Assessing Federal Grade Criteria for Fruits and Vegetables: Should Nutrient Attributes Be Incorporated?

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The U.S. Department of Agriculture (USDA) has a long-established system for fruit and vegetable grades (USDA, Agriculture Marketing Service (AMS) 1990). A primary purpose of federal commodity grades is to facilitate the wholesale exchange by allowing sale by description rather than by inspection (Office of Technology Assessment 1977). Consequently, buyers and sellers can consummate transactions without the time and expense necessary to physically congregate in one location to inspect the commodity being sold. The result is lower transaction costs, which in turn can mean lower prices for consumers and/or higher prices for producers.

Current grade standards for fruits and vegetables use attributes based on sensory characteristics,[2] shelf-life considerations, palatability, or a combination of these factors. During recent years "health consciousness" has increased among consumers. Furthermore, a growing number of studies has demonstrated health benefits from various nutrients contained in relatively large amounts in fruits and vegetables (e.g., *Consumer Reports* 1992, p. 648). Consequently, questions arise about the feasibility and desirability of incorporating nutrient attributes into current standards or replacing the current sensory-based standards with nutrient-based standards. These possibilities provide the impetus and focus for this research.[3]

Initially, we focus on the economic function and consequences of commodity grades and describe the current federal grading system for fruits and vegetables. From this description, we generate some generic components of the current federal grade standards and discuss the potential for adding nutrient attributes and the relationship between sensory and nutrient attributes. We conclude by evaluating the feasibility of a nutrient-based grading standard for fruits and vegetables.

The Economic Function and Consequences of Grades

Fruits and vegetables, like most farm commodities, exhibit a wide array of quality attributes. An important function of the grading system is the "grouping of continuous quality gradations of a commodity into a few grades or classes" (Rhodes 1988). If the resulting differentiation of the commodity communicates relevant information about quality attributes important to market participants, then the grading system will allow wholesalers, retailers, and others to exchange commodities on the basis of description rather than personal inspection. As a consequence, transaction costs are lowered, and overall marketing efficiency is enhanced (Farris 1960). In addition, federal grades also are thought to improve public price reporting (Henderson et al. 1983).

Once a commodity is sorted into a few grades, each grade can command a price based on its quality attributes. Thus, producers receive price signals through the market about what to produce—i.e., the quality attributes which maximize their

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[2]Those affecting consumers' senses, such as touch, sight, and taste.

[3]Given consumer concerns about pesticides in food, a similar question has been raised about incorporating chemicals in grade standards. This matter is discussed in the appendix to this paper.

returns. Also, grades can potentially affect the geographic distribution of production (Nichols et al. 1983).

Critics of the current grading system often argue that it does not capture the quality attributes which are the most relevant to buyers, particularly consumers. Some are excluded because they are difficult to measure and/or transmit through marketing channels. Moreover, Rhodes and Kiehl (1956) observe that the great differences among consumers make it difficult to establish homogenous grade categories. In short, a grading system must compromise between being easily understood by market participants, on the one hand, and capturing the complexity and diversity of consumer demand, on the other. However, Padberg (1977) argues that a grading system can have value even if it is not well understood and used by consumers in making purchasing decisions, for the mere existence of grades can reassure consumers that a government agency is monitoring product quality.

Current Federal Grades for Fruits and Vegetables

Current grade standards for fruits and vegetables are administered by USDA under authority of the Agricultural Marketing Act of 1946. One hundred fifty-eight grade standards cover 85 fresh fruit, vegetable, nut, and related commodities, while 155 grade standards cover 74 processed fruits, vegetables and related commodities. The grade standards for fruits, and vegetables can be grouped as follows:[4]

Fruits for Fresh Market:	#
Wholesale Market	29
Raw Products for Processing	15
Fruits for Processing	15
Canned Fruits	36
Dried and Dehydrated Fruits	14
Frozen Fruits	21
Vegetables for Fresh Market:	
Wholesale Market	58
Consumer Retail Market	12
Vegetables for Processing	24
Canned Vegetables	39
Frozen Vegetables	26

Although the dates when the current grade standards became effective vary widely, a majority for fresh fruit and vegetables were before 1960, while those for processed fruit and vegetables generally are of more recent vintage.

Grading factors listed in standards for fresh and processed fruits and vegetables can be broadly divided into four main categories: size, quality, condition, and tolerances. Size can be described by diameter, length, weight, and uniformity of sizing (USDA, AMS 1988). Quality factors, defined as "the combination of the inherent properties or attributes of a product which determines its relative degree of excellence" (Harl 1990), generally refer to attributes that remain permanent once the commodity is harvested or processed. Examples include variety, cleanliness, and shape for fresh fruits and vegetables; and color, clarity, and flavor and aroma for processed fruits and vegetables.

Condition refers to: "the relative degree of soundness of a product which may affect its merchantability and includes those factors which are subject to change and may result from but not necessarily limited to age, improper handling, storage or lack of refrigeration. . ." (*Code of Federal Regulation* 1990). In contrast to quality factors, condition factors can change once the commodity is harvested or processed.

Tolerances are legal limits on unacceptable size, quality, and condition grading factors. They generally are stated in percentage terms and can vary by product, use, or size of the individually packaged product. For example, the tolerances for U.S. Number 1 apples for processing illustrate

[4]A complete listing of the fruit and vegetable grades is contained in the Office of Technology Assessment report, *Assessing Federal Grade Criteria for Fruits and Vegetables*, 1992.

the variety of forms that tolerances can take: (1) no more than 10 percent of apples with quality and condition defects including no more than 2 percent of apples with decay, 2 percent with internal breakdown and 5 percent with wormholes, and (2) the apples cannot be further advanced in maturity than generally firm ripe (*Code of Federal Regulation*, Part 7, Sections 51.300 to 51.349, 1990).

Unlike fresh fruits and vegetables, tolerances for processed commodities usually are stated in terms of a grade score for the attribute, based on an assessment of the degree to which the attribute is present. The higher the score, the better the grade. A minimum score exists for each grade. Any commodity failing to meet the minimum requirement of the lowest grade becomes part of the "substandard" grade. As examples of the scoring system, good color and clarity of U.S. Grade A frozen concentrated apple juice must have a score of 18 to 20, while U.S. Grade A canned orange juice must have a minimum total score of 90 (*Code of Federal Regulation*, Part 7, Sections 52.1551 to 52.1557 and 52.6321 to 52.6332, 1990).

Size, quality, and condition grading factors have three elements in common: (1) they are measurable or observable, (2) there is a common body of knowledge which allows a widespread acceptance of how the factor will be applied in determining the grade, and (3) the factor varies among individual specimens of the commodity. The existence of tolerances reflects this variability by allowing a sample to obtain a given grade even though all specimens in the sample do not meet minimum quality, condition, and size.

Nutrient Attributes and Federal Grades

The idea that federal grade standards might be based on nutrient attributes is not new. The Office of Technology Assessment released a report in 1977 that addressed this issue across a broad array of food items. Necessary conditions for nutrition to be included in grades are the three common elements shared by size, quality, and condition factors in the current grading standards: (1) measurability, (2) a body of information which provides a reference point in setting the grade, and (3) variability among individual specimens of the commodity. Each of these three necessary conditions is discussed below.

Assessment of Current Techniques and Methods for Measuring Nutrient Attributes

Besides water, fruits and vegetables usually contain significant amounts of most or all types of carbohydrates, such as sugars, starches, and fiber. They also contain vitamins (notably A and C) and smaller, but not nutritionally insignificant, amounts of minerals and protein.[5] Specific methods of analysis exist for each nutrient category but with varying degrees of accuracy, simplicity, and cost.

Beecher and Vanderslice (1983) have categorized methods of nutrient analysis as adequate, substantial, conflicting, or lacking (Table 1). They argue that "the boundary between acceptable and unacceptable methods lies between substantial and conflicting states of methodology" (p. 42). Adequate and substantial methodologies have an "analytical value within 10 percent of a true value when a nutrient is present in food at a nutritionally significant level, defined as greater than 5 percent of the RDA per standard serving or daily intake, whichever is greater" (p. 42). It is doubtful that conflicting and lacking states of methodologies can render valid results under conditions of routine analysis.

A general cost figure for nutritional analysis of fruits and vegetables is in the

[5]A few commodities, such as avocados and olives, have fat as a major component. In addition, fats are very important in treenuts, often listed among fruit commodities.

Table 1. State of Development of Methods for Analysis of Nutrients in Foods

Nutrient Category	State of Methodology[a] Adequate:	Substantial:	Conflicting:	Lacking:
Carbohydrates, fiber and sugars Energy		Individual sugars	Fiber Starch food energy	
Lipids		Cholesterol Fat (total) Fatty acids (common)	Sterols Fatty acids (isomeric)	
Minerals/inorganic nutrients	Calcium Copper Phosphorous Potassium Sodium Zinc Magnesium	Iron (total) Selenium	Arsenic Chromium Fluorine Manganese Iodine	Cobalt Heme-iron Molybdenum Nonheme iron Silicon Tin Vanadium
Proteins and amino acids	Nitrogen (total)	Amino acids (most)	Amino acids (some) Protein (total)	
Vitamins		Niacin Riboflavin Thiamin Vitamin B6	Vitamin A Carotenes Vitamin B12 Vitamin C Vitamin C Vitamin E Folacin Pantothenic acid	

[a]*Adequate* and *substantial* methodologies will have analytical values that are within 10% of true values for foods when the nutrient of interest is present at nutritionally significant levels (greater than 5% of the RDA per standard serving or daily intake, whichever is greater). *Conflicting* and *lacking* methodologies can occur for some nutrient categories for the following reasons: (1) methods lack specificity because some nutrient components have closely related molecular structures or (2) some methods lack sensitivity.

Source: Beecher and Vanderslice 1983, p. 43.

area of $10-15 per simple item, such as sugars, minerals, and vitamins, according to the publicly-available laboratories at The Ohio State University and its Extension Service. Such costs might be higher at private for-profit labs. Additionally, items difficult to assay or which exist in minute quantities in fruit and vegetable samples might require more elaborate testing and therefore be more expensive. For example, a complete amino acid analysis for protein costs about $300.

Technological advances are improving the ability to accurately and expeditiously measure nutrients. An example is flow injection chromatography (Stewart 1983) that permits numerous rapid sequential analyses and is appropriate for constituents other than proteins, including vitamins and carbohydrates. Advances in computer technology also point toward further miniaturization of techniques as well as improved speed and accuracy.

State of Knowledge Regarding Nutrient Value of Fruits and Vegetables

Beecher and Vanderslice's (1983) survey suggests that, while much is known about the nutrient value of fruits and vegetables, inadequate, little, or no data exist for nine nutritional components of fresh fruits, 14 nutritional components of frozen or canned fruits, 18 nutritional components of fresh vegetables, and 12 nutritional components of frozen and canned vegetables (Table 2). The lack of adequate information is due in part to the minute quantities of some nutritional components in fruits and vegetables. In addition, data are sometimes lacking as to the exact nature of these components' contribution to human nutrition. For example, the fat soluble vitamins (A, D, E, and K) can be accurately assayed and quantified in most samples.

Table 2. Knowledge of Nutrient Composition of Fresh Fruits, Frozen and Canned Fruit, Fresh Vegetables, and Frozen and Canned Vegetables

Nutritional component	Fresh fruits	Frozen and canned fruit	Fresh vegetables	Frozen and canned vegetables
Individual Sugars	S	I	I	I
Starch	I	I	S	I
Nutrient Fiber	I	I	I	I
Total Fat	S	S	I	S
Fatty Acids	I	I	I	I
Sterols	I	I	I	I
Calcium	S	S	I	S
Iron	S	S	I	S
Phosphorous	S	S	I	S
Sodium	S	S	I	S
Magnesium	S	S	I	S
Potassium	S	S	I	S
Zinc	S	I	I	S
Total Protein	S	S	S	S
Individual Amino Acids	I	I	S	I
Folacin	I	I	I	I
Vitamin D	NA	NA	NA	NA
Vitamin E	S	I	I	I
Biotin	I	I	I	I
Choline	I	I	I	I
Pantothenic Acid	I	I	I	I
Vitamin A	S	I	S	S
Vitamin B1 (Thiamin)	S	S	S	S
Vitamin B2 (Riboflavin)	S	S	S	S
Vitamin B6	S	I	I	I
Vitamin B12	NA	NA	NA	NA
Vitamin C	S	S	S	S
Niacin	S	S	S	S

Key code: S - substantial data, I - inadequate, little, or no data, and NA - not applicable.

Source: Beecher and Vanderslice 1983, pp. 34-41; prepared from USDA, Nutrient Data Research Branch, Consumer Nutrition Division of the Human Nutrition Information Service research publications.

However, quantities of these vitamins may be present in bound form or other forms not utilizable or under-utilized in human physiological processes. Besides these considerations, additional research on the nutrition of fruits and vegetables is needed before all nutrient attributes can be included in a grading standard.

Variation in Nutrient Attributes

To examine whether the nutrient attributes vary among individual specimens of a fruit or vegetable, we selected for special study apples, oranges, potatoes, and tomatoes—commodities that represent a wide variety of grade standards and have relatively high per capita consumption in today's food markets. Annual per capita consumption of these four commodities ranges from about 15 pounds for oranges to over 127 pounds for potatoes (USDA 1993). We examined the *International Food Science and Technology Abstracts* for the past 10 years. This reference, a comprehensive source of international research, abstracts hundreds of academic journals, books, technical and trade publications from all subject areas related to plants, food, and human nutrition, including such diverse areas as cellular biochemistry, nutrition, plant genetics and public policy.

The review found that the nutritive composition of apples, oranges, potatoes, and tomatoes varies, depending on climate, geographic location, cultivar, soil variables, irrigation practices, fertilization practices, seasonal and annual factors. Furthermore, the complicated area of post-harvest physiology and handling introduces additional sources of variation in nutritional composition.[6]

[6]A complete annotated listing of the literature reviewed is presented in the Office of Technology Assessment Report, *Assessing Federal Grade Criteria for Fruits and Vegetables*, 1992.

Interrelationship of Nutrient and Sensory Attributes

A related consideration is whether sensory attributes also convey information about nutrient attributes. To examine this possibility, we constructed a matrix relating current sensory grade criteria to nutrient attributes (Table 3). Columns in this matrix are various nutrient attributes; rows are the current grade criteria (quality, condition, and size) generalized across all fruits and vegetables. Quality criteria commonly involve maturity, cleanness, shape and form, color, and quality defects; while condition criteria usually cover firmness, condition defects, and ground color.

Not all cells of the matrix are expected to be of equal relevance. Furthermore, if a nutrient standard is adopted, *all* the nutrient criteria in the columns would not necessarily be included in the standard. There are no compelling reasons to exclude cells formed by the matrix from examination, except for those involving cleanness and shape/form. These two current sensory grade criteria are not related to nutrition attributes; therefore, they are shaded to indicate no correlation is expected.

Each of the remaining 117 cells, in effect, defines a specific topic where knowledge from scientific journals could exist. Again, we reviewed the scientific literature, using the past 10 years of the *International Food Science and Technology Abstracts*, for relevant literature. Results of this review are summarized in Table 3. A letter for each of the investigated commodities (A for apples, O for oranges, P for potatoes, and T for tomatoes) is placed in a cell if information existed about the nutrient-sensory interaction. At least one research article exists for only 8 percent of a total of 468 cells (117 for each commodity). The inevitable conclusion is that much is unknown about the interrelationship between sensory and nutrition-related attributes. However, this conclusion is not

Table 3. Summary Table of Scientific Literature on the Relationship Between Sensory and Nutrient Attributes for Apples, Oranges, Potatoes, and Tomatoes

Current Grade Criteria, Generalized Across All Fruits & Vegetables[a]	Nutrient Attributes								
	Vitamins	Minerals	Calories	Enzymes & Proteins	Carbo-hydrates	Oils & Fats	Sodium	Calcium	Fiber
Quality									
Maturity	A, O, P, T	A, O, P, T	T	O	A, O, P, T	O, T		A, O, T	A, T
Cleanness									
Shape/Form									
Color									
Quality Defects									
Fungus Injury									
Insect Injury									
Mechanical Injury					P				
Other[b]									
Condition									
Firmness									A, T
Condition Defects									
Decay	O				O			A	
Bruising	P								
Freezing	P, T				P	T			
Discoloration									
Ground Color/Color									
Size					P				

Key Code: A = apples, O = oranges, P = potatoes, T = tomatoes

[a] This list contains the criteria that *predominate* across all fruits and vegetables. Other criteria are specific to an individual fruit or vegetable. Their omission has little consequence for the present assessment.

[b] Other is defined as ill-shaped, undesirable color, sunburn, growth cracks, and/or dirt.

unexpected because the linkage between nutrient content and quality and morphological considerations is a relatively new research area.

Nevertheless, there are some relationships to note. The relationships between maturity and nutrition, especially vitamin C and carbohydrates, have been most researched. The more mature the potatoes or tomatoes, the greater the concentration of vitamin C. In contrast, vitamin C decreases dramatically in oranges and potatoes the longer these commodities are held in storage. Carbohydrates in apples and tomatoes are positively related to maturity. In potatoes, starch is more readily converted to sugars after harvest. Conversely, oranges show a decrease in glucose and fructose during storage as they do when in a decaying state.[7]

Many of the articles reviewed address post-harvest changes—changes not related to maturity but illustrating the importance of post-harvest storage and handling techniques to the nutritional value derived by consumers.

This analysis has *not* extrapolated across cells, even though it could be reasonable to do so. For example, research shows that maturity generally positively correlates with vitamin content. Because firmness and color (e.g., in tomatoes, a deeper red color) increase with maturity, the considerable research findings concerning maturity could probably be extrapolated to firmness and color.

Evaluation and Conclusions

This manuscript has evaluated the potential for shifting from the current sensory based federal grading standard for fruits and vegetables to one based on nutrient attributes. The evaluation of this policy change focused on three necessary conditions that an attribute must meet in order to be included in a grade standard: (1) measurability, (2) a body of information which provides a reference point in setting the grade, and (3) variability among individual specimens of the commodity.

Cost effective and timely measurement of the nutrient attributes of fruits and vegetables is available only for some nutrients; likewise, adequate information is available only for some of these nutrients. In contrast, nutrient attributes vary among specimens of a given fruit and vegetable. Thus, only one of the three necessary conditions for the use of nutrients in a grading standard is unequivocally met. Consequently, a shift from the current sensory standards to one based on nutrient attributes does not appear to be economically feasible at present for many nutrients, and for some nutrients measurement is not even physically possible.

Another consideration, however, is the role of public policy in "signaling." This role recognizes that numerous real-world scenarios produce statistically indistinguishable outcomes with respect to the traditional concerns of economic policy: efficiency, equity, market power, and market failure. In its signaling role, government aggregates concerns through the political process, then signals the private sector how the public would like the private sector to "act" or "allocate resources" within the set of feasible outcomes. Should the private sector respond satisfactorily, the public sector would not impose regulations or codes of conduct.

Current federal grades perform a signaling function by indicating to the private sector that consumers value sensory attributes of fruits and vegetables. Economic arguments, as well as empirical and anecdotal evidence suggest that sensory-based grades have caused private resources to be allocated so as to assure consumers

[7]A complete annotated listing of the literature reviewed is presented in the Office of Technology Assessment Report, *Assessing Federal Grade Criteria for Fruits and Vegetables*, 1992.

that these attributes are attained. Thus, it could be argued that nutrients should be included in grading standards for fruits and vegetables because they signal the private sector to devote more resources to monitoring and improving the nutritional value of fruits and vegetables in particular, as well as the nutritional value of food in general. Furthermore, by creating grades based on nutrient levels, the grading system could allow consumers to express their desires through premiums and discounts for various nutrient levels. Based on existing scientific information, improved quality of life and lower medical costs could be generated by including nutrients in current grades. These positive externalities may be large enough to justify the transition costs involved in including nutrient attributes in fruit and vegetable grades, especially in a policy environment where public health care is a top priority.[8]

Thus, a feasible policy option would be to conduct a pilot study of incorporating certain nutrients into grade standards for selected fruits and vegetables. These nutrients should meet the necessary conditions discussed above.

Another feasible policy option is to increase funding for studies to investigate the link between current sensory attributes and nutrient attributes, an emerging research area holding some promise. If sufficient links are found, the current sensory standards might be used to provide nutrient information.

[8]Health professionals often point out that the only relevant link is between diet and health, not between consumption of one food and health. Diet includes all foods consumed and is important because of significant known interactions among foods. This observation tempers the value of nutrient information about an individual food, but it does not negate the signaling value of including nutrients in grading standards for fruits and vegetables.

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Appendix: Chemical Residues and Federal Grades

In response to consumer concerns about pesticide "contamination" of food, the possibility of incorporating chemical attributes into grades has been raised. However, facts do not lend much support for the current degree of concern. For example, in 1989, the state of California sampled 9,403 food samples for pesticide residues and found (Parnell 1990):

No detectable residues	77.9% of the samples
Residues less than 10% of tolerance level	13.0% of the samples
Residues between 10% and 50% of tolerance	7.4% of the samples
Residues from 50% to 100% of tolerance	1.0% of the samples
Exceeded tolerance level	0.7% of the samples

The objective of implementing a chemical residue standard would be to allow consumer choice among various levels of "safe for human consumption residue" at alternative prices. However, including chemical residues in a grading system mixes aspects of food safety with aspects of food quality. This "mixing" markedly differs from the existing grading system, which essentially assigns grades only to food determined to be safe for human consumption (Sporleder et al. 1983). Thus, the chances are probably high for consumer misinformation from incorporating chemical residues into a grading system; therefore, a chemical residue base for grading standards is unlikely to be viable.

Besides, the continued presence of a given pesticide residue on food is likely to be associated with other environmental problems, especially in the farm production environment. Hence, a more appropriate policy response would probably be to restrict the use or pull the registration of a pesticide that continually leaves residues on food.

Meyer: Zulauf and Sporleder expanded Jones' ideas of differentiation by considering the nutrient content of fruits and vegetables as grading criteria. The critical role of measurement technology was underscored by their conclusion that timely determination of nutrient content was not available for most fruits and vegetables today. I have no doubt that it some day will be. Their discussion also dealt with "residue-free" produce and its market potential. But, they failed to deal with the most perplexing part of this question: If a portion of production is marketed as residue-free, what does that imply about the remainder? And, if the implication is negative, is there enough residue-free product being marketed to leave consumers unconcerned about the portion viewed as "contaminated"?

Jim Shaffer, Michigan State: I'm interested in the organic labeling problem. Is there any objective way of telling what's organic, or do you have to go out and watch it being produced? I saw in a store recently some "organically produced" pork and wondered what that means. Do you have an inspection service that goes out and watches crops or animals grow?

Clayton: Julie Anton, AMS, is directly involved in developing standards for organics. We expect the program, authorized in the 1990 farm bill, to be coming on line this year. We have an advisory group representing a range of interests. The concept is that there will be standards in place that go back all the way to the production level. For example, the well water on the farm will be checked.

Extensive record keeping will be required. And there will be certifiers out in the field. The federal role will be to assure that the standards are there, certifiers are audited, and some overall integrity is provided to the program.

There are still a lot of questions. Like with livestock, how far back do you take it? There will be a hearing on livestock standards next week in Washington. There are labeling issues with the Food Safety and Inspection Service. It also has international implications. The European Community has a directive that has diverse requirements for organic which make it difficult for us to get organic into the EC. There are international organic organizations that do their own certification activities.

Grading Systems in the Pork and Beef Industries

Marvin Hayenga and James Kliebenstein[1]

Government commodity grading systems have a long and sometimes controversial history in the livestock and meat industry. Historically, the only way to develop standard procedures for a very independent and fragmented group of producers and processors has been to utilize the auspices of government. Originally, the primary reason for government grading systems was to facilitate (1) more accurate identification of value-related differences in commodities being marketed for both buyers and sellers, (2) an improved competitive process, and (3) improved resource allocation (producing the "right" products) in the industry.

The government grading system in the beef industry has been a frequent subject of controversy and, infrequently, changed in the last 30 years, while the pork government grading system has fallen into disuse. In this paper, we focus primarily on the pork industry grading system, its history, alternative criteria and grading approaches, and offer some recommendations. Then we discuss some related issues regarding the beef grading system and consider possible changes.

[1]This paper draws extensively from "The Pork Grading System" in *A New Technological Era in Agriculture*, published by the Office of Technology Assessment. See that report for detailed references omitted in this paper. We received valuable comments from R. G. Kauffman on an earlier draft of this paper.

Question: Why not let the beef industry develop private standards the way the pork industry did?

Response: That would be throwing the baby out with the bath. There's a lot of investment in the system, so it would be better to adjust the system rather than reinvent the wheel.

Question: Isn't there still a lot of consumer dissatisfaction with pork standards? Bacon, for example.

Response: The pork industry is moving rapidly toward being more responsive to consumer demand.

Grading System Objectives[2]

The objective of commodity grading systems is to sort a population with heterogeneous characteristics with some economic importance for commodity users, into lots with more uniform or homogeneous characteristics. A desirable grading system should increase product uniformity, reduce the perceived risk of commodity users in purchasing a particular grade of a product, and facilitate purchases on the basis of description rather than personal observation or testing. Grades can serve as the basis for determining product prices in line with product value. A more accurate and equitable pricing system can

[2]For an excellent discussion of the economics of grades, see Nichols, Hill and Nelson (1983) and Bockstael (1987).