

Original Research Article

Variation in Crude Protein Content Among Recombinant Inbred Lines of Rice (*Oryza sativa* L.)

Abstract

Cereals constitute the primary dietary staple for humans, supplying a significant portion of energy, protein, and essential nutrients. Protein, crucial for growth, antibody production, and immunity, ranks as the second most abundant storage component in rice grains. Various factors, including grain protein content, amino acid composition, and fat content, influence the nutritional quality of rice, with grain protein content being particularly significant. This study conducted screening and evaluation of crude protein content across 200 recombinant inbred lines of rice, derived from an inter-specific cross between BPT5204 and HPR14 parents. Results indicated a range of total crude protein content from 13.17 (mg/g) to 28.94 (mg/g) among samples. Grouping analysis based on available crude protein content categorized the lines into three major groups: approximately 18% (36 lines) exhibited significantly higher protein content (>25mg/g), 69% (140 lines) displayed moderate content (15 mg/g to 25 mg/g), and 13% (26 lines) showed low protein content (<15 mg/g). The identification of high protein content genotypes in this study holds potential for mapping key genomic regions associated with protein content in rice.

Key words: Rice, crude protein, RILs.

Introduction:-

Rice stands out among cereals as a fundamental dietary staple for over half of the global population, profoundly shaping the cultures, diets, and economies of billions, particularly in Asia with its extensive history of cultivation deeply integrated into daily life (Narayanan et al., 2000). However, cereal-based diets have contributed to widespread undernutrition, especially protein deficiency, a pressing issue in developing nations where only twenty percent of the population has access to a nutritious diet. Protein energy malnutrition affects approximately 230 million children in these countries (WHO Bulletin, 1993), with over 50 percent of Indian children receiving insufficient calories daily for optimal growth (Mahendra et al., 2004). Sub-Saharan Africa and South Asia remain focal points for child malnutrition (Andersen et al., 1999). Studies on children recovering from protein energy malnutrition highlight the importance of essential amino acids like lysine and tryptophan in enhancing nitrogen retention (Pellett and Ghosh, 2004). The milling process of rice grains, while removing the bran layer, not only eliminates a nutritionally valuable component but also reduces the quantity of rice available for human nutrition by up to 15 percent. Glutelin constitutes the majority of seed protein, with albumin and globulin major components in rice bran (Cagampang et al., 1966; Juliano, 1972; Villareal and Juliano, 1978).

Comment [A1]: The sources are old

Comment [A2]: Not present in the review

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Comment [A4]: Per Pinstrup-Andersen

Comment [A5]: The writing of the source in the text and the review unite the third name of the researcher

Comment [A6]: One source is enough

Successive milling layers reveal that the outermost fraction holds the highest protein content (Hogan et al., 1964). Rice provides a significant portion of calories and protein in tropical Asian diets (Shobarani et al., 2006), although it lacks in lysine and tryptophan compared to other protein sources (FAO, 1957). However, rice protein contains the highest lysine content among cereal proteins. Banerjee et al. (2011) observed a positive correlation of tryptophan with lysine content but a negative correlation with total protein content. Environmental factors significantly influence cereal protein content, with rice exhibiting a wide range of grain protein accumulation (IRRI, 1963). Milled rice has relatively low protein content, while brown or dehulled rice contains more protein. Increasing rice protein content could enhance protein supply in rice-based diets. Rice harbors extensive genetic diversity, offering a rich resource for essential nutrients such as zinc, iron, proteins, and vitamins. Screening and exploiting this diversity are critical for genetic improvement aimed at addressing malnutrition (Khush and Virk, 2002). Enriching rice with protein, whether through conventional breeding or marker-assisted introgression, holds promise for sustainable food solutions (Graham et al., 2001). The primary objective of this investigation was to evaluate rice protein content variability in an association mapping panel for subsequent genetic enhancement endeavors.

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Material and Methods:-

Plant

The materials which were utilized in the present study consisted of 200 recombinant inbred lines of rice derived by pedigree method by crossing Samba Mahsuri (BPT-5204) and HPR-14.

Materials:

Experimental design:

The study was undertaken during Summer and Kharif seasons of the year 2020 in the experimental plots at A block of College of Agriculture, V C Farm, Mandya, which is located at an altitude of 697 m above mean sea level (MSL) and 76°50'01.7''E latitude and 12°34'25.4''N longitudes. Care was taken to raise the crop by adopting package of practice, UASB including regular irrigation to raise a good crop growth for both the seasons. Three samples per accession were evaluated for total soluble protein content. The dried seeds were dehusked using hand palm dehusker, ground evenly and sieved up to the talcum powder size with pestle and mortar. The powdered samples of unpolished rice were used for protein analysis using modified Lowry's method (Lowry et al., 1951).

Extraction of Protein

Sample preparation

Powdered samples were subjected to extraction of protein by 0.1M phosphate buffer with pH of 7.4. One gram of sample from each entry was macerated with 50 ml of phosphate buffer using Pestle and Mortar and centrifuged at 15000 rpm for 15 minutes at 4°C. The supernatants were collected for protein estimation by discarding the pellet. The

above steps were performed for each entry separately until a clear extract was obtained. The extract was stored in deep freezer until further analysis.

Protocol:

Total protein was estimated by modified Lowry's method given by Hartree, 1972. Determination of protein concentration by ultraviolet absorption depends on the presence of aromatic amino acids in the proteins. Although different proteins will have different amino acid compositions and thus different molar absorptivities, this method can be very accurate when comparing different solutions of the same protein (UKassays, 2017). Extracted samples of 0.2 ml were taken into test tube and the volume was made up to 1 ml with distilled water. To it, 4.5 ml of alkaline CuSO_4 reagent was added and incubated at room temperature for 10 minutes followed by 0.5 ml of Folin's phenol reagent. The contents were mixed well and the absorbance was measured at 650 nm after 15 minutes in a spectrophotometer. From the standard graph, the amount of protein in the given unknown solution was calculated.

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Result and Discussion:

Protein energy malnutrition impacts a significant portion, 25%, of children who primarily rely on rice and staple crops with low levels of essential amino acids (Gearing, 2015). In Southeast Asia, rice serves as the primary source of both carbohydrate and protein (Cagampang et al., 1966), albeit with the lowest protein level of 7.3g/100g in brown rice among cereals (Souci, Fuchmann, and Kraut, 1986). With a mean true digestibility of 93 percent compared to highly digestible proteins like egg, milk, cheese, meat, and fish (WHO, 1985), rice plays a crucial dietary role.

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The recommended dietary allowance for protein intake stands at 0.8 grams per kilogram of body weight per day (Harvard Men's Health Watch, 2015). Despite the presence of other protein-rich foods such as eggs, meat, milk, fish, and pulses, their affordability varies across different sections of society. Low-income groups often rely heavily on rice-based diets. Protein energy and micronutrient malnutrition are prevalent among rural and impoverished populations. Thus, identifying a viable source of rice protein from the available gene pool is imperative to meet the necessary protein thresholds in their diets.

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Total Protein Content

Among 200 RILs of rice taken for the present study, the protein content ranged from 14.99 mg/g in BH-RIL-00623 to 28.11 mg/g in BH-RIL-00317 with a coefficient of variation of 10.058 mg/g (Table 1). Seven lines were found to have significantly higher protein content than the grand mean of 20.646 mg/g. About 38 % (76 RILs) of RILs had low protein content (<15.00 mg/g) and 3.0 % (8 RILs) recorded higher protein content of more than 25.00 mg/g of sample. About, 59.00 % (119 RILs) of samples recorded moderate level of protein content

with range of 20.00 to 25.00 mg/g, (Fig. 1 and Table 2). It could be realized that in general most of the genotypes categorised under moderate protein content. However, there is a handful of material representing 3.00 % of the RILs with high protein that gives the ray of hope that a significant variation exists among the rice recombinant inbred lines taken for our investigation.

Previous studies by Kennedy and Burlingame (2003), Cao et al. (2009), and Silveira et al. (2010) proposed a classification system for protein contents, categorizing them as high ($\geq 12\%$), medium (11.9–9%), and low ($\leq 8.9\%$). In our association mapping panel, we follow a classification scheme based on the range of protein content: high ($>10.5\text{g}/100\text{g}$), moderate (9.01-10.5g/100g), and low levels of proteins ($<9.0\text{g}/100\text{g}$). Similarly, Heda and Reddy (1984) considered values $>10\%$ as high protein content in their analysis of F1 to F3 progenies of six crosses. Research has demonstrated that protein content in 1622 milled rice samples from 24 countries ranged from 4 to 14 percent, with a mean protein content ranging from 6.3 to 9.2 percent and an overall mean of 7.8 percent at 12% moisture (Juliano and Villareal, 1993). Kennedy and Burlingame (2003) analyzed the protein contents of 2,869 rice genotypes (2,674 *O. sativa* and 195 *O. glaberrima*) and found a mean of 8.8% for *O. sativa*, ranging from 4.5 to 15.9%. In their present analysis, comprising *O. sativa* germplasm, the mean protein content is 8.88%, with the highest protein estimation of 14.70 g/100g, closely aligning with their findings.

The crude protein content of ten Philippine rice cultivars, as evaluated by Riza et al. (2004), exhibited a range from 6.3% (PR-27423-MS6) to 9.1% (PR-31595-PSC101). Chandel et al. (2005) reported a wide variation in protein concentration, ranging from as low as 2.8% to as high as 9.9% in milled rice germplasm lines of Chhattisgarh.

Cao et al. (2009) observed considerable variation in storage protein content (ranging from 7.38% to 15.41%) among Chinese varieties of *O. sativa* rice. Banerjee et al. (2010) found a wide range of protein content (6.19% to 10.75%, mean 8.07%) in brown rice of 46 genotypes, including cultivated indica and japonica cultivars, germplasm accessions, advanced breeding lines, and wild rice genotypes.

Silveira et al. (2010) reported storage protein contents ranging from 4.4% to 20.2% across 550 accessions in the rice Core Collection of Embrapa, with an average of 10.31%. Mohanty et al. (2011) documented crude protein levels of 16.41% and 15.27% in brown rice of ARC 10063 and ARC 10075 rice accessions, respectively, on a dry weight basis.

According to Totok et al. (2011), genotype \times location interaction influenced grain protein content in 10 upland rice genotypes. They identified three genotypes—UNRAM 4E, UNRAM 9E, UNRAM 17E—as possessing stable protein content ($>8.0\%$) in their milled rice using Kjeldahl's method. Additionally, Banerjee et al. (2011) analyzed the protein content of milled grain among 258 landraces of rice belonging to the extra-early group (95 days) maintained at IGKV, Raipur, Chhattisgarh. They found a range from 4.91% to 12.08%, with a mean of 6.63%. Out of the total 258 lines analyzed, 52 exhibited $<6.0\%$ protein, 202

landraces had protein levels between 6.0% and 9.0%, while four lines showed >9.0% of grain protein.

They observed that the total free amino acid content was higher in these accessions, and lysine content was positively correlated with grain protein content, contrary to the views of Juliano et al. (1964) and Cagampang et al. (1966). Hanumantrao (2013) estimated protein content in brown rice of 58 rice germplasm lines and varieties using the modified Micro Kjeldahl method. Protein content varied from 6.09% in the variety CGR-436 to 11.2% in Danteshwari.

By utilizing ARC 10075 as a donor, CR Dhan 310 (IET 24780) rice variety was developed with a high protein content of 11% and was rich in threonine and lysine (NRRI Annual Report 2014–2015). Santos et al. (2013) analyzed twenty-nine accessions of the wild rice species *Oryza glumaepatula*, collected from five Brazilian states, and two commercial cultivars for storage protein profile and amino acid content. Total protein levels ranged from 14.94% (wild genotype BGA14280) to 9.07% (BGA14179). The control cultivars BRS Bonança and Primavera, along with the wild accessions BGA14210, BGA14232, BGA14233, and BGA14179, showed the lowest levels of total protein. Seven accessions possessed high protein content, ranging from 13.98% to 14.94%. The second group had nine accessions with a range of 12.3% to 13.35%. Thus, out of 29 genotypes evaluated, 16 had high total protein content, and 13 had medium protein content.

A scrutiny of the above findings on the estimation of protein content by different workers reveals that the low protein category ranged from 2.8% to 7.38%, while the other extreme ranged from 9.07% to 15.9% in genotypes belonging to *O. sativa*. The lowest value of 7.54g/100g recorded in this study material is above the range mentioned by earlier workers.

The present study of the total available protein content in 200 recombinant inbred lines of rice grains using modified Lowry's method. Modified Lowry's method was considered as highly feasible method to estimate even the negligible amount of protein and this method provides the real picture of soluble protein level which directly depicts the bio-available level of protein content in the human body. In this study among 200 RILs of rice 7 lines were found to record significantly higher protein content, 76 lines had low protein content and 119 lines of RILs recorded moderate level of protein content.

The present knowledge on the total accumulation of protein in recombinant inbred lines of rice would be helpful for breeders to enhance the level of nutrient accumulation in rice grains.

In near future, conventional breeding along with marker assisted selection or advanced genomic strategies will give fruitful results to achieve the targeted level of accumulation of proteins and other important nutrients in grains.

Reference:**Comment [A11]:** Conclusion!!!!

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Tables:

Table1: Total available crude protein content (mg/gram) in 200 recombinant inbred lines of rice

Sl.No.	RIL.No.	PC (mg/g)	Sl.No.	RIL.No.	PC (mg/g)	Sl.No.	RIL.No.	PC (mg/g)	Sl.No.	RIL.No.	PC (mg/g)
BPT 5204	C1	17.39 3	BPT 5204	C1	17.39 3	BPT520 4	C1	17.39 3	BPT520 4	C1	17.39 3
HPR-14	C2	23.96 6	HPR-14	C2	23.96 6	HPR-14	C2	23.96 6	HPR-14	C2	23.96 6
1	BH-RIL-0001	18.26 3	51	BH-RIL-00248	20.87 4	101	BH-RIL-00522	15.13 6	151	BH-RIL-00829	22.43 7
2	BH-RIL-00009	18.36 9	52	BH-RIL-00249	19.95 6	102	BH-RIL-00523	17.20 5	152	BH-RIL-00830	20.28 6
3	BH-RIL-00022	18.53 4	53	BH-RIL-00260	20.47 4	103	BH-RIL-00529	15.84 1	153	BH-RIL-00836	21.65
4	BH-RIL-00023	18.60 4	54	BH-RIL-00262	20.34 5	104	BH-RIL-00530	18.25 2	154	BH-RIL-00793	22.35 5
5	BH-RIL-00024	19.25 1	55	BH-RIL-00263	20.82 7	105	BH-RIL-00540	16.22 9	155	BH-RIL-00843	21.86 1
6	BH-RIL-00028	19.96 8	56	BH-RIL-00264	20.38	106	BH-RIL-00573	18.95 7	156	BH-RIL-00845	21.95 5
7	BH-RIL-00029	19.45 1	57	BH-RIL-00269	20.86 2	107	BH-RIL-00576	18.38 1	157	BH-RIL-00852	21.74 4
8	BH-RIL-00030	17.41 7	58	BH-RIL-00272	19.82 7	108	BH-RIL-00594	17.18 2	158	BH-RIL-00856	22.34 3
9	BH-RIL-00031	17.32 3	59	BH-RIL-00282	20.67 4	109	BH-RIL-00595	17.57	159	BH-RIL-00859	19.54 5
10	BH-RIL-00032	16.65 3	60	BH-RIL-00287	20.28 6	110	BH-RIL-00595	16.71 1	160	BH-RIL-00861	19.90 9
11	BH-RIL-00037	18.54 6	61	BH-RIL-00298	21.62 6	111	BH-RIL-00610	17.57	161	BH-RIL-00865	19.59 2
12	BH-RIL-00038	18.68 7	62	BH-RIL-00302	23.24 9	112	BH-RIL-00618	17.60 5	162	BH-RIL-00866	21.07 3
13	BH-RIL-00039	18.60 4	63	BH-RIL-00306	23.09 6	113	BH-RIL-00623	14.99 5	163	BH-RIL-00867	18.39 3
14	BH-RIL-00041	18.07 5	64	BH-RIL-00317	28.11 6	114	BH-RIL-00633	17.98 1	164	BH-RIL-00869	21.41 4
15	BH-RIL-00042	19.18	65	BH-RIL-00332	22.77 8	115	BH-RIL-00636	16.61 7	165	BH-RIL-00877	19.55 7
16	BH-RIL-00045	17.84	66	BH-RIL-00333	22.28 5	116	BH-RIL-00638	18.04	166	BH-RIL-00881	20.07 4
17	BH-RIL-00047	17.98 1	67	BH-RIL-00334	26.54 1	117	BH-RIL-00640	16.88 8	167	BH-RIL-00884	22.01 4
18	BH-RIL-00048	16.79 4	68	BH-RIL-00339	27.50 5	118	BH-RIL-00641	16.18 2	168	BH-RIL-00896	20.58
19	BH-RIL-00049	18.93 4	69	BH-RIL-00344	20.96 8	119	BH-RIL-00656	15.97 1	169	BH-RIL-00914	21.81 4
20	BH-RIL-00053	19.23 9	70	BH-RIL-00345	19.06 3	120	BH-RIL-00662	19.07 5	170	BH-RIL-00923	21.02 6
21	BH-RIL-00051	20.47 4	71	BH-RIL-00347	20.52 1	121	BH-RIL-00669	20.93 2	171	BH-RIL-00947	20.22 7
22	BH-RIL-00065	20.07 4	72	BH-RIL-00348	23.91 9	122	BH-RIL-00670	23.04 9	172	BH-RIL-00950	18.51
23	BH-RIL-00066	22.54 3	73	BH-RIL-00349	19.11	123	BH-RIL-00673	24.33	173	BH-RIL-00976	17.74 6
24	BH-RIL-00071	20.47 4	74	BH-RIL-00350	21.55 6	124	BH-RIL-00677	22.94 3	174	BH-RIL-01004	19.15 7
25	BH-RIL-00072	21.63 8	75	BH-RIL-00352	19.46 3	125	BH-RIL-00680	21.88 5	175	BH-RIL-01005	20.86 2

26	BH-RIL-00082	19.20 4	76	BH-RIL-00353	20.50 9	126	BH-RIL-00682	20.49 7	176	BH-RIL-01009	22.23 8
27	BH-RIL-00083	21.00 3	77	BH-RIL-00357	19.51	127	BH-RIL-00684	19.99 2	177	BH-RIL-01017	20.48 6
28	BH-RIL-00095	20.79 1	78	BH-RIL-00358	20.39 2	128	BH-RIL-00692	20.18	178	BH-RIL-01034	20.14 5
29	BH-RIL-00132	19.01 6	79	BH-RIL-00361	18.27 5	129	BH-RIL-00694	22.80 2	179	BH-RIL-01044	21.29 7
30	BH-RIL-00136	20.09 8	80	BH-RIL-00362	20.33 3	130	BH-RIL-00701	19.29 8	180	BH-RIL-01048	20.75 6
31	BH-RIL-00139	19.48 6	81	BH-RIL-00364	20.29 7	131	BH-RIL-00706	20.60 3	181	BH-RIL-00554	23.06 1
32	BH-RIL-00142	19.15 7	82	BH-RIL-00368	23.19	132	BH-RIL-00719	19.48 6	182	BH-RIL-01061	23.64 8
33	BH-RIL-00152	19.98	83	BH-RIL-00369	23.07 2	133	BH-RIL-00722	22.01 4	183	BH-RIL-01067	22.02 6
34	BH-RIL-00153	20.53 3	84	BH-RIL-00370	21.46 1	134	BH-RIL-00722	22.57 8	184	BH-RIL-01068	24.47 1
35	BH-RIL-00155	19.80 4	85	BH-RIL-00386	20.90 9	135	BH-RIL-00727	22.00 2	185	BH-RIL-01073	22.02 6
36	BH-RIL-00180	21.22 6	86	BH-RIL-00421	25.48 3	136	BH-RIL-00731	22.81 4	186	BH-RIL-01078	24.40 1
37	BH-RIL-00190	17.67 5	87	BH-RIL-00439	22.57 8	137	BH-RIL-00749	20.87 4	187	BH-RIL-01089	23.74 3
38	BH-RIL-00196	19.28 6	88	BH-RIL-00440	22.96 6	138	BH-RIL-00762	21.76 7	188	BH-RIL-01101	26.89 4
39	BH-RIL-00200	17.88 7	89	BH-RIL-00441	22.35 5	139	BH-RIL-00764	18.51	189	BH-RIL-01107	25.57 7
40	BH-RIL-00203	18.06 3	90	BH-RIL-00442	19.93 3	140	BH-RIL-00770	18.46 3	190	BH-RIL-01108	22.34 3
41	BH-RIL-00205	22.33 2	91	BH-RIL-00443	23.26	141	BH-RIL-00771	22.03 8	191	BH-RIL-01110	22.77 8
42	BH-RIL-00208	22.43 7	92	BH-RIL-00030	21.35 6	142	BH-RIL-00773	21.23 8	192	BH-RIL-01112	21.56 7
43	BH-RIL-00209	22.29 6	93	BH-RIL-00453	22.80 2	143	BH-RIL-00791	21.12 1	193	BH-RIL-01116	21.15 6
44	BH-RIL-00214	20.88 5	94	BH-RIL-00456	23.08 4	144	BH-RIL-00793	21.27 3	194	BH-RIL-01117	22.01 4
45	BH-RIL-00215	20.95 6	95	BH-RIL-00465	25.48 3	145	BH-RIL-00796	20.93 2	195	BH-RIL-01118	22.63 7
46	BH-RIL-00216	19.93 3	96	BH-RIL-00466	22.62 6	146	BH-RIL-00800	22.24 9	196	BH-RIL-01120	22.49 6
47	BH-RIL-00225	20.63 8	97	BH-RIL-00501	21.73 2	147	BH-RIL-00805	22.29 6	197	BH-RIL-00876	20.97 9
48	BH-RIL-00230	19.60 4	98	BH-RIL-00503	23.55 4	148	BH-RIL-00810	19.46 3	198	BH-RIL-01025	20.00 4
49	BH-RIL-00231	21.77 9	99	BH-RIL-00508	23.17 8	149	BH-RIL-00826	22.94 3	199	BH-RIL-01054	23.24 9
50	BH-RIL-00242	19.12 2	100	BH-RIL-00509	21.17 9	150	BH-RIL-00827	20.78	200	BH-RIL-01125	21.37 9

Protein content among RIL population

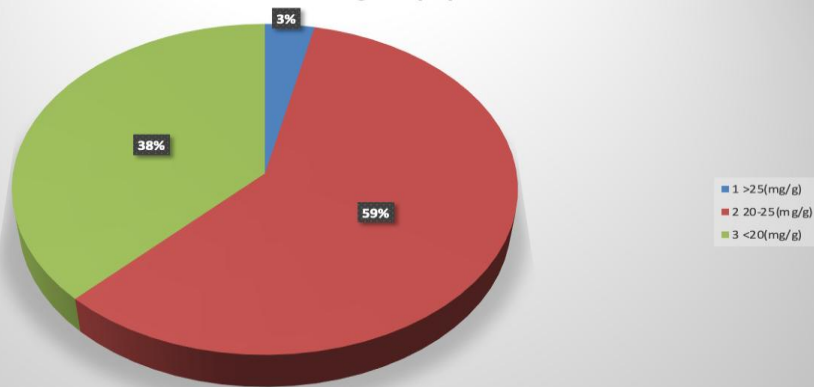


Fig.1: Pie chart representation of protein content among 200 recombinant inbred lines of rice

Table 2: Grouping of Recombinant inbred lines based on mean crude protein content

Crude protein content (mg/g)	Individuals	Number of Recombinant inbred lines	Percentage of individuals	*Classification
>25 (mg/g)	BH-RIL-00317, BH-RIL-00339, BH-RIL-01101, BH-RIL-00334, BH-RIL-01107, BH-RIL-00421, BH-RIL-00465	7	3 %	High
20 to 25(mg/g)	BH-RIL-01025, BH-RIL-00065, BH-RIL-00881, BH-RIL-00136, BH-RIL-01034, BH-RIL-00692, BH-RIL-00947, BH-RIL-00287, BH-RIL-00830, BH-RIL-00364, BH-RIL-00362, BH-RIL-00262, BH-RIL-00264, BH-RIL-00358, BH-RIL-00071, BH-RIL-00260, BH-RIL-00061, BH-RIL-01017, BH-RIL-00682, BH-RIL-00353, BH-RIL-00347, BH-RIL-00153, BH-RIL-00896, BH-RIL-00706, BH-RIL-00225, BH-RIL-00282, BH-RIL-01048, BH-RIL-00827, BH-RIL-00095, BH-RIL-00263, BH-RIL-01005, BH-RIL-00269, BH-RIL-00248, BH-RIL-00749, BH-RIL-00214, BH-RIL-00386, BH-RIL-00669, BH-RIL-00796, BH-RIL-00215, BH-RIL-00344, BH-RIL-00876, BH-RIL-00083, BH-RIL-	119	59 %	Moderate

<p>00923, BH-RIL-00866, BH-RIL-00791, BH-RIL-01116, BH-RIL-00509, BH-RIL-00180, BH-RIL-00773, BH-RIL-00793, BH-RIL-01044, BH-RIL-00030, BH-RIL-01125, BH-RIL-00869, BH-RIL-00370, BH-RIL-00350, BH-RIL-01112, BH-RIL-00298, BH-RIL-00072, BH-RIL-00836, BH-RIL-00501, BH-RIL-00852, BH-RIL-00762. BH-RIL-00231, BH-RIL-00914, BH-RIL-00843, BH-RIL-00680, BH-RIL-00845, BH-RIL-00727, BH-RIL-00884, BH-RIL-00722, BH-RIL-01117, BH-RIL-01073, BH-RIL-01067, BH-RIL-00771, BH-RIL-01009, BH-RIL-00800, BH-RIL-00333. BH-RIL-00209, BH-RIL-00805, BH-RIL-00205, BH-RIL-00856, BH-RIL-01108, BH-RIL-00441, BH-RIL-00793, BH-RIL-00208, BH-RIL-00829, BH-RIL-01120, BH-RIL-00066, BH-RIL-00722, BH-RIL-00439, BH-RIL-00466, BH-RIL-01118, BH-RIL-00332, BH-RIL-01110, BH-RIL-00694, BH-RIL-00453, BH-RIL-00731, BH-RIL-00677, BH-RIL-00826, BH-RIL-00440, BH-RIL-00670, BH-RIL-00554, BH-RIL-00369, BH-RIL-00456, BH-RIL-00306, BH-RIL-00508, BH-RIL-00368, BH-RIL-00302, BH-RIL-01054, BH-RIL-00443, BH-RIL-00503, BH-RIL-01061, BH-RIL-01089, BH-RIL-00348, HPR-14, BH-RIL-00673, BH-RIL-01078, BH-RIL-</p>			
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	01068			
<20 (mg/g)	BH-RIL-00623, BH-RIL-00522, BH-RIL-00529, BH-RIL-00656, BH-RIL-00641, BH-RIL-00540, BH-RIL-00636, BH-RIL-00032, BH-RIL-00595, BH-RIL-00048, BH-RIL-00640, BH-RIL-00594, BH-RIL-00523, BH-RIL-00031, BPT-5204 , BH-RIL-00030, BH-RIL-00595, BH-RIL-00610, BH-RIL-00618, BH-RIL-00190, BH-RIL-00976, BH-RIL-00045, BH-RIL-00200, BH-RIL-00633, BH-RIL-00047, BH-RIL-00638, BH-RIL-00203, BH-RIL-00041, BH-RIL-00530, BH-RIL-00001, BH-RIL-00361, BH-RIL-00009, BH-RIL-00576, BH-RIL-00867, BH-RIL-00770, BH-RIL-00764, BH-RIL-00950, BH-RIL-00022, BH-RIL-00037, BH-RIL-00039, BH-RIL-00023, BH-RIL-00038, BH-RIL-00049, BH-RIL-00573, BH-RIL-00132, BH-RIL-00345, BH-RIL-00662, BH-RIL-00349, BH-RIL-00242, BH-RIL-01004, BH-RIL-00142, BH-RIL-00042, BH-RIL-00082, BH-RIL-00053, BH-RIL-00024, BH-RIL-00196, BH-RIL-00701, BH-RIL-00029, BH-RIL-00352, BH-RIL-00810, BH-RIL-00139, BH-RIL-00719, BH-RIL-00357, BH-RIL-00859, BH-RIL-00877, BH-RIL-00865, BH-RIL-00230, BH-RIL-00155, BH-RIL-00272, BH-RIL-00861, BH-RIL-00216, BH-RIL-00442, BH-RIL-00249, BH-RIL-00028, BH-RIL-	76	38 %	Low

	00152			
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UNDER PEER REVIEW