Agriculture Canada

Publication 1888/E

Production and feeding of naked oat

Canada

Printed with the financial support of the following:

Agrocentre Belcan (1983) Ltd.
C & M Seeds
Kemptville College
New Brunswick Department of Agriculture
Newfoundland Chicken Marketing Board
Proven Seed, a division of United Grain Growers Ltd.
Saskatchewan Agriculture and Food
The Ontario Egg Producers' Marketing Board
W.G. Thompson & Sons Ltd.

Production and feeding of naked oat

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Agriculture Canada 1888/E
available from
Communications Branch, Agriculture Canada
Ottawa, Ont. K1A 0C7

Cat. No. A53-1888/1993E ISBN 0-662-20220-1
Printed 1993 9.1M-03:93

Produced by Research Program Service

Également disponible en français sous le titre
Avoine nue : production et alimentation animale

Contents

Introduction 6
Covered versus naked oat 6

Producing naked oat 9
Treating the seed 9
Seeding 9
Threshing 9
Storing grain 11
Cleaning naked oat 11
Protecting the operator 13

Cultivars 13

Feeding naked oat 14
Producing poultry 14
  Broiler chickens 14
  Turkey broilers 14
  Eggs 16
Producing swine 17
  Weaner pigs 17
  Pork 18

Recommendations 19

Future opportunities 20

Appendix A 21

Introduction

Canada has become a leader in the breeding and use of naked oat (*Avena sativa* L.). During the past 40–50 years, production of conventional oat with covered seeds has declined worldwide along with the number of work horses. Other feed grains have emerged such as corn with its high metabolizable energy and low fiber content. Their production has increased steadily.

The hull of covered oat has almost disqualified it as an ingredient in diets for nonruminants such as pigs and poultry. However, the breeding and release of high-performance naked oat cultivars has largely overcome this problem. Current cultivars contain not only the metabolizable energy of corn but also more high-quality protein than corn (Table 1). Naked oat may now be used as a major ingredient, if not the sole source of energy and protein, in pig and poultry diets. The oat groat (the dehulled kernel) is a remarkable feed package. It needs only the addition of minerals and vitamins, and possibly a small amount of the essential amino acid lysine, to make a complete diet for pigs and poultry.

Covered versus naked oat

Covered oat of the standard varieties such as Newman and Calibre has a fairly thick hull (Fig. 1*a*). The hull clasps the true seed or groat and remains part of the threshed seed. It forms 25–30% of the kernel weight and is thus 25–30% of the harvested yield. The hull is low (1–2%) in protein and high in fiber, which reduces both the total digestible energy and protein content of the total kernel. For food processing, the kernels must be dehulled before the groats can be used to make oatmeal, whole flour, or oat bran.

In contrast, naked oat of the less familiar cultivars, such as Terra, Tibor, AC-Lotta, AC-Hill, AC-Percy, and AC-Belmont, has a thin, papery hull (Fig. 1*b*). The hull separates from the groat during the threshing operation in the field. Therefore the groat yield of naked oat cultivars is about the same as that of the groat yield of covered oat cultivars after dehulling. Although the trait for thin hull is under genetic control, the "naked" gene(s) is not usually completely expressed. Typically, threshed naked oat samples of the older licensed cultivars Terra and Tibor contain 5–10% covered seeds or more depending upon growing and harvesting conditions. Newer cultivars AC-Lotta, AC-Hill, and AC-Percy have fewer covered seeds. Cool weather conditions at flowering (before heading) produce more covered seeds than warm conditions produce. Covered seeds present different problems for food manufacturers and for feed formulators. The former must separate covered seeds from naked oat groats before the groats are processed for food. The latter find that any variation in hull percentage makes it difficult to calculate energy and protein values.

Table 1 Chemical composition and energy content of naked oat vs. corn

		Tibor oat	Corn
		MJ/kg	
Gross energy		19.8	18.8
True metabolizable energy:	rooster	16.9	16.4
	chick	16.2	16.4
		g/kg	
Fiber, crude		25	29
ß-glucan		42	0
Ash		23	15
Protein, crude		184	62
Amino acids			
Arginine		11.7	5.5
Histidine		3.7	3.3
Isoleucine		5.7	3.6
Leucine		12.4	13.8
Lysine		6.5	3.4
Methionine + cystine		7.8	5.0
Phenylalanine + tyrosine		13.8	9.5
Threonine		5.0	3.7
Valine		7.8	4.8
Fat, ether extract		55.4	44
		%	
Fatty acids			
C 16:0		18	12
C 18:0		2	2
C 18:1		40	29
C 18:2		37	56
C 18:3		1	1

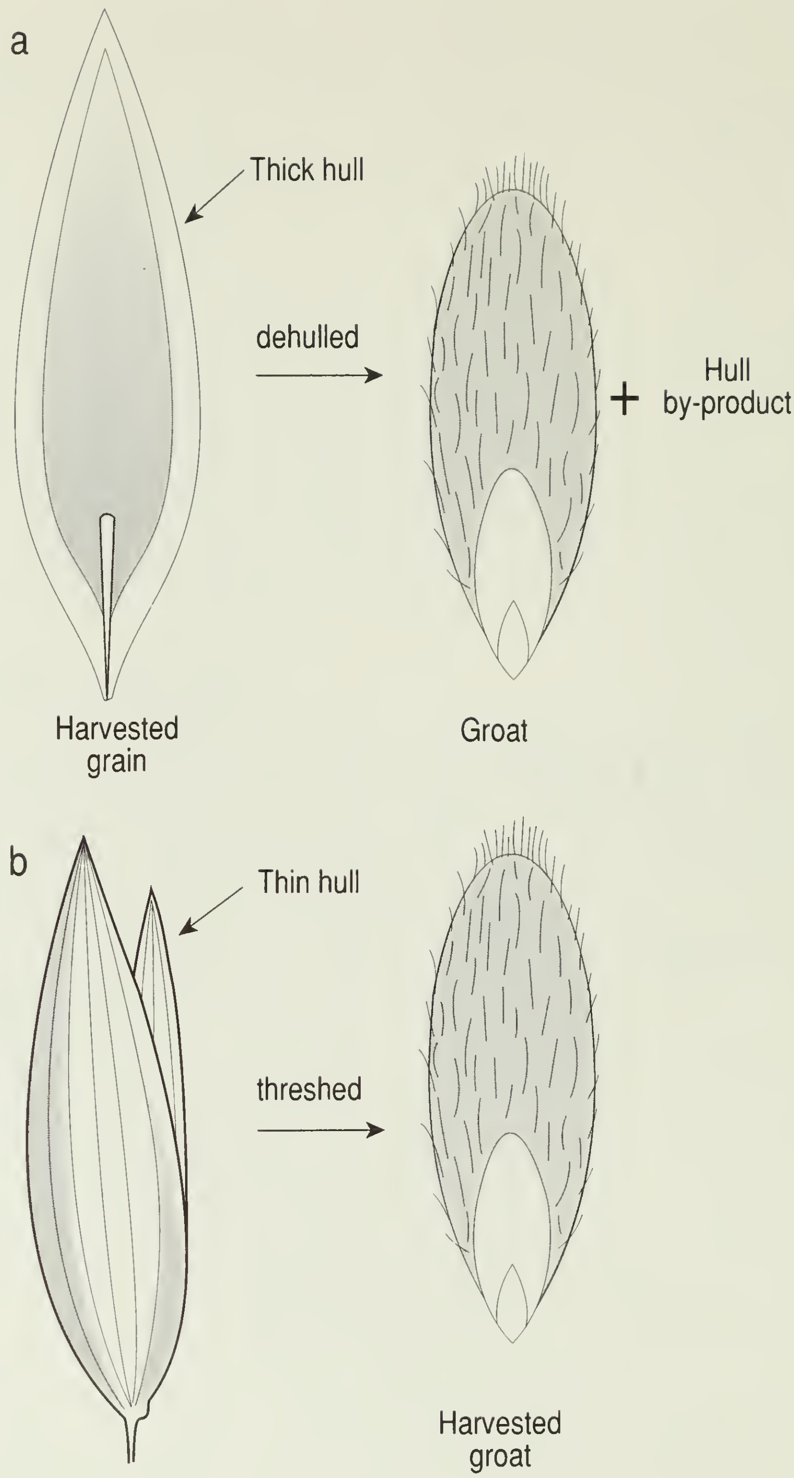

Fig. 1 **Comparison of *a* covered and *b* naked seeded oats. The thick hull of covered oat is harvested with the groat and must be removed by force using dehulling machines in food processing plants. The groats are processed into food products and the hulls are a by-product. The thin hull of naked oat is removed during threshing and is left in the field. The groat is the harvested grain.**

Producing naked oat

Canadian farmers know well how to sow, grow, harvest, store, and clean covered oat but must follow certain practices when growing naked oat, especially for seed. Methods for controlling weeds and using fertilizers are common to both types of oat. Care is needed when handling because the groat is quite fragile and is easily damaged at any stage (Fig. 2). In the following sections, we describe the production practices that have so far proven most useful.

Treating the seed

Prior to sowing, seed may be treated with a wide-spectrum fungicide such as maneb, metiram, or a mixture of carbathiin plus thiram. Powdered fungicide applied at the rate recommended for wheat rather than at the rate recommended for covered oat gives better coverage than liquid prior to sowing. Include lindane in the treatment if insects or maggots are expected to be a problem in the soil. Treat the seed close to the seeding date or use a drill box treatment. Check seed that has been treated and stored for long periods for germination and normal seedling development to be certain that the chemicals have not damaged the seed.

Seeding

Adjust the seeder to deliver about 200–250 seedlings per square metre, which corresponds to a rate of 55–70 kg/ha. Use the lower rate when planting early in the season. For late seeding, we recommend the higher rates, because higher temperatures at that time of year reduce tiller production. The drill setting will be closer to that for wheat and rye than for covered oat. Watch for "bridging" in the seed box caused by the "hairy" seeds sticking together. Sow naked oat at the same depth as for covered oat. Because naked oat neither germinates nor emerges well under wet conditions, reduce the depth when sowing sodden soils.

Threshing

Take care in threshing to avoid damaging the seed, especially if the grain is to be used for seed or milling purposes. In covered oat the hull protects the groat during threshing and handling. However, in naked oat the exposed groats are more vulnerable to damage. The embryo tip is particularly fragile, so the crop must be threshed gently to avoid removing the tip because it gives rise to the primary roots (Fig. 2). Therefore, reduce the speed of the thresher cylinder to about 900 rpm and carefully adjust the distance between concaves to prevent damage. When setting the concave gap, we suggest narrowing the gap until the bars rub and then open the gap slightly. Examine the threshed groats to determine the thoroughness of threshing and the amount of damage.

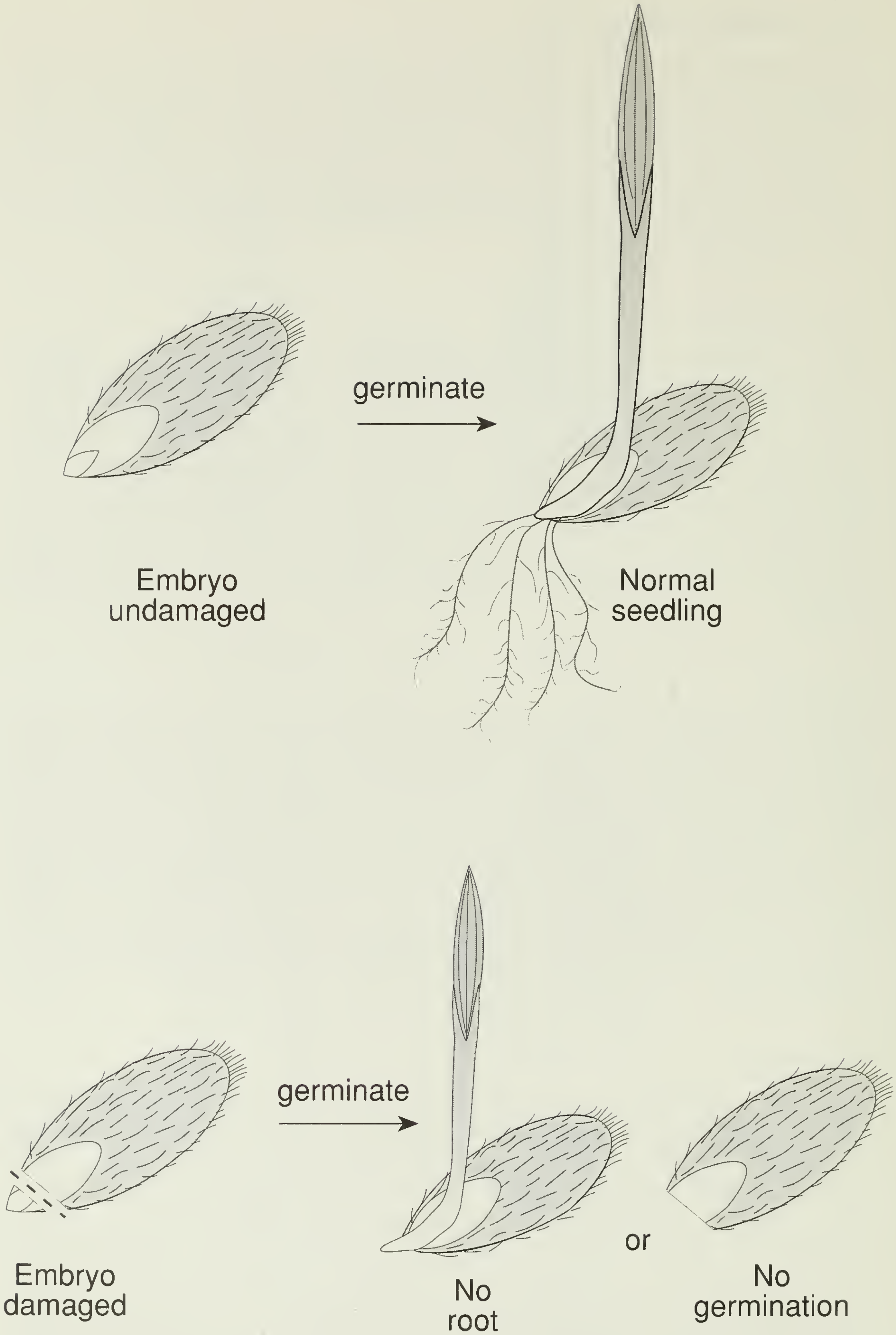

Fig. 2 Damage to the embryo either results in stunted seedlings without roots or prevents germination.

The straw cushions the seed and helps protect it during threshing. When producing grain for seed purposes we do not recommend diverting very much grain to the return path. It is better to clean seed as a separate operation rather than put it through the threshing cylinder twice.

Naked oat may be either harvested with a combine or swathed and combined later. If it is swathed, seed losses from shattering may occur at the pick-up. Be sure that the pick-up turns only fast enough to raise the swath into the combine. When it rotates too fast, it threshes out many of the seeds before they enter the combine. The best advice for operators is to look carefully at the grain entering the hopper to see if damage is being done to the embryo. Also check the losses that may be occurring either at the front (pick-up) or at the rear of the combine (check heads for unthreshed kernels). Adjust the combine if needed to suit changing moisture contents and weather conditions during the day. Seed growers have to take more care than farmers who are going to feed their harvested grain.

Storing grain

Moisture content is critical to proper storage of grain. Grain containing 12% moisture or less will store properly and germinate well when sown. If moisture is above 12%, aerate the bin to prevent the grain from heating and developing molds. Store naked oat in aerated bins where heat or air can be applied to reduce moisture content. During long-term storage turn on the aeration fans periodically to keep the seed in good condition. Ensure that bins are rodent proof and free of insects before filling, because storage insects have a great affinity for naked oat.

Cleaning naked oat

For seed Damage to the grain can also occur when it is cleaned after harvest, usually during winter. At this time the seed is usually dry and brittle and there is a tendency to chip the embryo or cause cracks in the endosperm. Never put naked oat through a debearder or scutcher. Any rough treatment either produces abnormal, stunted seedlings commonly lacking primary roots or the seeds fail to germinate. Take great care in moving naked oat through any conveying system. Pneumatic systems, which can transport most grains quickly without damage, can easily damage naked oat. Use either an auger or “chain bucket” system. Generally, the less the seed is handled the higher its germination percentage.

For food The objectives when preparing naked oat for processing as food are twofold:

- remove weed seeds, stones, straw, foreign grains, and foreign plant material by cleaning
- deal with oat kernels that escaped dehulling during threshing by polishing.

Foreign material can be removed using conventional seed-cleaning equipment either before or after delivery to the processing plant. Fortunately, because the hulls of naked oat are thinner than those of covered oat, they can readily be removed during polishing by passing the dry grain through a scutcher or debearder (Fig. 3). The churning and abrasive action within the debearder rubs the seeds against one another releasing and pulverizing the thin hulls to dust and removing surfaceborne groat hairs. This debris can easily be separated from the polished groats by wind aspiration. About 8% of the groats are broken during threshing, cleaning, and polishing. The polishing operation is best done just before food processing so the polished seeds do not have time to develop rancidity and a bitter taste.

For feed Little cleaning is required. The emphasis is placed on removing weed seeds, stones, and short lengths of straw that will interfere with the flow of grain.

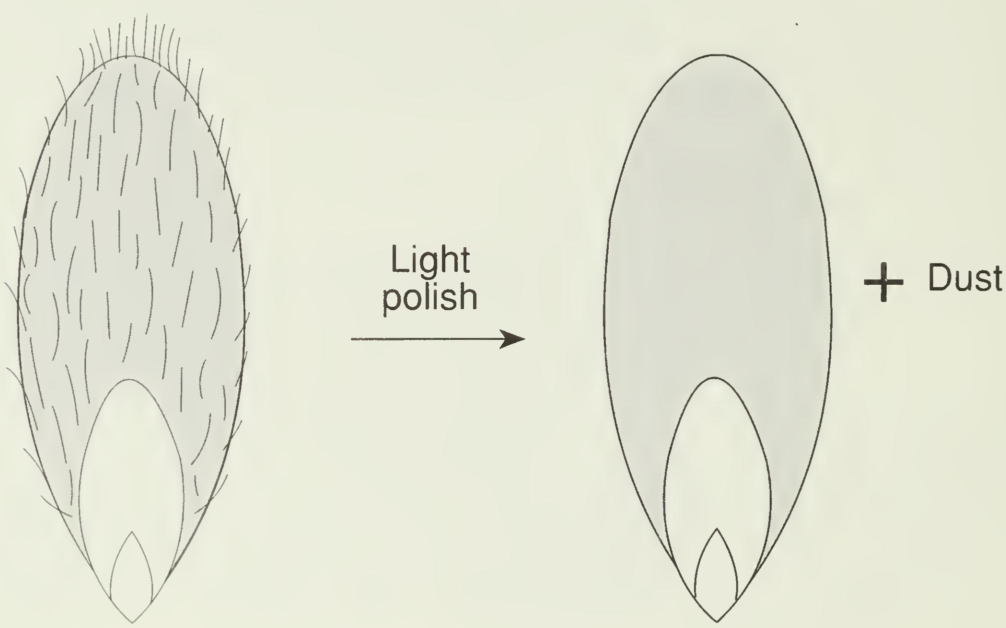

Fig. 3 Surfaceborne hairs, and any hulls that failed to be removed during threshing, are easily removed from groats by rubbing seeds together in a seed polisher. The hulls and hairs are converted to dust and are separated from the groats by aspiration. The polished seed now flows readily.

Protecting the operator

Oat groats have fine hairs or trichomes on the kernel surface many of which are released into the air when the grain is handled. These hairs can cause skin and respiratory irritation unless operators are isolated in cabs, or protected by adequate ventilation, or both. We advise operators to use a suitable filter or mask to protect themselves against all forms of grain dust.

Cultivars

Seed of six naked oat cultivars is available in Canada. Terra (licensed in 1976) and AC-Belmont (1992) were bred for western Canada and Tibor (1985), AC-Hill (1991), AC-Lotta (1991), and AC-Percy (1992) for eastern Canada. There has been a steady improvement in yield, straw-strength, seed size, and protein content of new cultivars. Terra outperforms Tibor in western Canada but the reverse is true in eastern Canada. Terra, Tibor, AC-Belmont, and AC-Lotta cultivars contain 4–6% covered seeds in threshed grain samples, whereas, the percentage is lower in AC-Hill and especially in AC-Percy.

AC-Lotta is Canada's first high-yielding naked oat insensitive to daylength. It should find acceptance by the food and feed industries both inside and outside Canada. Because it contains the first described gene for insensitivity to daylength, it flowers normally during the normal growing season at all latitudes. In Ontario, AC-Lotta is early maturing and resistant to loose smut and crown rusts. Its early maturity may make it a useful component in oat–barley mixtures where its naked seed will raise the protein and energy content of mixed grain.

AC-Hill is also resistant to smut and crown rust but, because it is a daylength-sensitive cultivar, its usefulness will be restricted to geographical areas having long days and short nights. These conditions are met in Canada.

AC-Percy is similar to AC-Hill in flowering behavior and agronomic traits. Both cultivars have large seeds and fewer covered seeds than Tibor, Terra, or AC-Lotta in threshed grain samples. Both are tall and later maturing than AC-Lotta and should produce higher yields of straw for bedding.

AC-Belmont was bred at the Winnipeg Research Station, Agriculture Canada. It is a daylength-sensitive cultivar with resistance to smut and stem and crown rust.

All these new cultivars can be used successfully for feed, food, and industrial purposes. Seed stocks of these cultivars should be adequate in 1993–1994 and obtainable from the companies listed in Appendix A.

Feeding naked oat

Experiments have been conducted at the Centre for Food and Animal Research, (CFAR) Ottawa, Ont., and the Research Station, Kentville, N.S., of Agriculture Canada, and the Ridgetown College of Agricultural Technology (RCAT), Ontario Ministry of Agriculture and Food, to determine what level of naked oat (Tibor) can be incorporated into poultry and swine diets. Corn–soybean meal served as the control diet in these trials. Within the experiment, most diets had similar caloric values; some were formulated also to provide equal amounts of lysine.

The value of naked oat as a feed for pigs and poultry depends upon the cost of the corn–soy diet, which varies in the different regions of Canada.

Producing poultry

Broiler chickens

Early results showed that in starter broiler chickens (0–28 days), fed only 20% naked oat in the diet, growth was depressed and sticky droppings were a problem (Table 2). In grower broiler chickens (29–48 days) a diet containing 30% naked oat supported high weight gain and acceptable feed conversion.

Subsequent experiments showed that growth depression in the starter broiler chickens resulted from decreased nutrient availability and feed intake caused by the presence of ß-glucan (a cell wall constituent) in the oat grain (Table 3). Attempts to improve the naked oat by steam and pelleting processes were unsuccessful. Interaction among ß-glucan, bile salts, and fats is believed to reduce absorption of nutrients, including fat-soluble vitamins, from the intestinal tract. The addition of antibiotic and vitamins A_1, D_3, and E in a water-miscible form improved performance of broilers (7–21 days). These additives allowed inclusion of naked oat up to 50% of both starter and grower diets with good results (Table 4). Broiler meat showed a moderate increase in fat stability as oat level increased. Research is proceeding to reduce the content of ß-glucan in oat to low levels through breeding so that specialized feed oat cultivars can be bred for broiler diets.

Turkey broilers

Body weight gains of turkey poults fed starter diets (1–28 days) containing 10, 20, or 30% naked oat between 7 and 28 days of age were similar to those given the corn–wheat–soybean control diet. Supplementing the starter diets with the enzyme ß-glucanase improved weight gains, except for the 30% naked oat diet. Regardless of ß-glucanase supplementation, feed conversions were lower with the naked oat diets than the controls. Except for the 20% naked oat diet,

Table 2 Performance of broiler chicks* fed starter diets containing naked oat from 0–28 days of age

Diet	Weight gain (g)	Percentage of control	Feed/ gain (g/g)	Percentage of control
Corn–soy control	919	100	1.49	100
20% Tibor oat	838	91	1.54	103
40% Tibor oat	745	81	1.57	105
60% Tibor oat	588	64	1.84	123

* Three replications of 100 male and three replications of 100 female Ottawa meat-strain broilers per diet.

Table 3 Performance of broiler chicks* fed corn–soy starter diets containing graded levels of ß-glucan rich oat bran

Diet	Weight** gain (g)	Percentage of control	Feed/ gain (g/g)	Percentage of control
Corn–soy control	388	100	1.44	100
+ 0.64% ß-glucan	389	100	1.43	99
+ 1.90% ß-glucan	373	96	1.45	101
+ 3.06% ß-glucan	343	88	1.59	110

* Five replicate groups of 10 Starbro broilers per diet.

** 7–18 days of age.

Table 4 Performance of broiler starter and grower chickens* fed diets containing graded levels of naked oat

	Weight (g)		Feed/gain (g/g)	
Diet**	28 days	43 days	0–28 days	0–43 days
Corn–soy control	830	1590	1.29	1.73
25% Tibor oat	864	1615	1.18	1.72
50% Tibor oat	881	1698	1.18	1.73
75% Tibor oat		1543		1.76

* Six replicate groups of 60 male and six replicate groups of 60 female Ottawa meat-strain broilers per diet.

** Included supplements of neomycin and water-miscible vitamins A_1, D_3, and E.

Table 5 Performance of broiler turkey poults* fed starter diets from 7–28 days of age containing naked oat without or with added ß-glucanase

Diet	Glucanase**	Weight gain (g)	Percentage of control	Feed/ gain (g/g)	Percentage of control
Corn–wheat–soy control	-	786	100	1.373	100
	+	802	100	1.355	100
10% Tibor oat	-	773	98	1.428	96
	+	811	101	1.407	96
20% Tibor oat	-	775	99	1.408	98
	+	797	99	1.461	93
30% Tibor oat	-	776	99	1.516	91
	+	771	96	1.474	92

* Three replicates of 24 females and three replicates of 24 male Medium White poults per diet.

** Commercial ß-glucanase added at 1 g/kg of diet.

adding ß-glucanase improved feed conversion, although the effect was small (Table 5). The incidences of mortality were similar among the dietary treatments.

Broiler turkeys were fed grower (29–63 days) and finisher (64–83 days) diets containing 50% naked oat combined with either barley, corn, or wheat. Body weight gains during the grower and finisher periods were lower for birds given the naked oat diets than those fed the corn–wheat–soybean control diet regardless of whether or not the diets contained supplemental methionine. The results were similar for female and male turkeys. Irrespective of methionine supplementation, birds given the naked oat diets made significantly better feed conversions during the finisher period than the controls. Dietary treatment had little effect on mortality.

Further research is being done at Kentville, N.S., to determine the effects on the performance of broiler turkeys of incorporating naked oat into starter, grower, and finisher diets.

Eggs

Research shows that naked oat can be included at levels up to 60% in layer diets to replace corn, soybean meal, and fat. Yield of egg mass was equal to a corn–soybean control diet up to 60% and was reduced by only 4% at 80% naked oat, when no soybean meal was used (Table 6).

Table 6 Performance of laying hens* fed diets containing graded levels of naked oat

Diet	Eggs laid** (No.)	Egg weight (g)	Egg yield (g/hen-day)	Feed efficiency (g/g egg)	Yolk color***
Corn–soy control	280	59.0	46.3	2.33	7.3
30% Tibor oat	280	59.8	46.8	2.26	6.8
60% Tibor oat	275	59.8	46.1	2.22	5.5
81% Tibor oat	261	60.4	44.4	2.25	4.0

* Four replications of 20 White Leghorn hens per diet.

** 20–71 weeks of age.

*** Roche yolk color fan.

When naked oat was supplemented with feed-grade lysine and methionine or with canola meal, to the exclusion of soybean meal, dietary levels of 70 or 88% naked oat supported egg yields equal to the corn–soy control. At the 88% level of naked oat, egg size was significantly increased. This is of benefit to younger laying flocks, giving better egg grades and higher monetary returns. With older flocks, however, larger eggs are not desired and the level of naked oat might be reduced after about 50 weeks of age.

The efficiency of conversion of feed to egg material was significantly improved over the corn–soy control at all dietary levels of naked oat, excepting at 88% without amino acid additions. This result is a major plus factor for this feedstuff. Because of lack of carotene pigment in oat compared with corn, yolk color was reduced as the level of oat increased. Generally, consumers do not favor pale yolks but recently a large market in the United States for liquid eggs with pale yolks has been identified. If needed, including other dietary sources of pigment, such as marigold meal or carotenoids, easily increases yolk color as is done commonly with wheat and barley diets. No consistent detrimental effects of naked oat were found from tests on shell quality, interior egg quality, or from taste panel tests.

Producing swine

Weaner pigs

For weaner pigs, as for starter chickens, daily gain on a 90% naked oat diet was less than with a corn–soybean control diet. The feed-to-gain ratio was also impaired. Adding an enzyme preparation to reduce the viscosity of the gum improved daily gain and the feed-to-gain ratio. However, performance of oat-fed weaner pigs was still less than that of pigs on the corn–soybean diet (Table 7).

Table 7 Performance of weaner pigs* fed corn–soy and naked oat control diets or an oat diet supplemented with enzymes

Diet	Daily gain (g)**	Percentage of control	Feed/ gain (g/g)
Corn–soy control	400	100	2.04
90% Tibor oat control	333	83	2.35
90% Tibor oat + 1% enzyme***	347	87	2.26

* 16 boars and 16 gilts per diet.

** 8–23 kg liveweight.

*** Mixture including ß-glucanase and pentosanase.

Pork

Research at RCAT shows that, in some respects, naked oat can completely replace corn and soybean meal in grower–finisher swine diets. The weight gains and feed conversions obtained with up to 97% inclusion of naked oat were as good as those of a standard corn–soybean diet (Table 8). In a comparable experiment at CFAR, taste panelists concluded that the meat of oat-fed pigs was superior in texture, flavor, and tenderness to that of pigs fed the corn–soybean diet. In a second experiment, they found flavor was improved but texture and tenderness were equal in the two diets. In one experiment however, weight gain was reduced 7% with a 95% oat diet; addition of lysine ensured high weight gain and improved feed conversion with the diet (Table 9). Because of the high energy content of naked oat, increasing the dietary oat level produced fatter marketed hogs with correspondingly less lean meat and higher dressing percentage. When the grower–finisher diet is supplemented with lysine, average daily gain improves, excess fat does not accumulate, and carcass quality is comparable to that obtained with the corn–soy diet.

Table 8 Performance of finisher pigs* fed diets containing graded levels of naked oat

Diet	Daily gain (g)**	Percentage of control	Feed/ gain (g/g)	Dressing percentage	Fat thickness (mm)
Corn–soy control	820	100	3.18	77.4	32.6
30% Tibor oat	840	102	3.09	76.9	32.6
65% Tibor oat	830	101	2.89	78.5	32.4
97% Tibor oat	840	102	2.81	78.4	33.4

* Four replications of eight (Hampshire–Duroc) × (Yorkshire–Landrace) pigs per diet.

** 32–97 kg liveweight.

Table 9 Performance of grower–finisher pigs* fed naked oat diets with or without supplemental lysine

Diet	Daily gain (g)**	Percentage of control	Feed/ gain (g/g)	Carcass lean %	Loin fat thickness (mm)
Corn–soy control	875	100	2.50	42.1	29.4
48% Tibor oat + 0.14% lysine	931	106	2.45	42.2	30.4
95% Tibor oat	816	93	2.58	39.4	33.4
95% Tibor oat + 0.27% lysine	909	104	2.44	41.9	32.4

* Nine boars and nine barrows per diet from the CFAR herd of specific pathogen-free Yorkshire pigs.

** 27–90 kg liveweight.

Recommendations

To maximize the use of naked oat as animal feed, include them to the following levels:

- laying hens, 87%
- chicken broiler growers, 50%
- turkey broiler growers and finishers, at least 50%
- grower–finisher swine, 95%.

Add lysine at levels appropriate for the class of poultry or swine. Incorporate amino acids with the vitamin premix. Swine producers, however, should consider using a mixture of 50% naked oat and 50% corn–soybean mixture, because, at CFAR, this diet produced pigs that outgrew those reared on the standard corn–soybean meal diet.

Although certain feed additives were identified as beneficial in feeding naked oat to broiler starter chicks and weaner pigs, no recommendation can yet be made for younger animals. Current experiments aim to improve naked oat for these young animals by grain processing and by breeding cultivars low in ß-glucan.

Future opportunities

The success of naked oat as a food or feed grain will depend upon research, production, processing, and market development, and on how well these interest areas are coordinated. Future production may also depend upon current research developments in the industrialization of naked oat to make products such as ethanol, bran, concentrated ß-glucan gums, and cosmetic and pharmaceutical products. Because of its outstanding adaptability, naked oat represents an opportunity for producers to grow good-quality protein and metabolizable energy in all grain-growing regions of Canada on both good- and marginal-quality land. If substantial areas of naked oat were established this could

- provide cheaper feed grains at the local level
- reduce imports of energy and protein for pigs and poultry
- help establish crop rotations of the type that contribute to a more sustainable agriculture.

Naked oat would also aid in expanding the food milling industry by offering less bulkiness in storage and greater efficiency in handling and processing for domestic and foreign markets. An overall strategy is needed to be developed in Canada for the exploitation and commercialization of naked oat.

Appendix A

Cultivar	*Distributor*
AC-Belmont	• United Grain Growers Ltd. P.O. Box 6600, Winnipeg, Man. R3C 3A7
AC-Hill	• Agrocentre-Belcan Ltd. 180 Montée Ste-Marie Ste-Marthe, Cte Vaudreuil, Que. J0P 1W0
AC-Lotta	• C & M Seeds R.R. #3 Palmerston, Ont. N0G 2P0
AC-Percy	• Semico Inc. 1091 St-Régis Saint-Isidore, Que. J0L 2A0
Terra	• Hussin Seed Farm RR # 7 Calgary, Alta. T2P 2G7
Tibor	• W.G. Thompson and Sons Limited Hensall, Ont. N0M 1X0 • Coop Fédérée de Québec 9001 boul. de l'Acadie Bureau 200 Montreal, Que. H4N 3H7

CONVERSION FACTORS FOR METRIC SYSTEM

Multiply an imperial number by the conversion factor given to get its metric equivalent.
Divide a metric number by the conversion factor given to get its equivalent in imperial units.

Imperial units	Approximate conversion factor	Metric units	
Length			
inch	25	millimetre	(mm)
foot	30	centimetre	(cm)
yard	0.9	metre	(m)
mile	1.6	kilometre	(km)
Area			
square inch	6.5	square centimetre	(cm^2)
square foot	0.09	square metre	(m^2)
square yard	0.84	square metre	(m^2)
square mile	260	hectare	(ha)
acre	0.40	hectare	(ha)
Volume			
cubic inch	16	cubic centimetre	(cm^3, mL, cc)
cubic foot	28	cubic decimetre	(dm^3)
cubic yard	0.8	cubic metre	(m^3)
fluid ounce	28	millilitre	(mL)
pint	0.57	litre	(L)
quart	1.1	litre	(L)
gallon (Imp.)	4.5	litre	(L)
gallon (U.S.)	3.8	litre	(L)
Weight			
ounce	28	gram	(g)
pound	0.45	kilogram	(kg)
short ton (2000 lb)	0.9	tonne	(t)
Pressure			
pounds per square inch	6.9	kilopascal	(kP)
Power			
horsepower	750	watt	(W)
	0.75	kilowatt	(kW)
Speed			
feet per second	0.30	metres per second	(m/s)
miles per hour	1.6	kilometres per hour	(km/h)
Agriculture			
gallons per acre	11	litres per hectare	(L/ha)
quarts per acre	2.8	litres per hectare	(L/ha)
pints per acre	1.4	litres per hectare	(L/ha)
fluid ounces per acre	70	millilitres per hectare	(mL/ha)
tons per acre	2.2	tonnes per hectare	(t/ha)
pounds per acre	1.1	kilograms per hectare	(kg/ha)
ounces per acre	70	grams per hectare	(g/ha)
plants per acre	2.5	plants per hectare	(plants/ha)

Temperature

degrees Fahrenheit to Celsius — (°F − 32) x 0.56 = °C

degrees Celsius to Fahrenheit — (°C x 1.8) + 32 = °F

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