PHYSICAL ANALYSIS IN WHEAT GRAIN

Composition of wheat kernel

Wheat quality can be defined in terms of physical characteristics of the kernel including size, weight, and hardness (physical) and intrinsic properties such as protein contents and quality.

Wheat Kernel Quality:

1. Hectoliter Weight or Test Weight
2. Vitreous Kernel Content
3. Weight per 1000 Kernels
4. Kernel Size
5. Kernel Damage
6. Shrunken and Broken Kernels
7. Foreign Material
8. Protein Content
9. Falling Number
10. Moisture
11. Grade

Wheat grains include water, carbohydrates, protein, fat, cellulose, minerals, enzymes and vitamins. The amount of these substances in the grain of wheat varies according to the variety and the region in which it grows. On average, the amounts of these substances are as follows:

Table 1: Chemical Compositions of wheat grain (Belderok et al., 2000)

	Whole grain	Mealy endosperm	Bran	Germ
Proteins	16	13	16	22
Fats	2	1.5	5	7
Carbohydrates	68	82	16	40
Dietary fibers	11	1.5	53	25
Minerals (ash)	1.8	0.5	7.2	4.5
Other components	1.2	1.5	2.8	1.5
Total	100	100	100	100

The moisture content of lots of commercial wheat may vary between 12 and 18%, depending on the weather during harvest.

Wheat is an important source of proteins since large amounts of wheat is often included in the diet, and wheat contains 8-20% proteins but generally wheat grains contain approximately 12% protein. This ratio varies according to the factors such as soil, climatic conditions and wheat varieties. Wheat proteins are classified into several groups on the basis of their solubility properties, genetic background and amino acid composition etc. The most well known classification system classifies the wheat proteins into albumins, globulins, gliadins and glutenins on the basis of solubility.

It is one of the important factors in determining the economic value of wheat grain. Wheat with high protein content has higher economic value because high protein, flour is preferred in bread making. It should be remembered that protein quality as well as protein quantity is an important factor in bread quality.

Table 1: Wheat proteins are classified into groups on the basis of their solubility (Hussain, 2009).

Proteins		**Soluble in**	**Location in**
Non-gluten protein	Albumins	Water	Embryo (metabolic proteins) and endosperm cells (cytoplasmic proteins)
	Globulins	Dilute salt solutions (0.5 M NaCl)	Embryo and aleurone layer (storage proteins) and endosperm cells (cytoplasmic proteins)
Gluten proteins	Gliadins	70-80% ethanol	Endosperm (storage proteins)
	Glutenins	Dilute acids or alkali solutions (0.05 M acetic acid)	

Starch is a major carbohydrate which found in wheat grain and present in its endosperm. Wheat grain contains about 63-66% of starch, figures being higher for soft wheats than for hard wheats. The major components of starch are amylose and amylopectin. The contents of amylose and amylopectin are significantly different among varieties of cereals. The ratio of amylose and amylopectin differs among starches. The level of amylose and amylopectin in wheat flour is 25–28 and 72–75%, respectively (Hussain, 2009).

Wheat grain lipid content is low; they contain healthy polyunsaturated fatty acids. They are sources of vitamins; vitamins B and E and mineral; selenium, zinc, copper. Phytic acid– found in bran chelates the minerals

Structure of wheat grain

Wheat grain is constituted by three distinct parts: the germ (embryo), the bran and the mealy endosperm. Wheat grains contain 2–3% germ, 13–17% bran and 80–85% mealy endosperm (all constituents converted to a dry matter basis). The outer layer of kernel is removed as "bran" during milling. Bran is rich in "cellulose", "hemi cellulose" and "lignin". "Endosperm" of the kernel is like an energy depot .Endosperm is generally composed of starch particles and cytoplasm. Germination of the grain is managed by embryo (germ) and also supplies energy. About 80% of the daily energy and protein demand of population is provided by cereal grains in Turkey.

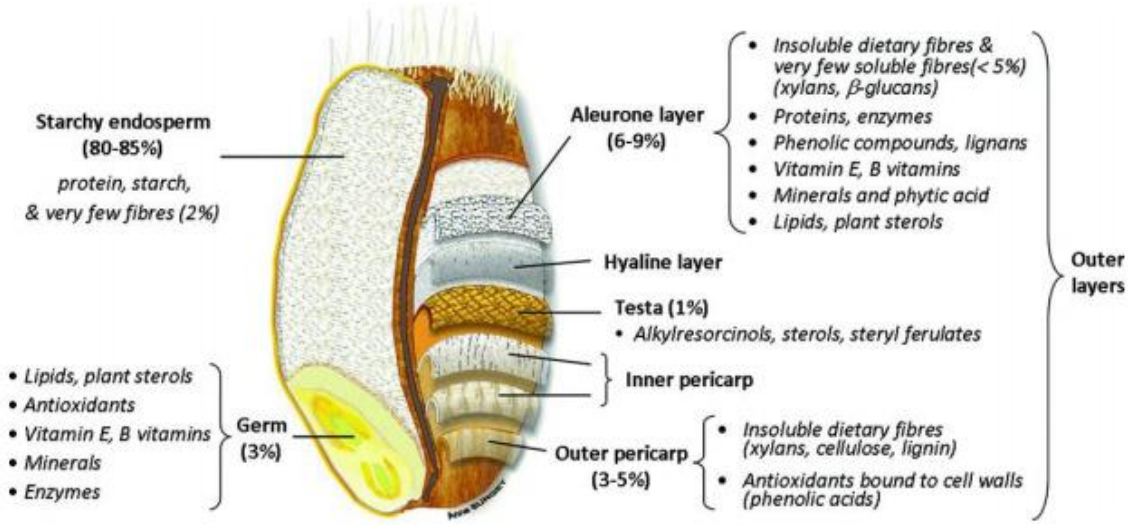


Figure 1: Wheat grain structure (Onipe et al., 2015)

Wheat Grain Quality Analysis

Foreign Matter Analysis

Foreign matter in wheat contains all the elements in the wheat sample except the main variety. These are organic and inorganic material other than wheat, broken kernels, other grains and filth. Organic matter is material of plant origin e.g. stalks, chaff, weed seeds, etc., while inorganic matter includes plastics, stones, glass, metals, etc. Foreign matter is a very important qualitative criteria for milling. Grains affected by diseases and pests before

harvesting reduce the yield of flour. In addition to the decrease in flour yield in frozen grains, ash content increases, and in grains stored in places with high moisture content, some problems are encountered. Some impurities adversely affect the storage stability; commercial value and flour yield of wheat and may be harmful to health. Moreover foreign materials such as metal, stone and sand damage the machines during grinding and cause dust explosion.

Procedure: Place a clean dry basin (Bottom Pan) in place to receive any materials that may go through the sieve. Weigh 200 grams of the representative sample. Put the Wheat in the sieve provided (1.6 mm slotted-hole sieve).Shake the sieve horizontally for 30 times for about 15 seconds. Collect all the foreign organic matter that has passed through the sieve. Weigh all the foreign matter collected from the bottom.

Foreign matter =	$\frac{Weight_2}{Weight_1} * 100$

Testing for Foreign Odour

Wheat should not contain any odours other than its own odour. Odours found in wheat can be grouped as follows:

Normal grain odor

- Fresh wheat smell
- Warehouse smell

Disordered grain smell

- Damp smell
- Mold smell

Foreign smells:

- Grass smell
- Gas
- Onion
- Garlic

Procedure: Determination of odour in wheat is done by two methods:

As the first method; obtain a representative sample. A handful of wheat is taken and a strong breath is given to the wheat in the hand, and then it is smell. The sensed odour is detected. If no odour is detected, return the sample into the container and seal it. The smell should be

typical of Wheat without other smells e.g. chemicals, mouldiness', earthy, rotten, musty smell, etc.

As the second method; put a small quantity of ground or un-ground wheat kernels in a container and pour some warm water (60 – 70 ˚C) (1:10 ratio) into the wheat and boiled and resulting steam is smell and note whether foreign odour is present.

Colour Analysis

Wheat comes in different colours: red, white, and amber. As the hardness of the grain increases, the colour darkens. Colour also varies according to nature conditions and harvest season. Improper storage conditions and diseases have a detrimental effect on color.

Figure 2: Colours of wheat

The colour determination is done by using the standard colour charts (scales). As the determination is subjective, the results differ slightly from the determinants.

Determination of Test Weight-Hectoliter Weight

Hectolitre mass, also referred to in some countries as bushel-, specific- test-, or hectolitre weight is the weight of a standard volume of grain and is generally believed to be a measure

of the bulk density and soundness of grain (Manley et al., 2009). It is one of the oldest specifications used in wheat grading and serves as a guide to a combination of characteristics. Hectoliter weight is an important indicator of the physical quality of wheat and has long been recognised as an indicator of the flour yield of wheat. An increase in hectolitre weight results in a higher allocated grade and subsequently in a higher price per ton of wheat unless other grade determining factors such as protein (in countries such as Australia and South Africa), weather or insect damage negatively impact the grade. The hectolitre weight values of sound wheat normally vary from 70 to 85 kg/hl , but can be higher or lower due to environmental conditions and insect damage. Several factors could influence the hectolitre weight value of wheat. The presence of impurities such as chaff or large weed seeds can lower the hectolitre weight value. This is the primary grading factor. It can also, in general, be an indicator of flour extraction rate. It is related with variety and environmental conditions. A high linear correlation coefficient was reported between test weight and flour yield in the range from 53 to 84 kg/hl. It is affected from the shape and uniformity of the kernel. Hectoliter weight is changing according to biological structure, moisture content and chemical composition. Hectoliter weight of Turkish wheat is between 72-83 kg/hl. The average is 78 kg/hl.

Table 1 – Illustration and a short description of the respective HLM devices

	Country	Description of HLM devices
	**Australia**	Aluminium 500 ml measure with filler and cutter bar.
	**Canada**	Ohaus 500 ml measure with Cox Funnel and round wooden striker. 500 ml measure supplied with certificate of calibration (calibrations performed traceable to national standard).
	**France**	Niléma Litre with filling hopper and cutter bar (1000 ml receiving cup). Designed in accordance with the AFNOR NF V 03-719 (1996) standard and standardised to a 50 l French reference.
	**Germany**	Kern 220/222 Grain Sampler with filler and cutter bar (1000 ml measuring cup). Compliant to ISO 7971-2:1995 standard.
	**South Africa**	South African two-level HLM device with funnel and 500 ml measuring container and wooden scraper.
	**United Kingdom**	Easi-Way Portable Hectolitre Test Weight Kit with cutter bar (500 ml measuring cup). Matched to EC 20 L volume (Directive 71/347/EC) and conforms to ISO 7971-2: 1995 and BS 4371 Part23 standards.
	**USA**	Seedburo 151 Filling Hopper with quart cup (1100 ml) and strike-off stick.

http://megep.meb.gov.tr/mte_program_modul/moduller_pdf/Un%20Ve%20Unlu%20Mamullerdeki%20Analizler%201.pdf

Thousand kernel weight

1,000 kernel weights is the weight in grams of 1,000 seeds. It will vary with seed. Some people regard this as a better indicator of flour extraction than test weight. Related to variety and environmental conditions. European prefer to use this criteria. The measurement of the thousand kernel weight includes weighing and counting the kernels. Weight data is obtained from scales and traditional methods based on manual counting are used to count the kernels. As manual counting is time-consuming and labor-intensive with subjective results, electronic counting devices are also commonly used. The ratio of endosperms of large and dense grains

to non-endosperms is higher than that of small grains. For same variety, a thousand grain weight is directly proportional to the amount of starch and inversely proportional to the amount of protein. It is important to give an idea about the grain size, fullness, ricidity and flour yield. It is generally higher in hard wheat. The weight of a thousand grains varies according to variety, climate and soil conditions. It is a healthy measure for estimating the flour yield of wheat grain.

Procedure:

- First, the impurities in the sample are removed.
- The weight of a thousand grains is then determined by counting 500 or 1000 grains and weighing weight of these 500 or 1000 grains or weighing 15 grams of grains and then counting them.

During analysis studied with at least three parallel and then the average of the parallel is taken. Calculation is done according to the following formula:

$$\boldsymbol{Thousand\ kernel\ weight} = \frac{\boldsymbol{Sample\ weight(g)}}{\boldsymbol{Number\ of\ counted\ grain}} \times \mathbf{1000}$$

It is stated that thousand kernel weight varies between 24-51 g for soft wheat and 26-58 g for hard wheat.

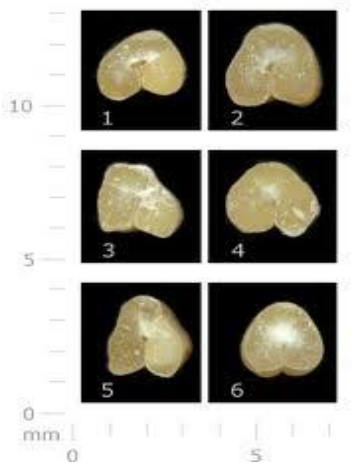
Grain hardness analysis

Grain hardness is important for the flour industry because it has significant impacts on milling, baking and qualities of wheat. The farmer generally makes more profit with harder textured wheat, due to the higher protein content. It is one of key determinant for classification of wheat and end product quality. Wheat hardness, defined as the force needed to crush the kernels, is, next to its protein content, a major quality trait. Bread wheat (Triticum aestivum L.) endosperm texture ranges from very soft to hard, whereas durum wheat (T. turgidum L. ssp. durum) has the hardest kernels of all wheat cultivars. Grain hardness is normally influenced by various environmental, physical and chemical factors like kernel protein, vitreousness of grain, kernel size, water-soluble pentosans, moisture content and lipid content. Differences in wheat hardness result probably from adhesion between starch granules and storage proteins. This is a grading factor and is also generally an indicator of protein

content. In general, glassiness is related to hardness and high protein content; opacity is considered to be associated with softness and low protein content. The light transmission property of the endosperm causes glassy or floury appearance of the grain. While wheat grain loses water during drying, air gaps may form as a result of compression and rupture in protein structure and the endosperm appears opaque. In the vitreous grains, the protein is compressed, there are no breaks in the structure so that reason, no air gaps occur. Starchy durum wheat tends to be lower in protein content than vitreous durum wheat, imparting weak breaking strength to dried pasta and poor cooking quality. It has been concluded in some studies that starchy durum wheat is softer than vitreous durum wheat, and gives a lower yield of coarse semolina and a higher yield of flour, thereby reducing milling potential. In general, vitreous kernels are associated with higher protein content and water-absorption capacity and with greater loaf volume potential in breadmaking. Therefore, in the production of bread, it is desirable for hard wheat to contain a high percentage of vitreous kernels (Baasandorj et al., 2015). Kernels that are glasslike and translucent in appearance are referred to as vitreous, whereas kernels that lack translucency or are light colored opaque are called nonvitreous (Starchy or piebald).

Wheat section:

- If it looks like glass, it's hard wheat (glassy, vitreous)
- If it looks floury, soft is soft wheat (starchy, mealy)
- If there are local starch spots on glassy region, it is piebald (Dönmeli buğday)



Procedure: The Grobecker cutting tool has a bottom plate with 50 holes on which the wheats are placed, a blade over it and a perforated plate on the blade.For the determination of the hardness, the blade between the two plates is taken out in the position to cut the grains. The

wheat is placed on the top plate of the hole and gently shaken to fill all the holes and the tool's special wood is pressed from the top. Then the grain is cut from the center of the wheat by a single action transversely with the blade and the cross-sectional surfaces of crosscut half-grains in the holes in the bottom plate are examined one by one by pouring the remaining portion on the blade. Since the Grobecker cross-section tool can take 50 cross-sections, the result is multiplied by two and the hard and soft grain rates are expressed as a percentage.

Determination of falling numbers

Falling numbers is an indicator of the extent of sprouting of wheat. Wheat germination released enzymes that cause digestion of the endosperm (starch). This is a measure of alpha-amylase activity. Amylases: enzymes that are hydrolyzing starch. Alpha-amylase; is an endoenzyme attacking to the bonds in the molecular structure of starch.(alpha 1-4 bonds). Fermentability of the dough is affected from the activity of this enzyme so the activity should be monitored. Falling number test is the rapid method that can analyze alpha amylase activity. Low FN value= high alpha-amylase activity (60-600). High activity: is seen in germinated grains after rainy harvesting period. But should not only related with germination. For an acceptable bread, desired value for wheat : 225-275

- If <150 bread crumb is wet inside and sticky
- If >350 small volume, dry crumb.

Activity can be regulated by using flour mixes or for increasing activity malt or amylase enzyme can be added. A falling number of 250 units or higher is usually desired.

Related to amount of sprouted wheat kernels in a parcel of grain. Apart from the three major types determining factors (hardness, gluten strength, protein content), soundness is another important wheat quality factor influencing baking quality. Sound wheat contains very low levels of an enzyme (α-amylase) that attacks and liquefies starch. Germination is associated with a rapid increase in enzyme activity and a severe sprouted kernel may be subject to several thousand times much activity than sound kernel.

High enzyme activity can cause severe problems in baking (lower absorption, sticky dough and in extreme cases, sticky crumb). In general, the following values are indicative of the flour’s baking qualities:

- A FN value of 250 sec. indicates flour with a normal α-amylase activity and good baking quality.
- A value of 65 sec. indicates a high α-amylase activity and production of sticky breads.
- High FN values in the range of 400 sec. indicate too low α-amylase activity for bread baking.

This test required specialised equipment. The basis of the test is to measure the time it takes for a stirrer to fall through gelatinised slurry in a test tube, made from flour of the wheat sample.

REFERENCES

Baasandorj, T., Ohm, J.-B., & Simsek, S. (2015). *Effect of Dark, Hard, and Vitreous Kernel Content on Protein Molecular Weight Distribution and on Milling and Breadmaking Quality Characteristics for Hard Spring Wheat Samples from Diverse Growing Regions. Cereal Chemistry Journal, 92(6), 570–577.* doi:10.1094/cchem-12-14-0249-r

Belderok B., Mesdag J., Donner D.A. (2000) The wheat grain. In: Donner D.A. (eds) Bread-making quality of wheat. Springer, Dordrecht

Hussain, A. (2009). *Nutritional and mixing characteristics of organically grown wheat genotypes* (No. 2009: 2).

Manley, M., Engelbrecht, M. L., Williams, P. C., & Kidd, M. (2009).Assessment of variance in the measurement of hectolitre mass of wheat, using equipment from different grain producing and exporting countries. *Biosystems engineering*, *103*(2), 176-186

Onipe, O. O., Jideani, A. I., &Beswa, D. (2015).Composition and functionality of wheat bran and its application in some cereal food products. *International Journal of Food Science & Technology*, *50*(12), 2509-2518.