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Biochemical and Mineral Changes in Green Gram Seeds: Raw vs. Sprout

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Abstract

The present experiment was carried out during July–December, 2023 at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Navsari Agricultural University, Bharuch Campus, Gujarat, India, sought to investigate the biochemical composition, anti-nutritional elements, and mineral content of raw and sprouted green gram (*Vigna radiata* L.) across seven genotypes: GM-7, GBM-1, CO-4, GM-4, GM-6, MEHA, and GAM-5. Green gram seeds are nutrient-dense and extensively consumed; sprouting is known to boost their nutritional content. Moisture, total sugar, total protein, total phenol, methionine, and ascorbic acid were measured in both raw and sprouted seeds. It also looked at anti-nutritional compounds including phytic acid and minerals like calcium, magnesium, copper, iron, zinc, and manganese. The results showed that sprouting enhanced digestibility by increasing protein and decreasing sugar content. Phytic acid levels dropped considerably during sprouting, increasing nutrient availability. Mineral analysis demonstrated higher concentrations of key elements such as zinc, manganese, and iron during sprouting, whereas copper content decreased. These studies show the health benefits of consuming sprouted green gram, which has higher nutritional content and bioavailability.GM-4 exhibited the maximum moisture content in raw seeds, the highest carotenoids and calcium content in both raw and sprouted seeds, and significant protein levels. CO-4 excelled in sprouted form, with increased levels of total protein, total phenol, moisture, calcium, magnesium, and manganese. This study gives important insights into the nutritional content of green gram genotypes, which will aid in the selection of healthy variants for consumption and agriculture.

Keywords: Digestibility, digestibility, proximate analysis, sprouting, nutritional quality

1. Introduction

Green gram (*Vigna radiata* L.) is a valuable food legume renowned for its high protein content and minimal flatulence-inducing factors (Adsule et al., 1986). Legumes are vital protein sources globally, with green gram recognized as an underutilized legume rich in lysine and potential nutritional benefits (Mensah and Olukoya, 2007). Green gram's composition includes protein (22.9%), carbohydrate (61.8%), fat (1.2%), fiber (4.4%), and ash (3.5%) (Offia and Madubuike, 2014), offering easy digestibility and minimal flatulence (Nair et al., 2013). Despite their nutritional value, challenges exist due to anti-nutritional factors (oligosaccharides, phytates, and polyphenols) causing gastrointestinal discomfort and nutrient availability issues (Liener, 1979). Cooking time and associated protein losses are also concerns (Almasand Bender, 1980). Green gram consumption and sprouting support gut health and lower health risks (Ganesan and Xu, 2018).

Sprouting enhances the nutritional properties of legumes, with increased protein, fiber, vitamins, and reduced phytic acid. Sprouting is known to improve the nutritional characteristics of legumes, especially green gram, by increasing protein, fibre and vitamins while decreasing phytic acid. (Shah et al., 2011; Afam et al., 2016). While sprouting duration impacts enzymatic activity (Nkhata et al., 2018), studies suggest optimal sprouting periods for functional benefits (El-Adawy et al., 2003; Elkhalifa et al., 2010; Helland et al., 2002). Sprouting characteristics, such as sprouting rate, serve as valuable indicators of seed age and viability. Aging adversely affects sprouting rates and overall seed viability, affecting seed quality and sensory attributes (Aguilera and Stanley, 1985).

Green gram contains significant amount of lysine and deficient in sulphur amino acid, specifically methionine. Sekhon et al. (1980) discovered that green gram exhibit a negative correlation between protein levels and the amino acids lysine and threonine. Conversely, they observed a positive correlation between these amino acids and methionine. This implies that when methionine content increases in green gram, the total protein content tends to decrease.

Furthermore, the biochemical and mineral changes that occur during the sprouting process improve the nutritional profile of green gram, making it an important dietary component (Mehta et al., 2021; Sudhakaran and Bukkan, 2021). Sprouting also improves thebioavaibility of essential nutrients while decreasing anti-nutritional factors (Song et al., 2016). Peroxidase, an enzyme that plays an important role in detoxifying phenolic compounds, is found in higher concentrations in sprouted green gram, increasing antioxidant capacity (Basha and Rao, 2017).

The transition from raw to sprouted green gram increases bioactive compound levels, which improves its pharmacological potential, including anti-inflammatory and antimicrobial properties (Mohapatra et al., 2024). The improved nutritional profile of sprouted green gram makes it especially beneficial to health, particularly in developing countries where it is a major dietary component (Mehta et al., 2021; Aryashad et al., 2023). Consumption of sprouted green gram has been shown to improve various health indicators, including immune function and oxidative stress levels (Rama Rao et al., 2018). Furthermore, sprouting improves protein and carbohydrate digestibility, allowing for better nutrient absorption and utilization (Josephine and Abbey, 2023).

The present research on comparative biochemical, anti-nutritional factors and mineral content of seven different genotypes of green grams aims to assess the nutritional quality of various green gram genotypes, a widely consumed legume. By comparing their biochemical, mineral content and levels of anti-nutritional factors like phytates, this study provides essential insights into their dietary and health implications. Understanding the variability in nutrient composition among genotypes informs the selection of more nutritious varieties for consumption and agricultural production. Additionally, the research contributes to agricultural sustainability by identifying resilient genotypes, thus advancing both nutritional science and sustainable food production practices.

2. Materials and Methods

2.1. Seed sample preparation

The present experiment was carried out during July–December, 2023 at Department of Soil science and Agricultural Chemistry, College of Agriculture, Navsari Agricultural University, Bharuch Campus, Gujarat, India.The laboratory experiment took place at the College of Agriculture, Navsari Agricultural University, Campus Bharuch. We utilized seven different green gram genotypes [GM-7, GBM-1, CO-4, GM-4, GM-6, MEHA and GAM-5] sourced from the Mega Seed Pulses and Castor Research Unit at NAU Navsari. These raw seeds were meticulously cleaned to eliminate any contaminants. Subsequently, the seeds were ground into powder form and sealed in airtight plastic bags for subsequent analysis.

To prepare the sprouts for analysis, the seeds of all seven genotypes were soaked overnight. Afterward, excess water was drained, and the moisture content was maintained for a period of 36 hours. Freshly prepared sprouts were then utilized for the subsequent stages of our analysis.

2.2. Determination of biochemical and mineral content

For the assessment of various parameters in the green gram genotypes, a systematic approach was followed. Moisture content was determined by subjecting representative samples of the seeds to oven drying at 105°C until a constant weight was achieved. Total carotenoids, total sugar, total phenol, total protein, methionine, ascorbic acid and phytate content were analysed by following methodology described by Sadasivam and Manickam in 1996. Mineral analysis, including calcium, magnesium, potassium, phosphorous, sulphur, zinc, iron, manganese, and copper, was conducted as per the methods outlined by Jackson, 1973. All measurements were performed in triplicate to ensure accuracy, and the results were subjected to appropriate statistical analysis, which included FCRD. Subsequently, Principle Compound Analysis (PCA) was also conducted to further assess significant differences among the different green gram genotypes.

3. Results and Discussion

The results of the present investigation are presented in tables numbered 1 through 17. The analysis of moisture content revealed significant differences among genotypes and treatments. In raw seeds, the highest moisture content observed in MEHA (5.46%) and the lowest in GAM-1 (2.67%) (Table 1). These moisture contents of slightly lower than that of the study carried out by Shah et al., 2011 that may be due to genotypes variation. In sprouted seeds, CO-4 exhibited the highest moisture content (60.58%), while GM-6 had the lowest (47.93%). Our results are in accordance to the previous reports of increased moisture content on sprouting of chickpea and other legumes seeds (Osman, 2007; Khattak et al., 2008; Khalil et al., 2007; Khatoon and Parkash, 2006). These differences underscore the influence of genotype and sprouting on moisture retention, which is a critical factor in seed quality and nutritional value assessment.

Total carotenoids content was notably higher in GM-4 (0.28 mg 100 g^{-1}) and GAM-5 (0.44 mg 100 g^{-1}) for raw and sprouted seeds, respectively. The lowest carotenoids content werefound in GBM-5 for both raw (0.18 mg 100 g^{-1}) and sprouted (0.21 mg 100 g^{-1}) seeds (Table 2). These findings underscore the genetic influence on carotenoids accumulation in green gram seeds, which is essential for their nutritional quality.Yang et al. (2001) showed increased in beta carotenoids and ascorbic acid on germination of wheat.

Total sugar content ranged from 21.50% to 53.55% in raw seeds and 19.37% to 26.76% in sprouted seeds. Among raw

Table 1: Moisture % of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	2.67	58.55	30.61
GAM-5	3.66	51.33	27.49
CO-4	3.18	60.58	31.88
MEHA	5.46	52.44	28.95
GM-4	4.45	54.56	29.51
GM-6	4.24	47.93	26.08
GM-7	3.33	57.27	30.30
Mean	3.86	54.66	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.154	0.288	0.407
CD (*p*=0.05)	0.448	0.839	1.186
CV%		2.33	

Table 2: Total carotenoids (mg 100 g^{-1}) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.18	0.24	0.21
GAM-5	0.24	0.44	0.34
CO-4	0.25	0.36	0.31
MEHA	0.23	0.27	0.25
GM-4	0.28	0.38	0.33
GM-6	0.23	0.26	0.25
GM-7	0.23	0.30	0.27
Mean	0.24	0.32	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.002	0.004	0.006
CD (*p*=0.05)	0.006	0.012	0.017
CV%		3.467	

Table 3: Total sugar (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	44.02	23.52	33.77
GAM-5	46.09	22.52	34.30
CO-4	51.25	19.37	35.31
MEHA	41.48	26.47	23.99
GM-4	53.54	26.76	40.15
GM-6	53.37	20.65	37.01
GM-7	52.19	19.68	35.93
Mean	48.85	22.71	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.35	0.187	0.494
CD (*p*=0.05)	1.018	0.544	1.439
CV %		2.33	

Table 4: Total phenol (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.53	0.37	0.45
GAM-5	0.51	0.27	0.39
CO-4	0.46	0.70	0.58
MEHA	0.36	0.56	0.46
GM-4	0.55	0.43	0.49
GM-6	0.34	0.37	0.35
GM-7	0.44	0.41	0.43
Mean	0.46	0.44	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.004	0.007	0.011
CD (*p*=0.05)	0.012	0.022	0.031
CV %		3.932	

seeds, GM-4 (53.54%) and GM-6 (53.37%) had the highest sugar content, while MEHA (21.50%) had the lowest. In sprouted seeds, GM-4 (26.76 %) and MEHA (26.47%) exhibited higher sugar content, whereas CO-4 (19.37%) had the lowest (Table 3) result showed that total sugar were significantly reduced during sprouting.

The total phenol content was highest in GM-4 (0.55%) and lowest in GM-6 (0.34%) and MEHA (0.36%) among raw seeds. In sprouted seeds, CO-4 showed the highest phenol content (0.70%), while GAM-5 had the lowest (0.27%) (Table 4).These results of sprouts are higher than that of the study done by Kexin et al., 2021 on green gram sprouts. The faba beans, peas, chickpeas, and kidney beans exhibited varying degrees of reduction in phytic acid, tannins, total phenols, and trypsin inhibitor activity (Oghbaei and Prakash, 2017; Abd El-Hady and Habiba, 2003). Our results showed somewhat similar trend in some of the genotypes of green gram.

Total protein content ranged from 18.81% to 25.30% in raw seeds and 24.45% to 28.24% in sprouted seeds. CO-4 exhibited the highest protein content in both raw and sprouted seeds, while GM-5 (raw) and GM-6, GM-4 (sprouted) showed the lowest (Table 5). Camacho et al. (1992) noted increase in protein content onsprouting of beans, lentils, chickpea and pea's seeds. Our findings regarding the effect of sprouting on the proximate composition of green gram seeds, supports with Obizoba (1991) who reported increase in % moisture, % crude protein and % ash. Increase in the protein content

Table 5: Total soluble protein (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	19.45	25.76	22.60
GAM-5	18.81	26.45	22.63
CO-4	25.43	28.24	26.84
MEHA	23.68	27.04	25.36
GM-4	21.34	24.48	22.91
GM-6	22.71	24.45	23.58
GM-7	22.36	26.38	24.37
Mean	21.97	26.12	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.079	0.148	0.209
CD (*p*=0.05)	0.23	0.43	0.608
CV %		1.539	

in germinated grains was also noted by Parameswaran and Sadasivan (1994), Khatoon and Prakash (2006), Urbano et al. (2005), Ghavidel and Prakash (2007), and Kaushik et al. (2010). As per Bau et al. (1997), increased protein content was due to synthesis of enzyme proteins by germinating seed or a compositional change following the degradation of other constituents. Nonogaki et al. (2010) noted that protein synthesis occurred during imbibitions and that hormonal changes play an important role in achieving the completion of germination.

Methionine content was highest in GAM-5 (raw) and GM-6 (sprouted), while CO-4 had the lowest (Table 6). Our results indicate that the methionine content in green gram was lower compared to the findings of previous studies;(Rao and Belavady, 1979; Khaderand Rao, 1986; 1996; Geervani and Theophilus, 1980; Dzudieand Hardy, 1996; Kochharand Hira 1997; Mubarak, 2005). The variation in methionine content between these studies and our own may be attributed to genotypic differences within the green gram plant.

Table 6: Methionine (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.41	0.28	3.52
GAM-5	0.45	0.21	3.60
CO-4	0.24	0.17	2.08
MEHA	0.25	0.18	2.32
GM-4	0.33	0.35	3.40
GM-6	0.27	0.36	3.20
GM-7	0.25	0.21	2.76
Mean	0.32	0.25	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.001	0.002	0.003
CD (*p*=0.05)	0.003	0.006	0.008
CV %		1.531	

Raw seeds of GAM-5 had the highest ascorbic acid content (0.43 mg g^{-1}), whereas GM-4 and GM-7 had the lowest (0.23 mg g^{-1} and 0.24 mg g^{-1}, respectively). In sprouted seeds, GM-7 and GM-6 had the highest ascorbic acid content (0.96 mg g^{-1} and 0.93 mg g^{-1}, respectively), while CO-4 showed the lowest (0.43 mg g^{-1}) (Table 7). Our results are well in agreement with those of Fernandezand Berry, (1988) who reported a significant increase in ascorbic acid during sprouting, while Kexin et al., 2021 shows ascorbic acid content in green gram sprouts in the range of 0.09 to 0.14 mg g^{-1}, these may be due to varietal difference of green gram.

Table 7: Ascorbic acid (mg g^{-1}) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.35	0.83	0.59
GAM-5	0.43	0.77	0.60
CO-4	0.38	0.43	0.41
MEHA	0.26	0.55	0.41
GM-4	0.23	0.44	0.34
GM-6	0.41	0.93	0.67
GM-7	0.24	0.96	0.60
Mean	0.330	0.702	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.01	0.01	0.01
CD (*p*=0.05)	0.02	0.02	0.03
CV %		3.049	

Comparing raw and sprouted seeds, a decrease in phytate content observed in sprouted seeds. Among raw seeds, MEHA had the highest phytate content (9.16 mg g^{-1}), while GBM-1 had the lowest (5.58 mg g^{-1}). In sprouted seeds, GM-6, CO-4, and MEHA showed the highest phytic acid content (4.37 mg g^{-1}), and GAM-1 exhibited the lowest (3.34 mg g^{-1}) (Table 8). El-Adawy (2002), and Bakr (1996) revealed that sprouting helps to reduce Phytate content. Chitra et al. (2019) study showed Phytate reduction upto 60% in chickpea and pigeon pea while 40% in green gram.

Mineral content analysis indicated variation in calcium, magnesium, potassium, phosphorous, sulphur, zinc, copper, iron, and manganese (Table 9–17). In raw seeds, GM-6, CO-4, and GM-7 showed the highest calcium content, while GM-7 had the lowest. Among sprouted seeds, CO-4 had the highest calcium content and GBM-1 had the lowest (Table 9).

Table 8: Phytate (mg g^{-1}) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	5.58	3.34	4.46
GAM-5	7.45	3.72	5.58
CO-4	8.29	4.37	6.33
MEHA	9.16	4.31	6.74
GM-4	6.47	3.52	5.00
GM-6	8.50	4.37	6.43
GM-7	7.41	3.58	5.50
Mean	7.55	3.89	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.054	0.101	0.143
CD (p=0.05)	0.157	0.294	0.416
CV %		4.431	

Table 9: Calcium (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.35	0.33	0.34
GAM-5	0.42	0.36	0.39
CO-4	0.42	0.44	0.43
MEHA	0.37	0.34	0.35
GM-4	0.41	0.36	0.39
GM-6	0.36	0.42	0.39
GM-7	0.33	0.41	0.37
Mean	0.38	0.38	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.003	0.006	0.009
CD (p=0.05)	0.01	0.019	0.026
CV %		3.655	

Table 10: Magnesium (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.39	0.36	0.37
GAM-5	0.44	0.42	0.43
CO-4	0.45	0.44	0.44
MEHA	0.37	0.35	0.36
GM-4	0.47	0.32	0.39
GM-6	0.38	0.43	0.41
GM-7	0.36	0.42	0.39
Mean	0.41	0.39	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.002	0.005	0.007
CD (p=0.05)	0.007	0.013	0.019
CV %		2.936	

Table 11: Potassium (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.94	0.82	0.88
GAM-5	0.89	0.85	0.87
CO-4	0.95	0.77	0.86
MEHA	0.93	0.47	0.70
GM-4	0.86	0.57	0.72
GM-6	0.96	0.44	0.70
GM-7	0.92	0.50	0.71
Mean	0.92	0.63	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.011	0.02	0.028
CD (p=0.05)	0.031	0.058	0.081
CV %		2.939	

Magnesium was highest in GM-4 (raw) and CO-4 (sprouted), while GM-7 had the lowest in raw seeds, and GM-4 had the lowest in sprouted seeds. GM-6 and CO-4 exhibited the highest potassium content, while GM-4 had the lowest among raw seeds (Table 10)

Raw seeds had higher average potassium content (0.92%) than sprouted seeds (0.63%) (Table 11). Among the genotypes, GBM-1 and CO-4 had the greatest potassium concentration in raw seeds (0.94% and 0.95%, respectively). However, after sprouting, most genotypes showed a considerable fall in potassium concentration, with MEHA, GM-6, and GM-4 showing the greatest decrease. These findings imply that, whereas sprouting generally improves other nutritional aspects, it may reduce potassium levels in green gram genotypes.

Raw seeds of GBM-1 and GM-4 showed the highest phosphorous and sulphur content, respectively, while GM-4 and MEHA had the lowest. In sprouted seeds, GM-4 and GM-6 exhibited the highest phosphorous content, while MEHA showed the lowest. Among sprouted seeds, MEHA and GAM-5 had the highest sulphur content, while GM-7, CO-4, and GM-6 had the lowest. Upon sprouting, we observed a reduction in potassium content, with the initial potassium levels in raw seeds slightly lower than those reported by

Khairul Mazed et al., 2016. Interestingly, the levels of sulphur and phosphorus in our study aligned with their findings. Notably, our research indicated an increase in phosphorus concentration during sprouting, highlighting a unique aspect of our results compared to Khairul Mazed et al., 2016 (Table 12 and 13).

Table 12: Phosphorous (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.43	0.32	0.38
GAM-5	0.34	0.23	0.29
CO-4	0.29	0.24	0.27
MEHA	0.35	0.15	0.25
GM-4	0.24	0.33	0.29
GM-6	0.33	0.33	0.33
GM-7	0.32	0.24	0.28
Mean	0.33	0.26	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.003	0.005	0.007
CD (*p*=0.05)	0.008	0.015	0.021
CV %		4.437	

Table 13: Sulphur (%) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	0.23	0.55	0.39
GAM-5	0.23	0.75	0.49
CO-4	0.25	0.25	0.25
MEHA	0.21	0.78	0.50
GM-4	0.36	0.65	0.50
GM-6	0.33	0.25	0.29
GM-7	0.26	0.23	0.24
Mean	0.27	0.49	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.004	0.007	0.01
CD (*p*=0.05)	0.011	0.02	0.029
CV %		3.579	

Analyzing micronutrients, raw seeds of GBM-1, GM-4, and GM-7 had the highest zinc, copper, manganese, and iron content, respectively. In sprouted seeds, GM-6, GBM-1, CO-4, and GM-7 showed the highest zinc, copper, manganese, and iron content, respectively (Table 14-17).. Moreover, our research demonstrated a mixed trend in iron levels upon sprouting, with some genotypes displaying increased levels while others experienced a reduction..

Table 14: Zinc (mg kg^{-1}) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	50.44	64.60	57.52
GAM-5	38.17	60.41	49.29
CO-4	28.95	63.47	46.21
MEHA	21.70	47.11	34.41
GM-4	40.84	55.62	48.23
GM-6	31.79	80.72	56.25
GM-7	41.72	73.19	57.46
Mean	36.23	63.59	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.116	0.217	0.307
CD (*p*=0.05)	0.338	0.633	0.865
CV %		1.075	

Table 15: Iron (mg kg^{-1}) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	65.29	58.58	61.94
GAM-5	83.38	65.13	74.25
CO-4	69.79	58.50	64.15
MEHA	57.62	67.05	62.33
GM-4	97.18	53.77	75.48
GM-6	56.37	68.69	62.53
GM-7	57.36	77.89	67.63
Mean	69.57	64.23	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.183	0.341	0.483
CD (*p*=0.05)	0.532	0.994	1.406
CV %		1.242	

Principal Component Analysis (PCA) revealed that various factors contributed to variance in the data. PC1, PC2, and PC3 contributed 81.56% to the total variance in raw seeds (Table 18). Total phenol and iron were major contributors to PC1, while total carotenoids and calcium contributed to PC2 and PC3 (Table 19). PCA analysis of sprouted seeds indicated that PC1 to PC3 contributed to 73.83% of the total variance, with zinc, calcium, and potassium being key factors in determining variance (Table 20–21).

Table 16: Manganese (mg kg^{-1}) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	17.48	37.65	63.17
GAM-5	27.75	37.97	32.86
CO-4	33.65	46.62	40.14
MEHA	36.92	43.84	40.38
GM-4	43.64	40.51	42.08
GM-6	41.76	36.39	39.08
GM-7	38.42	30.71	34.56
Mean	34.23	39.10	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.224	0.120	0.317
CD (p=0.05)	0.652	0.348	0.922
CV %		1.498	

Table 17: Copper (mg kg^{-1}) contents of different green gram genotypes

Genotype/ Treatment	Raw	Sprout	Mean
GBM-1	17.15	17.44	51.59
GAM-5	13.63	12.40	13.02
CO-4	17.37	15.64	16.51
MEHA	22.55	16.55	19.55
GM-4	13.61	10.58	12.10
GM-6	13.53	11.53	12.53
GM-7	11.67	10.59	11.13
Mean	25.44	13.53	
	Treatment (T)	Genotype (G)	T×G
SEm±	0.163	0.087	0.23
CD (p=0.05)	0.473	0.253	0.669
CV %		2.523	

Table 18: Eigen values for raw seeds

Principal component	Eigen value	% of variance	Cumulative % of variance
PC1	5.755	33.851	33.851
PC2	5.605	32.968	66.819
PC3	2.507	14.746	81.565
PC4	1.701	10.004	91.569
PC5	1.000	5.883	97.452
PC6	0.433	2.548	100

Table 19: % contribution of variables on PCs (Raw seeds)

Variables	PC1	PC2	PC3
Moisture	2.81	5.378	4.51
Total carotenoids	1.336	15.786	0.859
Total sugar	1.123	7.032	16.545
Total phenol	14.711	0.532	0.549
Total protein	7.683	5.286	0.00
Methionine	8.764	5.626	2.048
Ascorbic acid	0.019	1.811	2.115
Phytate	10.75	3.482	2.855
Calcium	3.446	3.515	18.717
Magnesium	8.788	3.456	6.957
Potassium	9.522	2.198	1.298
Phosphorous	1.012	16.34	0.08
Sulfur	2.177	7.296	9.573
Zinc	8.795	4.644	8.528
Iron	13.076	2.414	4.079
Manganese	0.801	14.728	3.077
Copper	5.189	0.474	18.209

Table 20: Eigen values for sprouted seeds

Principal component	Eigen value	% of variance	Cumulative % of variance
PC1	5.76	33.884	33.884
PC2	4.625	27.207	61.091
PC3	2.165	12.734	73.826
PC4	1.872	11.012	84.837
PC5	1.63	9.587	94.424
PC6	0.948	5.576	100

Table 21: % contribution of variables on PCs (Sprouted seeds)

Variables	PC1	PC2	PC3
Moisture	2.528	2.784	16.839
Total carotenoids	0.822	0.032	6.665
Total sugar	4.426	14.036	3.753
Total phenol	6.399	8.288	0.965
Total protein	5.986	10.776	0.149
Methionine	9.281	8.344	0.025
Ascorbic acid	12.203	0.00	0.095
Phytate	0.486	8.072	15.405
Calcium	2.522	14.039	0.121
Magnesium	3.059	13.893	0.673

Table 21: Continue...

Variables	PC1	PC2	PC3
Potassium	2.148	0.013	29.872
Phosphorous	4.62	2.67	11.675
Sulfur	5.598	10.453	1.223
Zinc	13.708	2.619	1.456
Iron	5.744	2.521	10.93
Manganese	12.817	0.901	0.111
Copper	7.652	0.56	0.042

4. Conclusion

The effect of sprouting on green gram seeds, revealing significant differences in moisture, biochemical, and mineral content across genotypes. GM-4 emerged as the top among raw genotypes, with the highest moisture, carotenoids, and calcium content, as well as significant protein levels. CO-4 stood out among sprout genotypes for its high levels of protein, phenol, moisture, calcium, magnesium, and manganese. The study highlights the nutritional benefits of sprouting and sheds light on how genotype influences the nutritional profile of green gram.

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