ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(1): 96-101
www.agriculturaljournals.com
Received: 15-10-2025
Accepted: 20-11-2025

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Physical characteristics of selected major coarse cereals and pulses grown in tribal regions of Alluri Sitharama Raju District, Andhra Pradesh

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DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i1b.1126

Abstract
The present study evaluated the physical characteristics of selected major coarse cereals and pulses cultivated in tribal regions of the Alluri Sitharama Raju district of Andhra Pradesh and compared them with corresponding control samples. The crops analysed included kidney bean, red gram, cowpea, finger millet, little millet, and rice. Physical properties such as colour attributes (L*, a*, b*), 100-grain weight, grain dimensions (length, width, thickness, and grain size), bulk density, and true density were determined using standard analytical methods. Significant variations were observed between tribal and control samples for several parameters. Tribal samples of finger millet and little millet exhibited significantly lower lightness (L*) values along with increased redness and yellowness, indicating enhanced seed coat pigmentation. Little millet showed a significant increase in 100-grain weight, whereas most pulses did not exhibit significant differences. Grain dimensions varied marginally among crops, with finger millet width and rice grain length showing significant differences between treatments. Bulk density was significantly lower in tribal little millet, while true density values did not differ significantly for most samples. Overall, the results indicate that agro-ecological conditions and local cultivation practices in tribal regions influence the physical properties of coarse cereals and pulses. The generated baseline data are valuable for improving post-harvest handling, processing efficiency, and value addition of these nutritionally important crops in tribal areas.

Keywords: Coarse cereals, Pulses, Physical characteristics, Grain dimensions, Bulk density, Tribal agriculture, Andhra Pradesh

Introduction

India is characterized by remarkable social and cultural diversity, comprising tribal, caste, and peasant communities. During the British colonial period, Indian society was broadly classified into castes and tribes, a distinction that continues to influence socio- economic conditions and nutritional disparities (Rajak, 2016) [21]. Tribal communities, in particular, often face constraints related to food availability, access, and utilization, making nutritional security a persistent challenge. Nutritional quality is a critical component of food security, ensuring that consumed foods meet dietary requirements. Coarse cereals and pulses are important sources of protein, dietary fibre, vitamins, and minerals and contribute significantly to the diets of rural and tribal populations. However, the nutritional composition of these crops varies depending on the variety grown, agro-climatic conditions, and post-harvest handling practices.

Coarse cereals, also referred to as warm-season cereals, are valued globally for their food and functional uses. Crops such as oats, maize, barley, pearl millet, sorghum, and other minor millets are rich in energy, essential minerals, vitamins, and phytochemicals with antioxidant properties. Due to their relatively higher protein content and balanced amino acid profiles, coarse cereals and pulses are nutritionally comparable to, or superior to, major cereals (Kaur *et al*., 2014) [11]. Millets such as pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), and sorghum (*Sorghum bicolor*) are commonly cultivated in tribal regions and have served as staple foods for generations. These grains are rich in dietary fibre, iron, calcium, and phosphorus and are particularly suitable for individuals with diabetes and celiac disease due to their low glycaemic index and gluten-free nature (Rathore *et al*., 2013) [24].

Coarse cereals and pulses form a substantial portion of the daily diet because of their high content of macronutrients and functional components. Regular consumption of these foods has been associated with reduced risk of obesity and metabolic disorders, as they support gut health and help regulate gut microbiota, thereby contributing to overall metabolic well-being (Yao *et al*., 2020) [30]. Pulses are widely consumed owing to their high nutrient density, providing proteins, dietary fibre, resistant starch, vitamins, and minerals. However, the presence of anti- nutritional factors such as phytates, polyphenols, saponins, and protease inhibitors may influence nutrient bioavailability. Despite this, pulses offer significant health benefits, including low glycaemic response, gluten-free nature, and sustainability within agricultural systems (Bhat *et al*., 2018) [4].

In addition to nutritional composition, the physical characteristics of grains such as hundred-grain weight, grain dimensions (length, width, and thickness), grain size, bulk density, and true density play a crucial role in post-harvest handling, storage behaviour, processing efficiency, and end-use quality. These physical properties are influenced by crop type, varietal differences, and cultivation practices, particularly under the unique agro- ecological conditions prevailing in tribal areas. Therefore, the present study was undertaken to evaluate and compare the physical characteristics of selected major coarse cereals and pulses cultivated under tribal and control conditions in Andhra Pradesh, with the aim of generating baseline data to support improved processing, utilization, and value addition of these crops.

Materials and Methods

Sample Collection

The selected coarse cereals and pulses were collected from tribal regions of Alluri Sitharama Raju district, specifically from Dumbriguda mandal and Gudem Madugula mandal. The samples were selected based on their local availability, cultural relevance, and nutritional importance to the tribal communities of the study area. Representative samples of each crop were collected in their whole (seed) form. The collected samples were cleaned to remove foreign matter and were transported to the laboratory for further analysis. All samples were stored in clean, dry, and airtight containers under ambient conditions until physical characteristics were evaluated.

Determination of colour values

Determination of colour values

The colour values of coarse cereals and pulse grains were recorded using Hunter lab meter. The *L** value was used to measure the lightness ranging from 0 to 100. The + *a** value represents red,- *a** represents green, +*b** represents yellow and −*b** represents blue. Three readings were taken for each sample. The results presented were the means of three values (Koley *et al*., 2014) [15].

100-Seed Weight

100 seeds were counted thrice and weighed using an analytical balance with a precision of 0.001 g. Following the method described by Gani *et al*. (2015) [7], the total weight was recorded for each count, and the 100-seed weight was expressed as the weight in grams per 100 grains. This process was repeated for each sample to determine the average weight per 100 seeds.

Length, Width, and Thickness

The length, width, and thickness of cereal and pulse grains were measured using vernier callipers following the method of Ndirika and Mohammed (2005) [18]. Each grain was positioned between the jaws, and measurements were recorded to the nearest 0.01 mm. Length was taken from tip to base, width at the widest point, and thickness at the midpoint. Measurements were repeated for multiple grains, and averages were calculated for accuracy.

Bulk Density

The bulk density of both the seed samples was determined using the liquid displacement method as described by Amin *et al*. (2004). A known weight (10 g) of the seed sample was added to a 100 mL graduated cylinder containing a known volume of distilled water, and the volume displaced by the sample was recorded.

True Density

The true density of seed samples was determined using the toluene displacement method as described by Singh and Goswami (1996) [8]. A known weight of sample was gently added to a graduated cylinder containing approximately 50 mL of toluene (C_7H_8). The initial (V1) and final (V2) volumes were recorded, and the volume displaced was calculated as the difference between the two.

Results and Discussion

Color Characteristics of Selected Coarse Cereals and Pulses

The colour characteristics (L*, a*, and b*) of selected pulses and cereals showed distinct variations between control and tribal samples (Table 1). Among pulses, kidney bean exhibited a significant reduction in lightness (L*) in the tribal sample (77.08±0.49) compared to the control (80.45±0.53) ($p<0.05$). This reduction in L* was accompanied by a significant increase in redness (a*) from 4.22±0.37 (control) to 5.24±0.10 (tribal) and a significant increase in yellowness (b*) from 6.24±0.56 to 7.35±0.19 ($p<0.05$), indicating enhanced seed coat pigmentation in the tribal sample. In red gram, the tribal sample recorded a significantly higher L* value (80.01±0.13) compared to the control (76.42±0.57) ($p<0.05$), suggesting increased lightness. However, differences in a* values (3.72±0.41 in control and 3.11±0.04 in tribal) and b* values (11.58±0.64 in control and 13.76±1.67 in tribal) were not statistically significant ($p>0.05$). Cowpea showed no significant differences in lightness (L*) between the control (82.65±0.69) and tribal samples (81.69±0.31), and a* values also remained non-significant (3.21±0.43 and 2.89±0.13, respectively) ($p>0.05$). However, the b* value was significantly higher in the tribal sample (9.61±0.38) compared to the control (8.21±0.56) ($p<0.05$), indicating increased yellowness.

Among cereals, finger millet exhibited a significant decrease in L* value in the tribal sample (71.20±0.34) compared to the control (74.07±0.65) ($p<0.05$), reflecting darker grains. This was accompanied by a marked and significant increase in a* value from 2.18±0.47 to 6.04±0.07 and b* value from 4.57±0.59 to 6.53±0.26 ($p<0.05$), indicating enhanced red and yellow pigmentation. Similarly, little millet showed a significant reduction in L* value in the tribal sample (64.35±0.32) compared to the control (70.25±0.77) ($p < 0.05$). The b* value was also significantly higher in the tribal sample (18.79±0.31) than in the control (16.47±0.85) ($p<0.05$), whereas the increase in a* value from 5.58±0.66 to 6.59±0.23 was not statistically significant ($p>0.05$). In contrast, rice exhibited a significantly higher L* value in the tribal sample (92.14±0.37) compared to the control (84.14±0.68) ($p<0.05$), indicating greater grain lightness. The b* value showed a significant reduction from 6.87±0.66 in the control to 1.08±0.04 in the tribal sample ($p<0.05$), while changes in a* values (0.28±0.18 and 0.12±0.01) were not significant ($p>0.05$). Overall, the variations observed in L*, a*, and b* values between control and tribal samples reflect differences in seed coat pigmentation and surface colour attributes, which may be attributed to varietal differences, environmental conditions.

The colour parameters (L*, a*, b*) observed in the present study were comparable with earlier reports in the literature, reflecting varietal differences and seed coat pigmentation among pulses and cereals. Wani *et al.* (2020) [28] reported L* values for kidney bean flours ranging from 71.22 to 82.65, with a* values from −0.12 to −2.16 and b* values from 15.20 to 22.85, which aligns with the lightness and yellowness observed in the present kidney bean samples. In red gram, reported colour variations in seed coat and flour are attributed to genetic and structural differences, and the present L*, a*, and b* values were found to be within the range of earlier observations. Hamid *et al.* (2016) [9] noted that cowpea cultivars exhibited brighter seed coats with higher L* and positive a* values, which is consistent with the colour characteristics observed in the present cowpea samples. For cereals, Dasa and Binh (2019) [5] reported that millet flours exhibited L* values between 59.76 and 64.69, a* values from −0.11 to 1.66, and variable b* values, which agrees with the colour variations observed in the present little millet and finger millet samples. Ramashia *et al.* (2018) [23] documented finger millet L* values ranging from 19.23 to 52.97 for grains and 68.47 to 74.00 for flours, supporting the lightness trends observed in the present study.

Table 1: Colour values of selected coarse cereals and pulses from the Alluri Sitaramaraju District

S. No.	Variety	Treatment	L*	a*	b*
1	Kidney Bean	Control	80.45±0.53	4.22±0.37	6.24±0.56
		Tribal	77.08±0.49	5.24±0.10	7.35±0.19
		t-value	8.053	−4.605	−3.260
		p-value	0.001	0.010	0.031
2	Red Gram	Control	76.42±0.57	3.72±0.41	11.58±0.64
		Tribal	80.01±0.13	3.11±0.04	13.76±1.67
		t-value	−10.665	2.551	−2.118
		p-value	0.000	0.063	0.102
3	Cowpea	Control	82.65±0.69	3.21±0.43	8.21±0.56
		Tribal	81.69±0.31	2.89±0.13	9.61±0.38
		t-value	2.193	1.234	−3.579
		p-value	0.093	0.285	0.023
4	Finger Millet	Control	74.07±0.65	2.18±0.47	4.57±0.59
		Tribal	71.20±0.34	6.04±0.07	6.53±0.26
		t-value	6.791	−14.060	−5.267
		p-value	0.002	0.000	0.006
5	Little Millet	Control	70.25±0.77	5.58±0.66	16.47±0.85
		Tribal	64.35±0.32	6.59±0.23	18.79±0.31
		t-value	12.231	−2.514	−4.449
		p-value	0.000	0.066	0.011
6	Rice	Control	84.14±0.68	0.28±0.18	6.87±0.66
		Tribal	92.14±0.37	0.12±0.01	1.08±0.04
		t-value	−10.884	1.543	11.167
		p-value	0.000	0.198	0.000

Note: The significance of differences between Control and Tribal samples was assessed using independent t-tests. Values with $p<0.05$ were considered statistically significant (*), while $p > 0.05$ were considered not significant (**).

100-Seed Weight

The 100-grain weight of selected pulses and cereals from the Alluri Sitarama Raju tribal region is presented in Table 2. Among pulses, kidney bean showed a decrease in 100-grain weight from 34.08±2.09 g in the control to 31.92±1.95 g in the tribal sample; however, the difference was not statistically significant ($p>0.05$). Red gram recorded a slight increase from 10.76±0.47 g (control) to 11.41±1.00 g in the tribal sample, while cowpea increased from 10.90±5.37 g to 11.53±0.55 g; both changes were statistically non-significant ($p>0.05$). Among cereals, finger millet exhibited a marginal increase in 100-grain weight from 0.25±0.01 g (control) to 0.27±0.01 g in the tribal sample, though the difference was not statistically significant ($p>0.05$). In contrast, little millet showed a significant increase in 100-grain weight in the tribal sample (0.23±0.01 g) compared to the control (0.20±0.01 g) ($p<0.05$). Rice showed a slight reduction in 100-grain weight from 1.05±0.01 g in the control to 1.03±0.02 g in the tribal sample, which was not statistically significant ($p>0.05$).

The present study findings were in line with earlier reports, showing considerable variation in 100-grain weights across pulse cultivars. Kidney bean exhibited a hundred-seed mass within the range of 22.47-41.76 g reported by Neha Pathak and Kulshrestha (2017) [20] and was consistent with observations for kidney bean germplasm by Singh & Chandra (2014) [26]. Red gram showed values comparable to previously reported ranges of 6.10-11.70 g (Khan *et al.*, 2020) [12] and slightly higher weights in tribal red gram, likely due to varietal and regional differences (Saroj *et al.*, 2013) [25]. Cowpea grain weight fell within the range observed by Ndiso *et al.* (2016) [19], who reported significant variations under different water-stress conditions. Among cereals, minor millets generally had lower kernel weights compared to major cereals such as rice (Raju, 2024) [22]. In the present study, tribal little millet showed lower grain weight, while finger millet showed no significant change compared to control samples, likely due to genotype, climatic conditions, and soil fertility. Rice exhibited relatively higher 100-grain weight, consistent with its classification as a major cereal and in agreement with literature reports (Kalita & Hazarika, 2022) [10].

Physical Dimensions of Pulses and Cereals

The physical dimensions of selected pulses and cereals from the Alluri Sitarama Raju district were evaluated and are presented in Table 2. Kidney bean exhibited a length of 14.75±0.90 mm, width of 7.32±0.45 mm, thickness of 5.93±0.36 mm, and grain size of 8.26±0.50 mm; the control sample had a slightly greater length of 15.30±0.93 mm. All differences were not statistically significant (p>0.05). Red gram measured 6.05±0.17 mm in length, 5.42±0.37 mm in width, 4.75±0.37 mm in thickness, and 5.48±0.39 mm in grain size, while cowpea showed a length of 6.04±0.26 mm, width of 5.42±0.37 mm, thickness of 4.75±0.37 mm, and grain size of 5.48±0.39 mm; for both Red gram and cowpea. However, none of the changes were statistically significant (p>0.05). Among cereals, Finger millet exhibited a length of 1.57±0.06 mm, width of 1.64±0.08 mm, thickness of 1.39±0.19 mm, and grain size of 1.62±0.12 mm. Width showed a statistically significant increase ($p<0.05$), while other traits were not significant (p>0.05). Little millet had a length of 1.74±0.10 mm, width of 1.50±0.06 mm, thickness of 1.24±0.10 mm, and grain size of 1.51±0.19 mm, with bulk density showing a statistically significant decrease ($p<0.05$) and other traits not significant. Rice showed a decrease in length (4.19±0.21 mm) and thickness (2.38±0.72 mm), and an increase in width (2.53±0.29 mm) whereas grainsize showed a decreasing trend compared to control (2.69±0.72 mm) length was statistically significant ($p<0.05$), while other changes were not significant.

The variations in physical dimensions of pulses observed in the present study were generally consistent with previous reports, although minor differences were noted. For kidney bean, the width and thickness were slightly lower than values reported by Eşref and Halil (2007) (width: 9.222±0.75 mm; thickness: 7.062±1.15 mm at 9.77% moisture), likely due to varietal differences and growing conditions. Red gram seed dimensions were slightly lower in length but within the lower range for width and thickness compared to ranges reported by Khan *et al.* (2020) [12] (length: 6.90-8.40 mm; width: 5.10-7.90 mm; thickness: 4.10-6.30 mm), indicating slightly smaller seeds in the tribal varieties. Cowpea exhibited thickness comparable to values reported by Appiah *et al.* (2011) [3] and Hamid *et al.* (2016) [9], while length and width were slightly lower, reflecting local genotype characteristics (Amadi & Okorie, 2020) [1]. Considering literature values, little millet grain length ranged from 3.266 mm, with tribal little millet showing a slightly lower length, whereas finger millet length reported by Sunil *et al.* (2016) [27] was comparable with tribal values. Grain width for little millet in literature was 1.831 mm, and tribal values were comparable, while finger millet width averaged 1.590 mm and tribal finger millet was slightly higher. For thickness, literature values for little millet were 1.372 mm, with tribal values higher; finger millet averaged 1.454 mm with tribal values slightly higher. Rice grain dimensions were within the ranges reported by Kalita and Hazarika (2022) [10], with tribal rice showing slightly higher length and width, but similar thickness.

Bulk Density and True Density

The bulk density of selected pulses and cereals presented in Table 2. In kidney bean, bulk density was higher in the tribal sample (0.82±0.05 g/ml) compared to the control (0.79±0.05 g/ml); however, the difference was not statistically significant (p>0.05). In red gram, the tribal sample recorded a lower bulk density (0.73±0.04 g/ml) than the control (0.78±0.04 g/ml), while cowpea showed identical bulk density values (0.75±0.03 g/ml) in both control and tribal samples; these differences were statistically non-significant (p>0.05). Among cereals, finger millet exhibited a lower bulk density in the tribal sample (0.83±0.07 g/ml) compared to the control (0.88±0.04 g/ml), whereas rice showed a higher bulk density in the tribal sample (0.84±0.07 g/ml) than in the control (0.80±0.08 g/ml); both differences were not statistically significant (p>0.05). In contrast, little millet recorded a significantly lower bulk density in the tribal sample (0.77±0.01 g/ml) compared to the control (0.80±0.01 g/ml) ($p<0.05$).

The true density of the analysed samples varied slightly across different grains from the Alluri Sitarama Raju district (Table 2). In pulses, Kidney Bean and Cowpea exhibited marginal increases to 1.04±0.06 g/ml and 1.20±0.14 g/ml, respectively, while Red Gram decreased to 1.00±0.06 g/ml, though these changes were not statistically significant (p>0.05). Among cereals, Finger Millet and Little Millet recorded slight reductions to 1.00±0.08 g/ml and 1.00±0.07 g/ml, whereas Rice increased to 1.62±0.31 g/ml, without significant differences (p>0.05).

The bulk density values observed in the present study were largely consistent with reported literature, reflecting inherent grain size, shape, and packing characteristics. In kidney bean, bulk density was slightly lower than values reported by Wani *et al.*, which may be attributed to minor varietal differences and seed morphology. Red gram exhibited bulk density values within the reported range of 0.82-0.89 g/ml (Khan *et al.*, 2017) [13], indicating comparable grain packing behavior. Cowpea recorded marginally higher bulk density compared with values reported by Yalçın (2007) [29] and Hamid *et al.* (2016) [9], suggesting denser and more uniformly packed seeds influenced by genotype and environmental conditions. Among cereals, little millet, finger millet, and rice showed noticeable variation in bulk density, reflecting inherent differences in grain structure. Finger millet exhibited slightly higher bulk density compared with the reported value of 0.71±0.02 g/ml (Khatoniar and Das, 2020) [14], indicating improved compactness in the tribal variety. Little millet demonstrated comparable bulk density values, suggesting efficient grain packing. Rice showed bulk density values comparable to those reported by Nazni and Bhuvaneswari (2015), reflecting uniform grain structure and suitability for handling and storage.

The true density values obtained in the present study reflected the actual solid material content and compactness of the grains and were largely in agreement with reported literature. Kidney bean exhibited true density values comparable to earlier reports, indicating stable internal grain structure. In red gram, true density was slightly lower than the reported range of 1.31-1.34 g/ml (Khan *et al.*, 2017) [13], possibly due to differences in moisture content and seed internal porosity. Cowpea showed marginally higher true density compared with values reported by Hamid *et al.* (2016) [9], indicating denser grain material influenced by genotype and growing conditions. Among cereals, little millet and finger millet exhibited true density values comparable to earlier findings. Finger millet showed slightly higher true density than the reported value of 1.12 g/ml (Khatoniar and Das, 2020) [14], suggesting enhanced grain compactness in the tribal variety. Little millet demonstrated true density values within reported ranges, indicating consistent solid mass per unit volume. Rice exhibited true density values comparable to those reported by Krishnan *et al.* (2011) [16], reflecting uniform endosperm composition and stable grain structure.

Table 2: Physical characteristics of selected coarse cereals and pulses from the Alluri Sitaramaraju District

S. No.	Varieties	Treatment	100-Grain Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	Grain Size (mm)	Bulk Density (g/ml)	True Density (g/ml)
1	Kidney Bean	Control	34.08±2.09	15.30±0.93	6.62±0.41	5.81±0.35	8.36±0.51	0.79±0.05	1.02±0.06
		Tribal	31.92±1.95	14.75±0.90	7.32±0.45	5.93±0.36	8.26±0.50	0.82±0.05	1.04±0.06
		t-value	-0.757	-0.424	-1.156	-0.240	0.140	-0.231	-0.240
		p-value	0.491**	0.693**	0.313**	0.822**	0.896**	0.828**	0.535**
2	Red Gram	Control	10.76±0.47	5.95±0.28	4.59±0.20	3.95±0.31	4.88±0.33	0.78±0.04	1.10±0.07
		Tribal	11.41±1.00	6.05±0.17	5.42±0.37	4.75±0.37	5.48±0.39	0.73±0.04	1.00±0.06
		t-value	-0.592	-0.316	-1.973	-1.688	-1.172	0.930	1.064
		p-value	0.586**	0.768**	0.142**	0.167**	0.306**	0.405**	0.348**
3	Cowpea	Control	10.90±5.37	6.33±0.42	4.76±0.33	4.70±0.46	5.13±0.33	0.75±0.03	1.00±0.081
		Tribal	11.53±0.55	6.04±0.26	5.42±0.37	4.75±0.37	5.48±0.39	0.75±0.03	1.20±0.14
		t-value	-0.117	-0.604	-1.322	-0.095	-0.683	-0.043	-1.605
		p-value	0.913**	0.584**	0.257**	0.929**	0.532**	0.968**	0.185**
4	Finger Millet	Control	0.25±0.01	1.57±0.15	1.32±0.05	1.03±0.07	1.35±0.16	0.88±0.04	1.14±0.11
		Tribal	0.27±0.01	1.57±0.06	1.64±0.08	1.39±0.19	1.62±0.12	0.83±0.07	1.00±0.08
		t-value	-2.45	-0.040	-3.330	-1.824	-1.380	0.077	1.011
		p-value	0.070**	0.971**	0.037*	0.180**	0.246**	0.943**	0.374**
5		Control	0.20±0.01	2.00±0.12	1.37±0.07	1.00±0.05	1.44±0.14	0.80±0.01	1.13±0.12
		Tribal	0.23±0.01	1.74±0.10	1.50±0.06	1.24±0.10	1.51±0.19	0.77±0.01	1.00±0.07
		t-value	-3.67	1.716	-1.382	-2.264	0.157	-7.78	-1.885
		p-value	0.021*	0.163**	0.240**	0.112**	0.883**	0.001*	0.134
6	Rice	Control	1.05±0.01	5.68±0.41	2.13±0.19	3.03±0.35	3.38±0.327	0.80±0.08	1.00±0.10
		Tribal	1.03±0.02	4.19±0.21	2.53±0.29	2.38±0.72	2.69±0.314	0.84±0.07	1.62±0.31
		t-value	2.45	3.279	-1.120	0.815	-0.372	-0.372	-1.924
		p-value	0.070**	0.046*	0.335**	0.476**	0.729**	0.729**	0.170**

Note: The significance of differences between Control and Tribal samples was assessed using independent t-tests. Values with $p < 0.05$ were considered statistically significant (*), while $p > 0.05$ were considered not significant (**)

Conclusion

The present study demonstrated that selected coarse cereals and pulses cultivated in tribal regions of the Alluri Sitharama Raju district exhibit noticeable variations in physical characteristics when compared with control samples. Differences in colour attributes, 100- grain weight, grain dimensions, bulk density, and true density highlight the influence of agro- climatic conditions, varietal diversity, and local cultivation practices prevalent in tribal areas. Tribal millets, particularly finger millet and little millet, showed distinct pigmentation and changes in grain physical properties, which may affect processing behaviour and end-use quality. Although most pulses exhibited non-significant differences, marginal variations in size and density were observed. Overall, the findings provide valuable baseline information that can support improved post-harvest handling, processing efficiency, and value addition of coarse cereals and pulses cultivated in tribal regions, thereby contributing to enhanced utilization and nutritional security.

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