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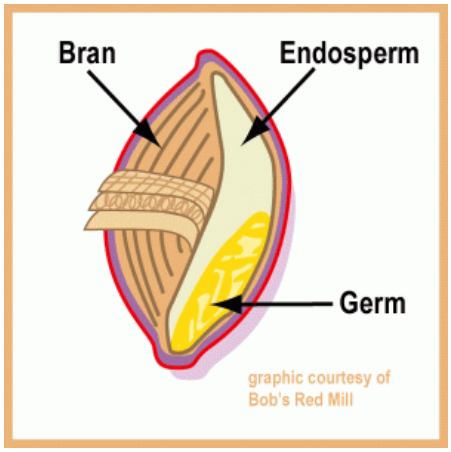
Sorghum (*Sorghum vulgare*, L.) Marketability
Grain Color and Relationship to Feed Value

Red (left) and white (right) sorghum varieties in a variety trial at Newsoms, VA, in 2012

Sorghum varieties come in a wide range of colors described as white, cream, yellow, orange, bronze, red, brown, and various combinations of these colors. The sorghum kernel has three distinct parts, the pericarp or bran at the outside, the germ or embryo, and the endosperm or storage tissue (Fig. 1).



In general, the endosperm represents 85% of the whole grain, the germ 9%, and the pericarp only 6% (Haikerwal and Mathienson, 1971). Some varieties have a thin layer of cells underneath the pericarp called testa. This layer may contain tannins, which are phenolic compounds similar with those in fruits and red wine. The pericarp can be white, red, or yellow, and the endosperm can be white or yellow. Pericarp thickness can vary from very thin (8 µm) to very thick (160 µm). Pericarp color and thickness, endosperm color, and presence or absence of testa determines the grain color (Rooney and Miller, 1981). In addition, two other genes are involved in grain color in sorghum, the 'intensifier gene' and the 'spreader gene'. Usually, sorghum high in tannin content is brown but may also be white, yellow-pink, orange, red, or bronze. For example, in the absence of the 'spreader gene' some high tannin hybrids with white pericarp may appear white.

Figure 1. Schematic representation of a sorghum kernel including the pericarp (bran), the germ (embryo), and the endosperm (storage tissue)

This is because the testa layer is masked. Inversely, in the presence of the 'spreader gene' some hybrids with thick red pericarp may appear brown even though they do not have tannins. High tannin hybrids are often called bird resistant hybrids because birds do not prefer them; these hybrids represent less than 2% of the total sorghum production in the United States.

Sorghum grain has 95 to 98% of the nutritional value of corn. Vitamin content is similar for corn and sorghum but sorghum has higher content of minerals than corn. Sorghum is used as a carbohydrate (energy) source with protein supplemented from alfalfa and soybean meal in ruminant animals such as cattle, sheep, and goats. For non-ruminant animals such as swine, poultry, and fish, sorghum is used based on dietary formulas. For example, sorghum may supply up to ⅓ for chickens and ⅓ for pigs of their dietary protein.

Factors that do not influence feeding value are pericarp thickness and grain color. Pericarp represents a small proportion of the sorghum kernel and the available nutrients. For example, in the pericarp total protein is 4%, fat approximately 11%, and starch 4% (Taylor and Schussler, 1986). Pericarp can affect feeding value only if the tannin content in the testa is high. As previously discussed, grain color is not related to the tannin content therefore it does not influence the feeding value (Sulivan and Douglas, 1989).

Factors that influence feeding value are endosperm type and texture, starch and protein digestibility, tannin content, test weight, growth environment, and processing methods. Hybrids with waxy endosperm (100% amylopectin) are more digestible than those with normal endosperm (25% amylose and 75% amylopectin). Unfortunately, only very few waxy hybrids are available because of their inferior agronomic characteristics in comparison with non-waxy sorghums (Lichtenwalner et al., 1978). Among the hybrids with non-waxy endosperm, those with intermediate texture outperformed the hard-corneous or soft-floury hybrids based on swine performance (Hancock and Bramel-Cox, 1992). Sorghum has lower protein and starch digestibility than corn. This is because of the structure of the starch granules and the protein matrix the starch is embedded in. However, through proper processing this problem can be overcome. Tannins have a negative effect on weight gain for poultry and swine primarily through binding the protein and making it indigestible (Butler, 1978). This problem can be reduced through supplementing the diet with additional protein. Tannins effect is not as detrimental for ruminants as it is for non-ruminant animals. It has been shown that sorghum grains with low test weight have a negative effect on the daily weight gains of chickens and swine, but sheep and cattle are not affected (Hancock and Bramel-Cox, 1992). It is well documented that the growth environment may affect the nutritional value of sorghum. For example under drought, the endosperm may become shrunken while the protein and tannin content increase (Luce *et* al., 1988). However a strong variety by environment interaction was observed, which points out that variety testing needs to be performed within each environment where sorghum will be grown. Finally, feeding value can be increased by post-harvest processing methods such as grinding, rolling, steam flaking or extruding. It appears that poultry and swine respond better to grinding, as stem flaking may be better suited for beef and dairy cattle (Hancock and Bramel-Cox, 1992).

Grading Grain Sorghum

Classes of grain sorghum defined by the Federal Grain Inspection Service (FGIS):

1. Sorghum – Sorghum in this class is low in tannin due to absence of testa, contains less than 98% white sorghum, and no more than 3% tannin sorghum. Color of the pericarp could be white, yellow, pink, orange, red or bronze.
2. Tannin Sorghum – Sorghum in this class has high tannin content and contains no more than 10% non-tannin sorghum. Color of the pericarp is usually brown, but it also could be white, yellow-pink, orange, red or bronze.
3. White Sorghum – Sorghum in this class is low in tannin with no more than 2% sorghum of other classes. Pericarp is white and includes sorghum with spots covering less than 25% of the kernel.
4. Mixed Sorghum – Sorghum not meeting requirements of any of the classes described above.

Grading factors for sorghum defined by FGIS are test weight, percent of damaged kernels, percent of broken kernels, foreign material, and the number of non-sorghum seeds including weed seed and other foreign particles (Table 1).

Table 1. Grades and grade requirements for sorghum.

Grading factors	Grades U. S. Nos. [1/]			
	1	2	3	4
Minimum pound limits of				
Test weight per bushel:	57.0	55.0	53.0	51.0
Maximum percent limits of				
Damaged kernels:				
Heat (part of total)	0.2	0.5	1.0	3.0
Total	2.0	5.0	10.0	15.0
Broken kernels and foreign material:				
Foreign material (part of total)	1.0	2.0	3.0	4.0
Total	3.0	6.0	8.0	10.0
Maximum count limits of				
Other material:				
Animal filth	9	9	9	9
Castor beans	1	1	1	1
Crotalaria seeds	2	2	2	2
Glass	1	1	1	1
Stone [2/]	7	7	7	7
Unknown foreign substance	3	3	3	3
Cockleburs	7	7	7	7
Total [3/]	10	10	10	10

[1/] Sorghum which is distinctively discolored shall not grade higher than U.S. No. 3.
[2/] Aggregate weight of stones must also exceed 0.2 percent of the sample weight.
[3/] Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, unknown foreign substances or cockleburs.
Source: Federal Grain Inspection Service, U. S. Department of Agriculture, 2008

Kernel discoloration due to head and grain mold and damage by worm and birds can result in significant down-grading of the grain sorghum.

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