier, giving producers an additional crop for rotation in marginal areas. Hulless barley is a viable, low-risk alternative to corn or milo (sorghum), the main sources of feed in the U.S. swine industry. This crop is also highly amenable to conservation tillage and other practices involved in sustainable agriculture.

*For feeding poultry* Hulless barley provides an excellent cereal base for all phases of poultry production. This includes not only broiler chickens and layers but also replacement pullets and turkeys. Dietary inclusion rates of up to 95% are acceptable. The only limitation on the use of hulless barley relates to the presence of  $\beta$ -glucan, which is a problem unique to young birds (all types) and which can be effectively counteracted by adding an inexpensive enzyme supplement. Hulless barley is closer in nutritive profile to wheat and should be valued as such. These qualities clearly make it superior to conventional hulled barley.

*For feeding swine* Hulless barley is at least equal to the other feed grains in energy value. However, it derives a distinct advantage in requiring less supplemental protein and lysine for prepared rations and in being somewhat easier to mill and mix. Dietary inclusion rates of up to 95% are acceptable. Producers can benefit from substantial savings in feed costs, depending on individual circumstances.  $\beta$ -Glucan does not present a problem when hulless barley is fed to swine. Therefore, enzyme additives are not required as with poultry. The volume of manure from hulless rations can also be reduced by as much as 50%, relative to that from hulled barley or corn, which can be an important environmental consideration.

## **Future opportunities**

Since hulless barley development is a recent undertaking in Canada, there is much room for improvement for what is, essentially, an ancient crop. Archeological evidence points to hulless barley probably being the first human food grain. There is much potential for hulless barley to recapture some of its former status in terms of human food uses. Research is now being done on producing human food cultivars whose flour can be blended with wheat products, enhancing the health value of baked goods while lowering their production cost. The health benefits of hulless barley flour include its  $\beta$ -glucan content, which has been shown to reduce cholesterol, and its anti-staling effect, known to naturally extend product shelf life. Hulless barley may have a processing advantage (where removal of the hull is required) over conventional hulled barley in the production of pearled barley, barley flour, and other foods.

Development of hulless barley as a specialized feed grain for poultry and swine is progressing rapidly. Breeding programs are developing future cultivars with higher lysine (an essential amino acid that is scarce in cereals), very low  $\beta$ -glucan, a more digestible form of starch (the energy source), a broader range of adaptation (including cultivars for eastern Canada, where currently none are recommended), and high yield potential with modest production inputs. If hulless barley is accepted by livestock operators as a substitute for feed wheat, the production of hulless barley may become more attractive than the production of wheat for feed. Not only is there a large potential feed market in Canada, but there are also large potential niche markets worldwide, especially where substantial numbers of hogs are being produced. The increased digestibility of hulless barley may offer cost-effective, "green" solutions to manure disposal problems in major swine-producing countries.

All of these developments will contribute to lowering the cost of livestock feed production, to reducing the need for imported feedstuffs, to creating value-added products, and most importantly, to enhancing the competitiveness and prosperity of the agricultural industry in Canada.



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