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Biochemical characterization and compositional relationships of traits associated with glycemic index in rice

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Abstract

Rice, being a staple food for a significant portion of the world's population, provides both sustenance and energy. However, its high carbohydrate content and tendency to raise blood glucose levels quickly make it unsuitable for individuals with diabetes. Key biochemical traits, such as carbohydrate composition, amylose content, and gelatinization temperature, influence the glycemic index (GI) of rice. The GI measures how rapidly glucose is released into the bloodstream after consuming a specific amount of food. The objective of this study was to anticipate the interconnections between various biochemical compositions and traits associated with glycemic index (GI). The rice genotypes used in this study included Chapti Gurmatia, Dagad Deshi, and a population of 159 RIL (Recombinant Inbred Line) derived from crossing Chapti Gurmatia with Dagad Deshi. The biochemical analysis revealed a considerable range in total carbohydrate content among the rice lines, with values ranging from 57.64% in the line CXD-298 to 87.75% in the line CXD-214, with an average total carbohydrate content of 77.74%. The apparent amylose content in the rice lines exhibited a range of 8.18% to 22.73%, with the lowest value observed in CXD-26 and the highest in CXD-280. On average, the apparent amylose content was found to be 18.79%. The alkali spreading value varied between 1 (CXD-84 and CXD-109) and 5 (in CXD-22 and CXD-26), with an average alkali spreading value of 2.69. Notably, the sample variance indicated substantial variation across the traits, with values of 55.89, 4.37, and 0.39 for total soluble carbohydrate, apparent amylose content, and alkali spreading value, respectively. The high amylose rice line, CXD-106, was identified to have a high carbohydrate percentage of 86.02%. This finding further reinforces the positive correlation between high amylose and high carbohydrate content. A negative correlation coefficient of -0.038 was computed between the carbohydrate percentage and apparent amylose content, indicating a weak inverse relationship between these two variables.

Keywords: Glycemic index, diabetes, carbohydrates, amylose, alkali spreading value

1. Introduction

Rice is the primary staple food for a large part of the global population, possesses a chemical composition rich in essential vitamins, minerals, and proteins, making it an excellent source of nutrients such as vitamin E, vitamins B, and potassium. However, most rice varieties are high in carbohydrates and quickly digested, leading to a rapid release of glucose in the intestines, causing spikes in blood sugar levels after meals. Therefore, individuals with diabetes require low glycemic index foods to avoid such spikes. In light of growing concerns regarding health-related issues and the nutritional needs of diverse populations, initiatives have been undertaken since 2000 to develop stable food options that offer enhanced levels of micronutrients, proteins, and other bio-molecules, particularly within the realm of vegetarian food. The concept of Glycemic Index (GI) was first introduced in 1981 by Jenkins and colleagues to evaluate the impact of starchy foods on postprandial blood glucose levels (Jenkins *et al*., 1981) [12]. The GI represents the rate at which glucose is released after consuming a specific amount of food. It is categorized into three types: Low GI (55 or less), Medium GI (56 to 69), and High GI (70 and above). High GI foods lead to immediate spikes in blood sugar levels and are associated with type II diabetes, which can result in severe health complications such as retinopathy (vision loss) and nephropathy (kidney failure). There is an inverse relationship between the glycemic index and amylose content. Amylose content (AC) and gelatinization temperature (GT) are key factors used to assess rice grain quality and starch structure. The concept of glycemic indexing is valuable in guiding food choices for a healthy diet. By assessing the glycemic index (GI) value of foods, it becomes possible to predict their impact on blood glucose levels when consumed. Foods with a low GI tend to elicit lower postprandial blood glucose and insulin responses (Wolever, 1992) [22]. The Food and Agricultural Organization (FAO, 1998) [6] recommends the inclusion of low-GI foods, particularly for individuals with diabetes or glucose intolerance. Consuming low-GI foods has been shown to have several positive effects on human health, such as improved blood glucose control (Wolever *et al*., 1991[21]; Gilbertson *et al*., 2001[7]; Stevenson *et al*., 2006[21]; Barakatun-Nisak *et al*., 2009[1]; Moses *et al*., 2009) [71], reduced risk of coronary heart disease (Liu *et al*., 2000) [15], and decreased total fat mass while increasing lean body mass (Bouche *et al*., 2002) [3]. Given the numerous benefits associated with low-GI foods and food products, it is important to prioritize the determination of their GI values.

2. Materials and Methods

The rice genotypes used in this study comprised Chapti Gurmatia, Dagad Deshi, and a population of 159 RIL (Recombinant Inbred Line) derived from the cross between Chapti Gurmatia and Dagad Deshi. These genotypes were cultivated and maintained at the research farm of the College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya in Raipur, Chhattisgarh, India. The laboratory experiment was conducted at the Department of Plant Molecular Biology and Biotechnology, also located within the same college of Agriculture, Indira Gandhi Krishi Vishwavidyalaya in Raipur, Chhattisgarh, India.

2.1 Grain Processing

Prior to analyzing the biochemical traits: carbohydrate, amylose, and alkali spreading values in all the rice lines, approximately 100 grams of cleaned rough rice was weighed and de-hulled using a Chinese mini rice de-husker. After de-hulling, the rice seeds were carefully cleaned and separated by hand, resulting in brown rice. To obtain polished white rice, approximately fifty grams of brown rice were placed in the chamber of a Kett rice polisher and processed for one minute, resulting in a polished appearance.

2.2 Carbohydrate Estimation

The total carbohydrate content was determined using the phenol-sulfuric acid method as described by Dubois *et al.* (1956) [5]. A solution containing 5% phenol, 96% sulfuric acid, and 2.5 N HCl was prepared. The absorbance of the test sample was measured at 490 nm using a spectrophotometer, and the values were compared against a glucose standard curve. The percentage of total carbohydrate in the sample solution was calculated using a standard graph.

2.3 Estimation of Apparent Amylose Content

The estimation of amylose in rice was conducted using the starch-iodine-blue value protocol developed by Sowbhagya and Bhattacharya (1979)[20]. For apparent amylose estimation, 100 mg of rice flour was placed in a long black cap boiling tube. To this, 1 ml of absolute ethanol was added and mixed thoroughly. Subsequently, 9 ml of 1N NaOH was added to the tube. The solution was vigorously shaken and then boiled at 100 °C for 15 minutes. The digested sample was transferred to a clear volumetric flask, rinsed twice with hot distilled water, and made up to 100 ml. To prepare the analysis samples, 5 ml of the solution was drawn into 100 ml brown color volumetric flasks in three replicates. For each 5 ml solution, 1 ml of glacial acetic acid and 2 ml of iodine solution were added. The flasks were thoroughly mixed and made up to 100 ml with distilled water. To protect the samples from light, all flasks were covered with black cloths and incubated at room temperature for 20 minutes, as iodine (I2 KI) loses color when exposed to light. The absorbance of the samples was measured at 620 nm using a spectrophotometer against an amylose standard curve. The percentage of total amylose in the sample solution was then calculated using the standard graph.

2.4 Estimation of Alkali Spreading Value and Gelatinization Temperature

Gelatinization temperature (GT) of polished rice grains was assessed, and the alkali spreading value was determined using a scale ranging from 1 to 7. The experimental procedure was based on the methodology described by Cruz & Khush (2000) [4] and Bhattacharya (2011) [2], with slight modifications. To determine the gelatinization temperature (GT), ten polished rice grains were placed in individual plastic Petri dishes. Then, 5 mL of a 1.7% w/v KOH solution was added to each dish. The Petri dishes were subsequently incubated at a temperature of 30°C for duration of 23 hours. The evaluation of the degree of spreading and dissolving of the rice grains was performed through visual observation using a 7-point scale. This scale was based on the work of Little *et al.* (1958) [14] and consisted of seven categories, ranging from one (indicating no effect) to seven (representing complete dissolution). Based on the observed scale ratings, the grains were classified into three categories: Grains with a scale rating of 1-3 were recorded as having a high gelatinization temperature (>74°C). Grains with a scale rating of 4 or 5 were classified as having an intermediate gelatinization temperature (70-74°C), and grains with a scale rating of 6 or 7 were considered to have a low gelatinization temperature (<70°C) (Jennings *et al.*, 1979) [13].

3. Results and Discussion

In this study, we aimed to determine the total soluble carbohydrate content, apparent amylose content, and gelatinization temperature of two parental rice varieties, namely Chapti Gurmatia and Dagad Deshi. Additionally, we analyzed a population of recombinant inbred lines (RILs) comprising 159 rice lines that were obtained through the crossbreeding of Chapti Gurmatia and Dagad Deshi.

3.1 Total soluble carbohydrate content

The analysis of total soluble carbohydrate percentage in 159 rice lines revealed a wide variation among the samples. The average carbohydrate percentage ranged from 57.64% in CXD-298 to 87.75% in CXD-214, with a mean value of 77.74% (Fig. 1). The coefficient of variation was calculated to be 9.70%. A phenotypic correlation analysis was performed between total soluble carbohydrate and apparent amylose content, resulting in a correlation coefficient of -0.0383. Similarly, the correlation between total soluble carbohydrate and alkali spreading was calculated to be -0.00167 (Table 2). In a separate study conducted by Oko *et al.* (2012) [18], the chemical nutrient composition of 20 rice cultivars was investigated. The carbohydrate percentage in that study ranged from 51.50% to 86.92%, with a mean value of 82.86% ± 7.52%. Among all the rice varieties studied, only one variety, the hybrid rice variety "E4197," had a notably low carbohydrate percentage of 51.50%. The remaining varieties exhibited high carbohydrate content. In our study, the mean total soluble carbohydrate percentage of 77.74% fell within the range of carbohydrate percentages observed in both parental varieties. Specifically, Chapti Gurmatia recorded a carbohydrate percentage of 86.56%, while Dagad Deshi exhibited a carbohydrate percentage of 72.80%. Another experiment conducted by Ibukun (2008) [9] focused on the effect of prolonged parboiling duration on the proximate composition of rice. The carbohydrate percentage in that experiment ranged from 73.63% to 76.74%. The percentage of carbohydrate obtained in most of the varieties in our study was found to be within the range reported in the literature. The high carbohydrate content observed among the rice varieties in our study is not surprising, as rice is well-known as a significant source of carbohydrates (Oko *et al.*, 2012).

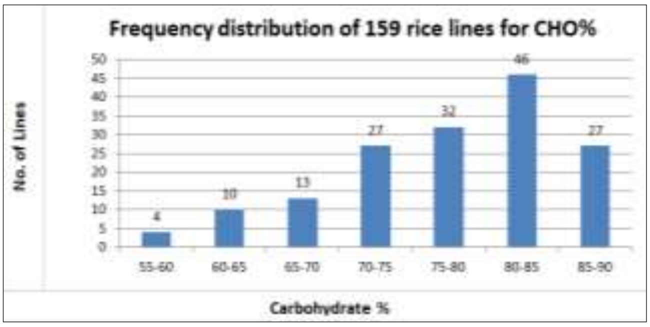

Fig 1: Variation in Carbohydrate content (%) in 159 rice lines derived from a cross (Chapti gurmatia X Dagad Deshi)

3.2 Apparent amylose content

This study assessed the amylose content in various rice lines and observed a wide range of values. The estimated amylose content ranged from 8.14% to 22.73%, with an average of 18.79% (S.E ± 0.16) and a coefficient of variation of 11.12% among 159 rice lines (Table 1). The rice lines included in the study exhibited amylose content within the low to intermediate range (Fig. 2), which is consistent with previous findings by Jain *et al.* (2012) [10] suggesting that the amylose content of rice can vary depending on the cooking method. He *et al.* (1999) [8] conducted a genetic analysis of rice grain quality using a population of 132 pure lines derived from a cross between ZYQ8 (Indica) and JX17 (Japonica). They found that the amylose content ranged from 15.31% to 22.64%. In another study by Paule *et al.* (1979) [19], amylose content variability in rice was analyzed using 34 rice varieties obtained from different locations such as IRRI, Taiwan, Peru, and Shrilanka. The analysis revealed that 23 varieties were classified as high-amylose, 9 as intermediate, and 2 as low-amylose. The amylose content ranged from 24.6% to 27.0% for high-amylose varieties, 19.9% to 25.4% for intermediate varieties, and 11% to 18.12% for low-amylose varieties. Interestingly, the amylose content of low-amylose varieties grown in Taiwan and Peru was higher compared to those from other sites (mean of 16.5% versus 13.8% at IRRI, 14.9% in Brazil, and 15.3% in Shrilanka). These findings suggest that the classification of rice varieties into low, intermediate, or high amylose groups is influenced by the geographic region where the rice is grown. Furthermore, in this study, two lines were identified as very low amylose transgressive segregants, exhibiting lower amylose content than the Dagad deshi parent, which itself has low amylose content. High amylose content is highly sought after in the market, and rice breeders are consistently concerned with achieving the desired amylose levels in their breeding programs. Amylose content is considered the most crucial characteristic for predicting rice's cooking and processing properties and is commonly used as an indicator of cooked rice texture. High amylose varieties tend to have a dry and separate grain after cooking, while low amylose cultivars are tender, glossy, and cohesive.

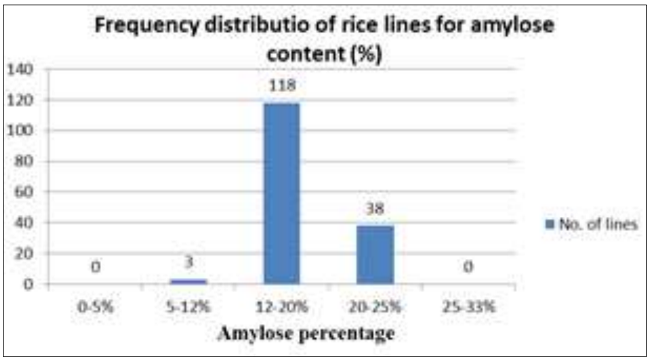

Fig 2: Variation in amylose content (%) in 159 rice lines derived from a cross (Chapti gurmatia X Dagad Deshi)

3.3 Alkali Spreading Value and Gelatinization Temperature

The alkali spreading value (ASV) was measured for the parent rice varieties as well as 159 RILs. Chapti Gurmatia showed a high gelatinization temperature with an ASV scale of 3, while Dagad Deshi exhibited an intermediate gelatinization temperature with an ASV scale of 4. Among the 159 rice lines analyzed, the ASV ranged from 1 to 5 on the ASV scale, with a mean ASV of 2.67 (S.E. ± 0.05) and a coefficient of variation of 14.60% (Table 1). Most of the rice varieties fell within the high ASV category (>74 °C) to the intermediate category (70-74 °C). Specifically, 91 rice lines were classified as ASV 3, 58 lines as ASV 2, and 2 lines as ASV 1 (identified as high ASV). Additionally, 6 lines were categorized as ASV 4, and 2 lines as ASV 5 (Fig. 3). Similarly, Janaliza *et al.* (2000) [11] conducted a study on the mapping of genes for cooking and eating qualities in Thai jasmine rice. They used 191 markers in 141 recombinant inbred lines (RILs) derived from the cross between two genetically diverse parents, KDML105 and CT9993-5-10-1-M. The distribution of gelatinization temperature in the progeny did not exhibit distinct classes. Most of the RIL lines had high gelatinization temperature values based on the alkali spreading values. The mean gelatinization temperature was determined to be 1.78 on the ASV scale, ranging from 1 to 6.5. Gelatinization temperature in rice quality research is traditionally defined as the temperature at which nearly all the starch granules in a sample lose their birefringence. This value typically ranges from 55 to 79 degrees Celsius in rice varieties. Various changes, such as starch granule alteration, viscosity and light transmittance increase, amylose solubilization, and swelling and degradation of rice kernels, occur during rice flour slurry gelatinization. Methods for measuring gelatinization temperature in rice utilize these changes, and gelatinization can be achieved through heat or alkali treatment. The measured parameter can be either the temperature or the alkali concentration required to produce a specific change or the extent of change observed under a given treatment. Among the methods used, alkali degradation and water uptake of rice kernels, light transmittance of heated or alkali-treated slurry, and solubilization of amylose from rice flour by dilute alkali are the most convenient for routine use. Therefore, in this study, the alkali spreading observation method was employed.

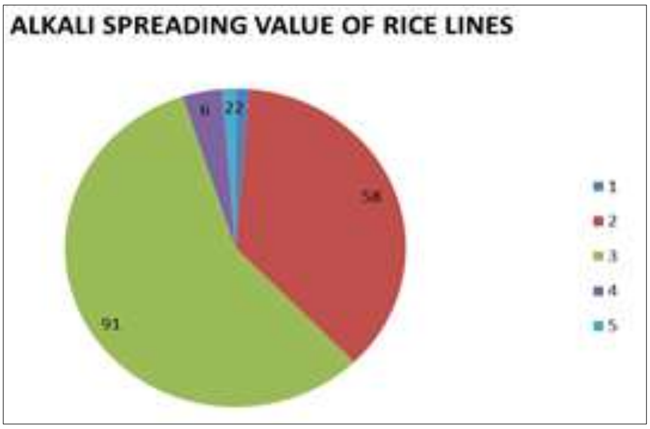

Fig 3: Frequency distribution for Alkali spreading value (1-7) of 159 rice lines derived from a cross (Chapti gurmatia X Dagad Deshi)

Table 1: Variability observed for CHO, AAC and ASV

Trait	Mean (±SEM)	Range	CV (%)
Total carbohydrate	77.47 (0.59)	57.64 to 87.75	9.70
Apparent Amylose Content	18.79 (0.16)	8.14 to 22.73	11.12
Alkali Spreading Value	2.67 (0.05)	1 to 5	14.60

Table 2: Phenotypic correlation coefficients among the traits

Trait	CHO%	Amylose %	ASV
CHO%	1		
Amylose %	-0.0383	1	
ASV	-0.00167	-0.18875	1

3.4 compositional relationships of traits: CHO%, AAC and ASV

The determination and characterization of biochemical values related to glycemic index in 159 rice lines revealed significant variability among the samples. The total soluble carbohydrate, apparent amylose content, and alkali spreading value exhibited sample variances of 55.89, 4.37, and 0.39, respectively (Table 3). The percentage of total soluble carbohydrates ranged from 57.64% in rice line CXD-298 to 87.75% in CXD-214, with a mean value of 77.47%. The highest amylose content of 22.73% was found in rice line CXD-280, while the lowest amylose content of 8.14% was observed in CXD-26. The mean amylose content across the population was estimated at 18.79% (Table 1). In terms of alkali spreading values, the mean calculated value was 2.67, with the highest value of 5 recorded in rice lines CXD-22 and CXD-26, and the lowest value of 1 observed in CXD-84 and CXD-109. Notably, the high amylose rice line CXD-106 exhibited a high carbohydrate percentage of 86.02%, supporting the positive relationship between high amylose and high carbohydrate content, which is associated with low glycemic index values. The correlation coefficient between carbohydrate percentage and apparent amylose percentage was calculated as -0.038 (Table 2). Rice line CXD-106, identified as having high amylose content (20.05%) and high carbohydrate content, aligns with similar findings reported by other researchers studying glycemic index in rice (Miller *et al*., 1992) [16]. Additionally, the correlation coefficient between carbohydrate percentage and alkali spreading value was calculated as -0.00167.

Table 3: Variability observed for CHO %, AAC% and ASV

Statistical Parameters	CHO%	Amylose %	ASV
Mean	77.477	18.790	2.673
Standard Error	0.593	0.166	0.050
Median	79.430	19.220	3.000
Standard Deviation	7.476	2.092	0.631
Sample Variance	55.891	4.378	0.399
Minimum	57.640	8.140	1.000
Maximum	87.750	22.730	5.000

4. Conclusions

The biochemical analysis of the rice lines revealed a wide variation in the measured parameters. The total carbohydrate percentage ranged from 57.64% in CXD-298 to 87.75% in CXD-214, with an average of 77.74%. The amylose percentage in the grains varied from 8.14% in CXD-26 to 22.73% in CXD-280, with an average of 18.79%. The alkali spreading value ranged from 1 in CXD-84 and CXD-109 to 5 in CXD-22 and CXD-26, with an average of 2.69. The observation of high amylose content and high carbohydrate percentage in line CXD-106, with values of 20.05% and 86.02% respectively, supports the positive relationship between high amylose and high carbohydrate content, which is associated with lower glycemic index values. Furthermore, a negative correlation was found between the carbohydrate percentage and alkali spreading value, with a correlation coefficient of -0.00167.

Table 4: Total soluble carbohydrate, apparent amylose content and alkali spreading value content of parents and 159 rice lines

S.N.	Rice lines	CHO%	Amylose %	ASV	GT (°C)
P1	Chapti Gurmatia	86.56	23.44	3	H
P2	Dagad Deshi	72.80	20.06	4	I
1	C X D - 1	85.73	21.73	3	H
2	C X D - 2	85.67	18.75	3	H
3	C X D - 3	83.05	20.12	2	H
4	C X D - 4	85.37	19.52	4	I
5	C X D - 5	83.31	21.83	2	H
6	C X D - 6	77	19.89	3	H
7	C X D - 7	74.62	21.39	3	H
8	C X D - 8	85.32	18.75	3	H
9	C X D - 10	85.01	15.7	2	H
10	C X D - 11	82.21	18.34	3	H
11	C X D - 12	79.21	10.9	3	H
12	C X D - 13	82.21	10.62	4	I
13	C X D - 15	78.03	14.49	3	H

14	C X D - 16	80.05	13.79	3	H
15	C X D - 17	76.25	21.18	2	H
16	C X D - 19	84.89	15.86	4	I
17	C X D - 20	85.24	19.92	3	H
18	C X D - 22	82.53	19.05	5	I
19	C X D - 23	82.8	17.84	3	H
20	C X D - 24	81.3	15.13	3	H
21	C X D - 26	78.8	8.14	5	I
22	C X D - 27	75.44	19.62	2	H
23	C X D - 28	82.59	17.14	3	H
24	C X D - 32	85.03	20.29	2	H
25	C X D - 33	83.23	21.83	3	H
26	C X D - 34	76.74	21.16	2	H
27	C X D - 37	70.93	20.75	3	H
28	C X D - 43	78.9	21.59	3	H
29	C X D - 44	81.76	18.68	2	H
30	C X D - 47	68.62	19.78	3	H
31	C X D - 48	68.36	17.5	3	H
32	C X D - 50	83.9	19.21	3	H
33	C X D - 51	85.67	18.91	3	H
34	C X D - 52	83.85	18	3	H
35	C X D - 54	85.17	20.39	3	H
36	C X D - 56	85.53	18.56	2	H
37	C X D - 57	78.69	21.13	3	H
38	C X D - 59	83.21	21.44	3	H
39	C X D - 60	74.58	19.85	3	H
40	C X D - 61	72.01	19.04	3	H
41	C X D - 63	66.11	19.55	3	H
42	C X D - 64	74.46	16.84	3	H
43	C X D - 65	79.19	19.85	3	H
44	C X D - 66	84.75	15.23	3	H
45	C X D - 67	71.25	20.22	4	I
46	C X D - 69	74.82	14.26	3	H
47	C X D - 70	66.12	15.43	3	H
48	C X D - 74	69.43	19.46	2	H
49	C X D - 76	77.96	19.4	3	H
50	C X D - 77	73.06	19.48	3	H
51	C X D - 79	74.42	17.79	3	H
52	C X D - 80	79.71	14.96	2	H
53	C X D - 81	79.99	20.52	3	H
54	C X D - 83	72.93	22.42	4	I
55	C X D - 84	62.8	15.8	1	H
56	C X D - 87	72.35	17	3	H
S.N.	**Rice lines**	**CHO%**	**Amylose %**	**ASV**	**GT (ºC)**
57	C X D - 90	85.62	15.97	2	H
58	C X D - 93	83.21	16.6	3	H
59	C X D - 94	80.04	17.65	3	H
60	C X D - 98	75.08	18.13	2	H
61	C X D - 99	71.91	17.23	3	H
62	C X D - 100	72.83	16.5	3	H
63	C X D - 101	71.77	18.7	3	H
64	C X D - 102	69.05	20.25	3	H
65	C X D - 106	86.02	20.05	4	I
66	C X D - 109	77.53	18.91	1	H
67	C X D - 112	59.12	19.35	3	H
68	C X D - 113	82.82	19.01	3	H
69	C X D - 114	79.87	19.71	3	H
70	C X D - 115	76.6	20.76	2	H
71	C X D - 116	69.6	20.19	2	H
72	C X D - 121	80.14	17.23	2	H
73	C X D - 122	58.54	19.42	2	H
74	C X D - 125	61.98	20.05	2	H
75	C X D - 130	81.89	19.22	3	H
76	C X D - 131	66.23	17.5	3	H
77	C X D - 132	68.6	19.79	3	H
78	C X D - 135	74.9	18.34	2	H
79	C X D - 136	85.05	18.39	2	H

80	C X D - 137	68.26	19.32	2	H
81	C X D - 138	81.52	17.82	3	H
82	C X D - 140	63.02	19.49	3	H
83	C X D - 141	70.5	20.29	3	H
84	C X D - 142	82.21	19.65	3	H
85	C X D - 143	85.76	18.5	2	H
86	C X D - 144	73.59	19.24	2	H
87	C X D - 146	81.08	19.65	3	H
88	C X D - 155	79.6	18.51	2	H
89	C X D - 157	77.27	19.38	3	H
90	C X D - 163	74.7	19.39	2	H
91	C X D - 164	61.15	18.06	3	H
92	C X D - 166	79.53	19.01	2	H
93	C X D - 167	61.56	19.28	3	H
94	C X D - 168	78.3	19.42	3	H
95	C X D - 169	73.48	18.34	2	H
96	C X D - 170	70.6	19.07	2	H
97	C X D - 175	81.12	17.94	3	H
98	C X D - 176	59.19	19.62	3	H
99	C X D - 178	77.17	20.09	3	H
100	C X D - 179	82.1	19.15	3	H
101	C X D - 180	74.19	18.55	3	H
102	C X D - 181	86.95	18.99	2	H
103	C X D - 182	84.81	18.23	3	H
104	C X D - 183	80.08	18.71	2	H
105	C X D - 185	79.43	19.16	2	H
106	C X D - 186	81	18.81	2	H
107	C X D - 187	85.05	18.08	3	H
108	C X D - 188	77.47	17.82	2	H
109	C X D - 189	65.75	19.18	3	H
110	C X D - 190	85.69	19.48	2	H
111	C X D - 191	81.33	17.06	3	H
112	C X D - 193	64.13	19.68	3	H
113	C X D - 196	84.04	19.78	2	H
114	C X D - 198	78.75	19.68	3	H
115	C X D - 202	84.37	20.12	3	H
116	C X D - 204	85.73	20.25	2	H
117	C X D - 205	85.08	19.99	3	H
118	C X D - 208	82.16	18.48	3	H
119	C X D - 210	81.83	19.82	2	H
120	C X D - 211	79.7	16.24	2	H
121	C X D - 214	87.75	19.76	3	H
122	C X D - 254	87.2	19.08	3	H
123	C X D - 255	85.75	16.7	3	H
124	C X D - 256	84.43	16.83	2	H
125	C X D - 257	83.1	17.31	2	H
126	C X D - 260	85.75	18.18	2	H
127	C X D - 274	87.01	20.19	2	H
128	C X D - 276	81.7	20.12	2	H
129	C X D - 280	85.61	22.73	3	H
130	C X D - 281	74.62	21.61	3	H
131	C X D - 283	65.3	21.44	3	H
132	C X D - 284	83.15	19.99	2	H
133	C X D - 285	73.57	22.13	2	H
134	C X D - 286	63.41	18.96	3	H
135	C X D - 287	84.3	21.23	2	H
136	C X D - 288	74.81	17.33	2	H
137	C X D - 289	87.32	17.75	3	H
138	C X D - 290	74.31	18	3	H
139	C X D - 291	61.08	15.19	2	H
140	C X D - 292	80.22	18.12	2	H
141	C X D - 297	80.15	17.07	3	H
142	C X D - 298	57.64	19.36	3	H
143	C X D - 299	63.51	18.94	2	H
144	C X D - 300	72.85	18.36	3	H
145	C X D - 301	78.22	17.7	3	H
146	C X D - 302	84.92	19.79	3	H

147	C X D - 305	67.94	19.51	2	H
148	C X D - 306	78.19	17.5	3	H
149	C X D - 308	81.44	19.88	2	H
150	C X D - 310	79.31	19.62	3	H
151	C X D - 311	75.63	20.46	3	H
152	C X D - 312	60.16	19.88	2	H
153	C X D - 314	75.55	20.45	3	H
154	C X D - 317	82.24	20.19	2	H
155	C X D - 318	83.73	20.25	2	H
156	C X D - 319	86.53	19.65	2	H
157	C X D - 322	70.62	21.46	2	H
158	C X D - 325	84.11	20.89	2	H
159	C X D - 327	75.88	19.76	3	H

#GT= Gelatinization Temperature, H=High, I= Intermediate, ASV= Alkali Spreading Value

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6. References

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