Oilseeds Grading - Quality Control in Oilseeds Marketing[1]

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ABSTRACT

Grading systems are used in many countries to aid in separating oilseeds into marketable groups according to quality. Factors are compared for two types of systems: the fixed grade system used in Canada, the USA and Sweden, and the sliding scale system used in Australia and the EEC (European Economic Community) which is being considered by the International Standards Organization. The relationship between grade, degrading factors and end-use quality is discussed, specifically for Canadian oilseeds. Future use of NIR technology and other rapid nonvisual techniques in systems which now rely on visual assessment is considered.

INTRODUCTION

Influences of environment can cause large variations in the quality of oilseeds. To maintain an acceptable standard of quality, many countries have established regulations which allow seeds of different quality to be segregated into grades reflecting different quality characteristics of significance to end-users. In general, there are two types of grading systems for oilseeds. The system used in Canada, Sweden and the USA segregates oilseeds by numerical grade, each grade having a distinct set of characteristics. The system used in Australia and the European Economic Community (EEC) establishes a base level of quality for which premiums or discounts are made based on individual quality factors.

This review compares and contrasts the two types of grading systems and includes a discussion of proposed International Standards Organization (ISO) specifications. The effects of some specific degrading factors are examined and future challenges in the area of oilseeds grading are considered. The discussion covers rapeseed, linseed, soybeans and sunflower seed and concentrates mainly on Canadian experience.

COMPARISON OF CANADIAN AND AMERICAN GRADING SYSTEMS FOR OILSEEDS

The Canadian Grain Grading System is established by an Act of Parliament known as the Canada Grain Act (1). Grades of grain are specified in the Act, which is administered and interpreted by the Canadian Grain Commission, a federal agency responsible to the Minister of Agriculture. Under the Canada Grain Act, the Canadian Grain Commission was established with the mandate of ensuring a dependable commodity for domestic and export markets. The Act includes schedules with grades for rapeseed, soybeans, sunflower seed, flaxseed and other grains.

The United States Grain Standards Act (2) authorizes the Administration of the Federal Grain Inspection Service (FGIS) which is under the supervision of the Secretary of Agriculture, to establish standards for flaxseed, soybeans and other grains. These standards are applied to grain to be exported from the USA. Sunflower and rapeseed are graded according to specifications established by State Departments of Agriculture and do not, at present, come within the jurisdiction of the FGIS.

Grades of oilseeds under both the Canadian and US grading systems include standards for quality and purity. Quality standards may be subdivided to include test weight and degree of soundness. Table I compares the Canadian and US standards for the top grades of rapeseed, sunflower seed, flaxseed and soybeans. The Canadian regulations have one more grade than the US regulations but the top grade specifications are generally quite comparable, partly due to cooperation between the Grain Commission in Canada and the FGIS in the USA in establishing the regulations.

Table II compares the purity standards for the top grades of oilseeds in Canada and the USA. Purity standards are applied to seed after the removal of dockage, i.e., after the removal of foreign material which can be separated by prescribed screening techniques (this is generally related to commercial cleaning operations). The calculated amount of inseparable foreign material is then added to the dockage assessment. There are some differences in standards of purity. For example, the Canadian regulations allow for a

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TABLE II

Purity Standards for the Top Grade of Oilseeds: Canada and USA (3,4,5,6)

	Total allowable admixture (%)	
	Canada	USA
Rapeseed	1 (5)[a]	1
Soybeans	1	1
Flaxseed	1	0
Sunflower seed	2.5	–

[a]Inconspicuous admixture including common wild mustardseed and/or domestic brown or oriental mustardseed.

TABLE I

Quality Standards for the Top Grade of Oilseeds – Canada and USA (3,4,5,6)

	Test weight[a]		Maximum damage		Maximum heated		Moisture content		Total number of grades	
	Canada	USA	Canada	USA	Canada	USA	Canada	USA	Canada	USA
	kg/hL (1b/bu)		%		%		%		%	
Rapeseed	–	–	3	3	0.1	0.1	10.0	10.5	3	3
Soybean	70 (54)	72 (56)	2	2	0	0.2	14.0	13.0	5	4
Flaxseed	65 (51)	63 (49)	12.5	10	0.2	0.2	10.5	9.5	3	2
Sunflower seed	–	32 (25)	2	5	0	0.5	9.5	10.0	3	2

[a]Bracketed values 1b/bu as specified in USA.

TABLE III

Specifications for Rapeseed in Canada in Sweden

	Canada (3)		
	Grade I	Grade II	Grade III
Damaged seeds (%)	3	10	20
Green-damaged (%)	2	6	20
Heat-damaged (%)	0.1	0.5	2
Conspicuous admixture (%)	1	1	1
Inconspicuous admixture (%)	5	5	5
Moisture (%)	10	10	10
Stones (%)	0.05	0.05	0.05
Sclerotia (%)	0.1	0.2	0.3
Ergot (%)	0.05	0.05	0.05
Appearance; smell		subjective assessment	
	Sweden (7)		
	Grade I	Grade II	Unacceptable
Appearance; smell		subjective assessment	
Purity (%)	90-100	90-100	90
Moisture (%) maximum	8	8	8
Chlorophyll (ppm in the oil)	30	70	70
FFA (%)	1	3	3

visible, but very small, percentage of stones and for small amounts of sclerotia to be present in rapeseed and sunflower seed. US regulations generally degrade to "sample grade" any seed (except soybean) which contains stones or foreign material. US regulations also have very strict limitations on the number of crotalaria seeds or castor beans, admixtures which do not occur in Canada.

Oilseeds other than soybeans are graded without respect to class, and no distinction is made between *B. napus* and *B. campestris* species of rapeseed or between oil and confectionary type sunflowers. Soybeans are graded according to color (i.e., yellow, green/brown, black or mixed).

Material which fails to qualify for the statutory grades described above is designated as "sample grade-account heated, damaged, admixture, odor or other designation."

There are also some differences in moisture penalties and prescribed levels of moisture content. In the US system, moisture is a grading factor and moisture allowances increase as the grade number increases, i.e., US No. 1 soybeans have a maximum 13.0% moisture whereas US No. 4 have a maximum 18% moisture. Samples with over 18% moisture are graded "Sample Account High Moisture." In Canada, moisture is not taken into account in grading but high-moisture samples are given special off grades, designated as "tough" or "damp" depending on the moisture content. Off-grade seeds may be dried through seed mixing or artificial drying to within straight-grade limits under the direction of the Grain Commission.

COMPARISON OF CANADIAN AND SWEDISH SYSTEMS FOR GRADING RAPESEED

Table III shows the Swedish and Canadian grading specifications for rapeseed. Because Sweden has a centralized handling system for all rapeseed grown in that country, and because the volume of seed involved is relatively small, it is possible for individual farm samples to be evaluated at one or two central laboratories. In this way, all samples can be tested for chlorophyll and free fatty acids (FFA) using sophisticated laboratory techniques (7).

In Canada, the large number of grading locations and the large number of samples coupled with rapid throughput and binning practices make a subjective (visual) grading system necessary. It is interesting to note that average values for chlorophyll and FFA on graded railcar unload composites from Canadian Export Terminals are well within tolerances allowed in the Swedish grade specifications (Table IV).

TABLE IV

Comparison of Swedish Grading Factors with Results from Canadian Surveys of Rapeseed

	Sweden	Canada
Grade:	Chlorophyll, ppm in oil	
1	30	25
2	70	50
3	no grade	55
	Free fatty acids, % in oil	
1	1	0.4
2	3	0.6
3	no grade	0.9

AUSTRALIAN, EEC AND ISO SPECIFICATIONS

The EEC has established basic standards for oilseeds which are to qualify for intervention price (8). In some cases there are price reductions and premiums which may be paid for oilseeds of inferior or superior quality, respectively. The Australian Oilseed Federation has adopted a similar system for grading (9) and the ISO is in the process of establishing basic specifications for international trade (10-13). Since these specifications represent baseline values, it is appropriate that specifications be compared.

Table V compares moisture, impurity and oil content specifications for various oilseeds by the Australian, EEC and ISO specifications. The specifications are remarkably similar except that the ISO specifications for oil content in rapeseed and flax and moisture content in soybeans tend to be low, and the Australian impurity limits are higher than both the EEC and ISO limits.

In addition to the above standards, the EEC has specifications for erucic acid in rapeseed with a base maximum of 7%, and price reductions for seed in the range of 5.01-10.0% erucic acid. Seed with more than 10% erucic acid may be refused. The EEC also has a scale of price reductions and increases for oil content.

TABLE V

Base Quality Specifications for Oilseeds under Australian (9), EEC (8), and ISO (10-13) Regulations

	Moisture			Impurities			Oil content		
	Australia	EEC	ISO	Australia	EEC	ISO	Australia	EEC	ISO
		%			%			%	
Rapeseed	9	9	9	4	2	2	40	40	36
Soybeans	13	14	12	4	2	2	–	18	18.5
Sunflower seed	9	10	9	4	2	2	40	40	40
Linseed	10	9	8	4	2	2	39	38	32

TABLE VI

Relationship Between Grade and Some Quality Factors for Canadian Oilseeds

Oilseed	Grade	Oil content (%)	Protein content[c] (%)	Chlorophyll in seed ppm	FFA in oil (% as oleic)
Rapeseed[a]	1 AN	45.6	22.0	15	0.4
	2 AN	44.9	23.5	30	0.6
	3 AN	44.5	23.2	33	0.9
Flaxseed[a]	1 AN	43.6	22.9	0.7	0.5
	2 AN	43.0	22.6	2.0	0.8
	3 AN	43.3	23.3	0.9	1.6
Sunflower seed[a]					
Whole	1 CAN	45.1	18.0	–	0.6
	2 CAN	45.2	16.8	–	0.7
	3 CAN	44.8	19.3	–	2.4
Dehulled	1 CAN	61.1	22.8	–	0.3
	2 CAN	60.5	22.5	–	0.4
	3 CAN	58.7	23.8	–	1.2
Soybean[b]	1 CAN	20.2	41.5	–	0.2
	2 CAN	20.3	41.5	–	0.3
	3 CAN	20.1	41.3	–	0.6
	4 CAN	20.1	40.4	–	0.7

[a]Based on analysis of composites from railway carlots (20% sampling).
[b]Based on analysis of composites from trucklots graded at official grading points.
[c]N X 6.25, whole-seed basis.

The Australian system is somewhat more complicated than the EEC system since it allows for price adjustments for impurity level (dockage), oil content, moisture content, broken or split seed (base 7%, 20% in soybeans), damaged seed (base 3%, maximum 40%) and free fatty acid level on 500-ton minimum purchases.

EFFECT OF DEGRADING FACTORS ON UTILIZATION QUALITY

All of the grading systems described above involve some sort of measurement of "degrading factors" in order to assign grain to different grades or to assess its monetary value. "Degrading factors" may be described as defects which a grain acquires due to environmental influences. To be classed as a defect, degrading factors must, in some way, restrict the usefulness of an oilseed in the end product. In designing grading systems it is necessary to consider the effect of the degrading factors on the end-use of the product along with an assessment of the ability of the local agricultural systems to produce oilseeds free of degrading factors.

Degrading factors can affect utilization quality of oilseeds in two ways: (a) by lowering the oil (or protein) content of the seed and thus reducing the economic return to the processor, and (b) by affecting the quality of the oil and meal derived from the seed making it more difficult (or impossible) to process the oil and meal into acceptable final products.

Assessment of degrading factors in grading systems ranges from direct measurement of the quality factors using laboratory tests (oil content determination, chlorophyll determination, free fatty acid analysis) to a visual assessment of the degrading factor in the seed sample. Visual assessment is subjective, and is subject to more error than laboratory tests.

In some countries, such as Canada, the grain handling system dictates the necessity of a visual assessment grading system. The volume of samples involved and the short time between sample receipt and binning make direct measurement of quality factors impossible.

To evaluate the effectiveness of the Canadian grading system in grading oilseeds according to end-use quality, composite grade samples of oilseeds passing through the Canadian handling system were analyzed for oil content, protein content, chlorophyll content and free fatty acids. Table VI shows the results for rapeseed, soybeans, linseed and sunflower seed. In general, oil content seems to decrease slightly with lower grades of rapeseed, flaxseed and sunflower seed whereas the protein content of the lower grade material is higher for these oilseeds. There does not seem to be any change with grade for soybean oil content but the protein content of lower grade beans is significantly lower than that of higher grade beans. Chlorophyll and free fatty acid levels are closely related to changes in grade.

The major degrading factors in oilseeds are immaturity (which includes frosted and shrivelled kernels), sprouted

TABLE VII

Relationship Between Percentage Green Seeds and Chlorophyll Content for Samples of Rapeseed Collected and Tested at Different Times and Locations (14)

Sample	Inspected by	No. of Samples	Correlation between % green and chlorophyll
1979 survey	Canadian Grain Commission	56	0.61
1980 survey	Canadian Grain Commission	46	0.67
1979-80 crushing plants	Canadian Grain Commission	115	0.65
1980 farm samples	Canola crushing plant	291	0.67

TABLE VIII

Effect of Sprouted Seeds, Weed Seeds and "Bin-Heating" on the Quality of Rapeseed

Sample	Oil content (%)	Chlorophyll in oil (ppm)	Free fatty acids (%) (in oil, as oleic)
		Swedish rapeseed (15)	
Sound[a]	45.8	8	0.4
Sprouted[a]	44.2	47	3.7
Weed seeds	13.2	66	4.7
		Canadian Rapeseed	
Sound[a]	42.2	0.2	0.0
Sprouted[a]	39.6	3.0	0.5
Bin-heated[b], 0%	–	–	0.3
28%	–	–	0.6
40%	–	–	2.3
66%	–	–	19.2
98%	–	–	37.9

[a]Hand separated from original sample.
[b]By visual inspection as defined in ref. 3.

seeds, broken seeds, heated seeds, weathering and admixture. Oilseeds harvested before attaining physiological maturity can have decreased quality for several reasons, including lower oil and protein content. This is most prevalent in the case of extreme immaturity where the ripening process has been interrupted by frost or disease. Immature seeds also contain high levels of free fatty acids and have a low germination capacity. Immature seeds also metabolize actively, producing heat and moisture which, in turn, contribute to further spoilage.

Presence of chlorophyll pigments makes processing of oil difficult. In Canada, chlorophyll is estimated by Grain Inspectors as a "percentage of green seeds." It has been estimated that 18-20 ppm chlorophyll in ripe rapeseed will give an oil which will meet normal trading specifications (14). Analysis of large numbers of seed samples for both "% green" and chlorophyll content (Table VII) indicates that a level of only 1.5% green seeds meets the 18-20 ppm level. Since individual deliveries are binned together, the maximum level of 2% green stated in the Canadian regulations should give an average level of less than 20 ppm maximum.

Sprouted

During germination, the seed uses oil as a source of energy. In doing so it creates free fatty acids and as the cotyledons develop, chlorophyll is synthesized. Thus, the oil content of sprouted seeds is decreased and the free fatty acids and chlorophyll are increased. Table VIII outlines work done in Canada and Sweden (15) to determine the effect that sprouting has on the quality of rapeseed. In general, these studies showed that sprouted seeds have a lower oil content and a higher level of chlorophyll and FFA than sound seeds. Further work in Sweden showed that, even when stored at 7% moisture, sprouted rapeseeds rapidly deteriorated in quality.

TABLE IX

Effect of Broken Seeds on Oilseed Quality

	Original sample	Whole seeds	Broken seeds
Soybean (17):			
Fe (ppm)	1.1	0.5	1.05
FFA (%)	1.2	0.9	1.4
Peroxide value (meq/kg)	1.5	1.4	1.9
Flaxseed (16):			
Oil content	–	42.2	43.2
Rapeseed (15):			
Oil content	–	45.8	46.4
Chlorophyll	–	8	28
Free fatty acids	–	0.4	5.0

Broken Seeds

Any damage that ruptures the seed coat will allow air, moisture and microorganisms to attack the stored oil and protein. Table IX outlines three studies on the effect of broken seed on quality (15,16,17). The oil content of broken seed is usually higher than that of sound seed since some of the fibrous seed coat is lost when the seed is broken. Besides the quality factors normally reported, studies on soybeans at the United States Department of Agriculture (USDA) have shown increases in the iron content in the oil from damaged soybeans as well as increases in peroxide value.

Both iron content and peroxide value are associated with the deveopment of oxidative rancidity. Studies from Sweden have shown that broken seeds not only have a higher chlorophyll and free fatty acid content but that the free fatty acid content of broken seed increases rapidly on storage.

Heated Seeds

Heated seeds can be divided into two types—those that are damaged through "bin-heating" (i.e. microbial action or respiration) and those that are damaged while being artificially dried. Bin-heated seeds generally impart an unfavorable odor and color to the oil which is difficult to remove. Free fatty acids drastically increase in heated seeds (Table VIII) whereas the protein quality is decreased due to the loss of amino acids such as lysine in browning reactions. The presence of mold on seeds also involves a risk of mycotoxicity and any moldy seed serves as a source of infection for other seeds.

Damage through overheating during drying operations is less common and is usually more difficult to detect. If the damage is so severe as to involve browning, then damage to the oil and protein will be similar to that observed in "bin-heating." If the damage is only severe enough to involve a loss in germination, then the storageability of the seed may be affected. Studies in the USA and Sweden (18,19) have shown that seeds with reduced viability increase in free fatty acid content and peroxide value more rapidly than sound seeds. In general, if the seeds are processed within about six months, there is no storage problem. Safe drying procedures result in no damage to seed quality.

Weathering

Weathering or field damage of soybeans has been studied extensively at the USDA (20). In general, it was found that weathered soybeans increased in free fatty acids and decreased in iodine value (unsaturation) possibly due to increases in peroxide value. Processing studies showed that field-damaged soybeans produced oils with poor flavor scores and increased nonhydratable phosphatides which made degumming difficult.

Weathering used to be considered a degrading factor in Canadian flaxseed (16,21). The type of damage most commonly observed involved a breakdown of the mucilage layer on the outer surface of the seed by water penetrating the boil. Sometimes septa from the boll will become glued to the seed coat. This causes a decrease in bushel weight.

Aside from a decrease in the mucilage content of the seed, no quality losses have been observed due to this type of damage in flax (Table X) although mucilage content may be related to the stability of meal/water slurries used for dairy cattle feeding. Because the laboratory testing showed that the quality of flaxseed was not reduced by weathering, this factor was removed from the Canadian specifications for grading of flaxseed.

TABLE X

Some Quality Characteristics of the 1977 Canadian Flaxseed Crop

	Grade		
	1 CW	2 CW	3 CW
Variable:			
Test wt. (kg/hL)	66.0	63.0	60.2
Scabbing[a] (%)	8.9	18.5	30.8
Oil content (%, dry basis)	44.7	44.2	44.8
Oil color index	6.9	7.8	10.4
Protein content (%, dry basis)	21.8	22.3	21.7
Suspension value (%)	92.7	81.5	68.6
Mucilage (%)	7.2	7.6	6.9

[a]Seed coat appears rough due to mucilage breakdown or adhered septa.

Admixture

The effect of admixture of stones, filth, dirt, etc. on material which is destined for grinding and for food use is obvious. Sclerotia bodies are particularly unwelcome in rapeseed since they contain active spores which are difficult to kill. Some countries, such as Japan, have essentially a "zero tolerance" for sclerotinia. Weed seeds also are deleterious to quality. Studies in Sweden (Table VIII) have shown that weed seeds have a lower oil content, but higher free fatty acid and chlorophyll content than sound rapeseed. Wild and domestic mustards, although containing significant quantities of oil, also contain erucic acid and glucosinolate, and lower erucic acid rapeseed may result in a lowering of the tolerance of mustard seed in inseparable admixtures.

FUTURE CHALLENGES FOR OILSEEDS GRADING

Changes in oilseeds grading systems over the next 10 years will probably be centered around the adoption of Near Infrared (NIR) technology for the handling of large numbers of samples, and the gradual elimination of many of the present visual grading assessments.

In the past, the application of NIR techniques to oilseeds has been hampered by the requirement to grind the sample to a uniform, fine texture. The difficulty in achieving this with high oil content seeds has been further complicated by the need to clean the glass cell with methanol between analyses. The adoption of nuclear magnetic resonance (NMR) for oil content analysis has relieved this problem partially, but NMR analyzers are expensive and inflexible.

Recent research has indicated that many of the problems associated with grinding may be avoided by NIR analyses of whole seed (22). This technique may be especially useful for solving the dilemma in rapeseed grading in which the correlation between percentage green seed estimation and actual chlorophyll in the seed has been poor. This discrepancy is most evident in samples where slight immaturity predominates. Initial studies of whole seed analysis using NIR technology (in the visible region) showed that this technique could possibly be useful for predicting seed chlorophyll in whole seed. However, variation in seed coat color and the presence of other seeds in commercial samples have made it necessary to grind seeds for practical applications.

A second problem in the future may be related to the differentiation of classes or varieties of oilseeds. In Canada, this problem is illustrated by the grain trade's demand for separation of rapeseed from canola. There is a rapid test procedure for doing this which estimates glucosinolate content by measuring glucose released by endogenous seed hydrolyses (23). This procedure is suitable for differentiating seed with very high levels of glucosinolates from seeds with low levels of glucosinolates. The procedure is not capable of differentiating between seeds with moderate levels of glucosinolates and seeds with low levels of glucosinolates because of relatively large errors caused by the presence of endogenous glucose and glucosinolates (both in the pure rapeseed and in admixed weed seeds) which are not implied in the definition of canola. The method might be useful for segregation at country delivery points since farm samples are likely to be relatively pure in variety. This procedure is not sufficiently reliable, however, to use at official grading points. A rapid (2-3 min) procedure for differentiating accurately between canola and rapeseed is required before grades for canola seed can be established. There have been no reliable visible seed markers incorporated by breeders to date for varietal identification, in rapeseed, flax, soybeans or sunflowers.

Oilseed grading will likely continue to be highly subjective for some time. It will take several years before developments in technology are inexpensive, accurate, or rapid enough to meet the demands of an improved grading and handling system. Research is still required to relate visual degrading factors to end-use quality in order that both the buyer and seller of the seed can evaluate its worth.

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