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The Hardness of Wheat and its Relation to Milling Qualities.

BY G. H. CLARK, B. S. A.*

It has been generally understood that the wheat most desired by the millers is a variety that is hard and flinty, because, in milling, it produces a flour of superior quality.

Wheat-growers are giving preference to those varieties from which they are getting the best returns, and it would be extremely unjust to censure them because they do not produce wheat to suit the miller's requirements unless sufficient allowance is made to compensate them for the deficiency in yield.

The question as to what determines the strength of flour is one which, so far as I know, is not very well understood. The ordinary method used by millers is to weigh out a definite amount of flour, note the amount of water required in order to obtain a given texture, and if little water is required, they conclude that it is low in the percentage of gluten. The gluten-content is also the measure of the nutritive value of the flour; consequently, a flour poor in gluten will produce a bread deficient in nutrients.

There is a noticeable connection, too, between the strength and the color of flours. Those varieties of wheat which produce a light, bulky, soft flour, white in color, are invariably those which require the addition of a large percentage of Manitoba wheat in order to increase the strength.

There appears to be a peculiar fancy among bread-consumers for a white loaf. This is undoubtedly of great importance to millers, and in order to supply the demand, an increased quantity of those wheats which are low in the percentage of nutritive constituents is used. Now, the intuition that leads us to prefer the white loaf to one of a darker shade may be sound; at the same time, it is possible to have too much of a good thing, and we sacrifice a great deal for the sake of the dazzling white loaf. With the increase in gluten there is also a peculiar sweetness in the bread which, although a question of individual taste, ought not to be objected to, especially when it is associated with increased nourishment.

A glutent-content of nine per cent. is insisted upon by the French Government.

It has been argued that amongst a nation of meat-consumers, there is no need for the consumption of nitrogen in the shape of bread; it might, however, be viewed from the point that being condemned to the consumption of starch creates a craving for meat. It certainly does not tend to diminish it.

It has been asserted that the gluten-content of wheat is increased in an inland and elevated district. This idea has perhaps been taken from the fact that western wheats contain a much higher per cent. of gluten than ours. There are, however, other causes which have a direct influence on the quality of their grain. Their soil is exceedingly rich in nitrogen, and it has been shown by experiment (Agr. Gazette, N. S. W., Vol. I., —91, p. 146) that the application of nitrogenous fertilizers increases the gluten-content of wheat. The stage of cutting also makes a perceptible difference.

The object of this (O. A. C.) experiment was to obtain an approximate relation with reference to milling qualities between the various varieties of winter wheat which are at present being grown on the experimental plots. Concluding that their milling qualities depend largely upon the proteid matter which they contain, and believing that the hardness of the caryopsis is an indication of its gluten-content, our idea was to determine the relative hardness of the varieties, and by analyzing a few typical samples, demonstrate the relation which we believe to exist.

The instrument used for testing the hardness of the grain consisted of a pair of forceps, one handle of which was firmly attached to the end of a short board. In the other handle a small hole was drilled in order to conveniently attach a wire, which was connected with a spring balance. On the opposite end of the board was fitted a small pully, whereby gradual traction could be applied to the balance, to which it was connected with a stout cord. The spring balance used was graduated in ounces, and would weigh up to four pounds.

The mechanical advantage in the leverage of the forceps handle was eight to one.

An average was taken of each variety from forty kernels of grain, which were throughout the entire lot uniform in size and true to type. They were invariably placed in the jaws of the forceps in the same position, and in case of a defective grain that would not register within the average range, the reading was not taken.

The following table shows the amount of direct pressure required to crack the average kernel of each of sixty-two varieties which were grown on the experimental plots in 1896. The table is arranged from Bulletin No. 103, with a view of indicating the relation between the comparative hardness of the varieties, and the color of the grain, percentage of rust, dates of maturity, percentage of straw lodged, weight per measured bushel, and the average yield of grain per acre during the years grown:

VARIETIES. Arranged according to average yield of grain per acre for the number of years grown. From O. A. C. Exp. Bulletin 103, 1896.	Color of grain.	Per cent. of Rust.	Per cent. of Straw lodged.	Weight per Measured Bushel.	Yield per acre. Bushels.	Pressure required to crack Ounce.
Grown for five years.						
Dawson's Golden Chaff	W	40	2	59.8	49.9	161.0
Egyptian	R	25	29	60.7	46.8	199.4
Golden Drop	R	30	47	61.5	46.5	194.8
Early Red Clawson	R	50	45	58.7	46.2	188.6
Reliable	R	15	14	61.7	45.3	194.8
Russian Amber	R	20	19	61.5	44.0	210.2
American Bronze	R	70	2	59.3	42.8	204.8
Bulgarian	W	40	18	61.1	42.1	199.3
Red Velvet Chaff	R	45	35	58.4	41.5	238.1
Golden Cross or Volunteer	R	50	22	60.1	40.4	235.2
Standard	W	45	16	58.5	39.4	191.2
Surprise	W	45	25	58.3	39.3	166.4
Bonnell or Sandreth	W	40	26	58.8	39.3	214.8
Jones' Winter Fyfe	R	40	22	59.2	38.4	206.8
Longberry Red	R	20	42	61.0	37.4	249.8
Valley	R	50	10	61.0	37.1	226.0
Mediterranean	R	55	31	60.4	36.9	222.4
Monette	R	25	17	59.6	36.5	220.2
Genesee	W	33	19	60.4	35.9	202.3
Velvet Chaff	R	35	5	62.8	34.9	217.6
Fultz	R	45	5	62.4	34.9	213
Grown for four years.						
Stewart's Champion	R	45	6	58.6	37.2	216.4
Early White Leader	W	70	5	56.5	33.8	189.0
Soules	W	60	7	57.4	33.7	169.6
White Star	R	70	6	59.8	32.8	198.1
Treadwell	W	35	6	59.5	29.2	180.2
Grown for three years.						
Early Genesee Giant	W	70	5	60.9	47.8	187.4
Imperial Amber	R	15	37	59.7	46.3	201.4
Tasmania Red	R	35	47	61.8	45.7	222.6
Early Ripe	R	45	18	61.7	45.0	205.4
Egyptian Amber	R	15	27	61.7	43.9	187.8
Pool	R	35	15	61.0	43.8	192.6
New Columbia	R	45	5	59.2	41.7	207.4
Siberian	R	35	19	62.3	41.6	224.2
Pride of Genesee	R	30	22	61.6	41.0	236.6
Red May	R	25	13	62.3	40.4	199.4
Geneva	R	25	33	62.5	40.3	218.8
Arnold's Hybrid	R	35	12	61.7	39.8	204.2
Bissell	R	20	34	61.5	39.3	222.4
Emporium	R	10	20	59.3	39.2	224.6
Rudy	R	50	34	60.7	39.0	224.0
Tuscan Island	R	65	30	60.2	38.4	241.4
McPherson	R	30	25	61.6	37.3	236.8
Golden Tankard	R	55	33	60.5	36.6	235.6
Andrews No. 4	R	60	17	60.0	36.0	229.4
Simcoe Red	R	35	25	59.2	35.8	197.2
Turkish Red	R	15	42	62.0	31.8	284.4
Kentucky Giant	R	35	32	59.3	34.6	253.2
Jones' Square Head	W	50	4	58.5	33.8	204.8
Penquit's Velvet Chaff	R	70	12	61.4	32.6	225.6
Currell	R	50	18	61.0	31.8	231.4
Hindostan	R	85	29	60.7	31.5	222.6
Bullard's Velvet Chaff	R	70	2	60.5	25.0	231.6
Grown for two years.						
Michigan Amber	R	40	8	61.5	46.2	211.6
Hunter's Wheat	R	25	8	61.8	40.1	216.0
Pride of Illinois	R	50	15	61.6	37.0	218.1
White Bearded	W	45	2	59.5	35.3	261.2
German Emperor	R	30	30	61.0	33.1	235.1
Silver Star	W	65	5	61.2	30.5	212.0
Kadina	R	60	5	60.2	27.9	240.0
Amherst Isle	R	10	43	59.9	27.2	271.2
Nonpareil	W	40	1	60.4	26.9	213.0

In the above table it may be noticed that the direct pressure required to crack the grain of the various varieties tends to increase as the average yield per acre decreases. From this the inference may be drawn that the actual amount of nitrogenous matter per acre would be approximately the same among many of the varieties which are adapted to our climate, and that the increased weight of grain from the large yielding varieties is due to a proportionate increase in the percentage of starch.

It may also be noticed, though perhaps it has but a slight bearing on the subject in question, that there is a perceptible relation between the hardness of the grain and the percentage of rust.

"The rust-resistant varieties (Queensland Bulletin No. 19, p. 13) are often, though not necessarily, inferior in appearance to the familiar white, starchy, rust-liable kinds. It seems to be true that the firm, hard red wheats are rust-resistant to a much greater extent than the plump white sorts." Dr. Cobb points out that the glabrous condition of the plants of such types renders them more resistant to the mycelium threads of the *Puccinia graminis*.

The varieties selected for determining the gluten-content were: Dawson's Golden Chaff, a soft white wheat; Early Red Clawson, a comparatively soft red wheat, and two of our hard red wheats, Pride of Genesee and Turkish Red.

Three pounds of wheat from each of these varieties were ground in a large-sized coffee mill. From this the flour was separated by using a No. 10 silk screen, according to directions of the foreman at Goldie's Mill, Guelph, who stated that the flour was identical with that placed on the market.

PROCESS OF TESTING FLOUR.

(1.) Strength of flour.

To 100 g. of flour water was added from a graduated burette until a definite texture was obtained. The cubic centimeters of water required were taken as an indication of the strength.

(2.) Gluten-content.

(a) Determined with 10 g. of flour the percentage of hygroscopic water present.

(b) To 100 g. of flour was added an excess of lukewarm water. This was allowed to stand for two hours. It was then kneaded in cold water until the starch was washed out, or until a drop of the tincture of iodine imparted no blue coloration to the water.

(c) Reduced (as much as possible) the excess of water and dried for six hours at 100° C.

The crude gluten thus obtained (Dr. Armsby—Cattle Feeding, p. 28) is a mixture of at least four albuminoids, and contains, besides, some starch and fat.

The following is the result of the analyses of the four varieties named:

VARIETY.	Appearance of Flour.	Water Absorbed. Cc.	Texture of Dough.	Hygroscopic Water. Percent.	Crude Gluten. Percent.	Pressure required to Crack. Ounce.
Dawson's Golden Chaff.	Bulky, soft, white.	46	Non-adhesive, slightly elastic, easily broken.	11.3	7.14	161.0
Early Red Clawson	Soft, slightly dark.	47.5	Non-adhesive, slightly elastic, easily broken.	11.6	9.63	188.6
Pride of Genesee	Dark and gritty.	52	Adhesive and quite elastic.	11.5	12.1	236.6
Turkish Red	Very dark and gritty.	54.5	Elastic and very adhesive.	11.3	12.36	284.4

The above table indicates that the appearance of the flour, the texture of the dough, the water-absorbing capacity and the hardness of the grain varies with its gluten-content.

In the process of breadmaking the water-absorbing capacity of flour is of great importance to